Exhibit H
Geological Hazards and Soil Stability

Boardman to Hemingway Transmission Line Project

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Application for Site Certificate

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ACRONYMS AND ABBREVIATIONS

ASC	Application for Site Certificate
ASCE	American Society of Civil Engineers
ASTM	ASTM International (formerly known as American Society for Testing and Materials)
BMP	best management practice
CSZ	Cascadia Subduction Zone
DOGAMI	Oregon Department of Geology and Mineral Industries
EFSC or Council	Energy Facility Siting Council
ESCP	Erosion and Sediment Control Plan
FEMA	Federal Emergency Management Agency
IBC	International Building Code
IPC	Idaho Power Company
km	kilometer
kV	kilovolt
LiDAR	light detection and ranging
MCE	maximum credible earthquake
MConE	Maximum Considered Earthquake ground motions
MMI	Modified Mercalli Intensity
MOP	Manual of Practice
MP	milepost
MPE	maximum probable earthquake
NESC	National Electrical Safety Code
NGDC	National Geophysical Data Center
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OAR	Oregon Administrative Rule
ODOE	Oregon Department of Energy
OPS	U.S. Department of Transportation, Office of Pipeline Safety
OSSC	Oregon Structural Specialty Code
PGA	peak ground acceleration
Project	Boardman to Hemingway Transmission Line Project
Second Amended Project Order	Second Amended Project Order, Regarding Statutes, Administrative Rules, and Other Requirements Applicable to the Proposed BOARDMAN TO HEMINGWAY TRANSMISSION LINE (July 26, 2018)
SLIDO	Statewide Landslide Inventory Database for Oregon
STATSGO	State Soil Geographic Database
U.S.	United States
USACE	U.S. Army Corps of Engineers
USFS	United States Forest Service
USGS	U.S. Geological Survey

Exhibit H
Geological Hazards and Soil Stability

1.0 INTRODUCTION

Exhibit H provides information regarding the geological and soil stability within the Site Boundary for the Boardman to Hemingway Transmission Line Project (Project). The information provided in Exhibit H shows that Idaho Power Company (IPC) has adequately characterized the site and potential geological and soils hazards, and that the Project can be designed, engineered, and constructed to avoid dangers to human safety presented by seismic, geological, and soil hazards.

2.0 APPLICABLE RULES AND SECOND AMENDED PROJECT ORDER PROVISIONS

2.1 General Standards for Siting Facilities

The Structural Standard set forth at Oregon Administrative Rule (OAR) 345-022-0020 provides, in relevant part:

> *(1) Except for facilities described in sections (2) and (3), to issue a site certificate, the Council must find that:*
>
> > *(a) The applicant, through appropriate site-specific study, has adequately characterized the seismic hazard risk of the site;*
> >
> > *(b) The applicant can design, engineer, and construct the facility to avoid dangers to human safety and the environment presented by seismic hazards affecting the site, as identified in subsection (1)(a);*
> >
> > *(c) The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and*
> >
> > *(d) The applicant can design, engineer and construct the facility to avoid dangers to human safety and the environment presented by the hazards identified in subsection (c).*
>
> *. . . .*[1]

2.2 Site Certificate Application Requirements

OAR 345-021-0010(1)(h) provides Exhibit H must include the following Information regarding the geological and soil stability within the Site Boundary:

> *(A) A geologic report meeting the Oregon State Board of Geologist Examiners geologic report guidelines. Current guidelines shall be determined based on consultation with the Oregon Department of Geology and Mineral Industries, as per (B).*

[1] Section (2) and Section (3) of OAR 345-022-0020 apply to energy generation facilities and special criteria facilities, respectively. Here, the Project is neither an energy generation facility nor a special criteria facility. Therefore, Section (2) and Section (3) of OAR 345-022-0020 do not apply to the Project.

(B) A summary of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate methodology and scope of the seismic hazards and geology and soil-related hazards assessments, and the appropriate site-specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.

(C) A description and schedule of site-specific geotechnical work that will be performed before construction for inclusion in the site certificate as conditions.

(D) For all transmission lines, and for all pipelines that would carry explosive, flammable or hazardous materials, a description of locations along the proposed route where the applicant proposes to perform site specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, dead ends (for transmission lines), corners (for transmission lines), and portions of the proposed route where geologic reconnaissance and other site specific studies provide evidence of existing landslides, marginally stable slopes or potentially liquefiable soils that could be made unstable by the planned construction or experience impacts during the facility's operation.

(E) An assessment of seismic hazards, in accordance with standard-of-practice methods and best practices, that address all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries under (B), and an explanation of how the applicant will design, engineer, construct, and operate the facility to avoid dangers to human safety and the environment from these seismic hazards. Furthermore, an explanation of how the applicant will design, engineer, construct and operate the facility to integrate disaster resilience design to ensure recovery of operations after major disasters. The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring and emergency measures for seismic hazards, including tsunami safety measures if the site is located in the DOGAMI-defined tsunami evacuation zone.

(F) An assessment of geology and soil-related hazards which could, in the absence of a seismic event, adversely affect or be aggravated by the construction or operation of the facility, in accordance with standard-of-practice methods and best practices, that addresses all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries under (B). An explanation of how the applicant will design, engineer, construct and operate the facility to adequately avoid dangers to human safety and the environment presented by these hazards, as well as:

(i) An explanation of how the applicant will design, engineer, construct and operate the facility to integrate disaster resilience design to ensure recovery of operations after major disasters.

(ii) An assessment of future climate conditions for the expected life span of the proposed facility and the potential impacts of those conditions on the proposed facility.

2.3 Second Amended Project Order Provisions

The Second Amended Project Order includes the following discussion regarding Exhibit H:

The Department understands that detailed site-specific geotechnical investigation for the entire site boundary is not practical in advance of completing the final facility design and obtaining full site access. However, OAR 345-021-0010(h) requires evidence of

> *consultation with the Oregon Department of Geology and Mineral Industries (DOGAMI) prior to submitting the application if the applicant proposes to base Exhibit H on limited pre-application geotechnical work. Exhibit H shall include written evidence of consultation with DOGAMI regarding the level of geologic and geotechnical investigation determined to be practical for the application submittal.*
>
> *Any geotechnical reports included in Exhibit H as supporting evidence that the proposed facility will meet the Council's structural standard shall meet the Oregon State Board of Geologist Examiners geologic report guidelines, as determined based on consultation with DOGAMI. In 2017, the Council underwent rulemaking amending the Oregon Administrative Rules (OARs) 345-021-0010, 345-022-0020, and 345-050-0060 to address rule language for structural, geologic, and seismic related issues and hazards. The amended rule language focuses on the requirements of Exhibit H and the Structural Standard to site-specific issues and risks, and allow for the appropriate consideration of evolving science of seismic risk and hazard based on consultation with DOGAMI.*

(Second Amended Project Order, Section III(h))

3.0 ANALYSIS

3.1 Analysis Area

The analysis area for Exhibit H includes all areas within the Site Boundary, which is defined as "the perimeter of the site of a proposed energy facility, its related or supporting facilities, all temporary laydown and staging areas, and all corridors and micrositing corridors proposed by the applicant" (OAR 345-001-0010(55)). The Site Boundary encompasses the following facilities in Oregon:

- The Proposed Route, consisting of 270.8 miles of new 500-kilovolt (kV) electric transmission line, removal of 12 miles of existing 69-kV transmission line, rebuilding of 0.9 mile of a 230-kV transmission line, and rebuilding of 1.1 miles of an existing 138-kV transmission line;
- Four alternatives that each could replace a portion of the Proposed Route, including the West of Bombing Range Road Alternative 1 (3.7 miles), West of Bombing Range Road Alternative 2 (3.7 miles), Morgan Lake Alternative (18.5 miles), and Double Mountain Alternative (7.4 miles);
- One proposed 20-acre station (Longhorn Station);
- Ten communication station sites of less than ¼-acre each and two alternative communication station sites;
- Permanent access roads for the Proposed Route, including 206.3 miles of new roads and 223.2 miles of existing roads requiring substantial modification, and for the Alternative Routes including 30.2 miles of new roads and 22.7 miles of existing roads requiring substantial modification; and
- Thirty temporary multi-use areas and 299 pulling and tensioning sites of which four will have light-duty fly yards within the pulling and tensioning sites.

The Project features are fully described in Exhibit B and the Site Boundary for each Project feature is described in Exhibit C, Table C-24. The location of the Project features and the Site Boundary is outlined in Exhibit C.

3.2 Methods

IPC will complete the studies necessary to generate the detailed information required by OAR 345-0210-0010(1)(h) in two phases. IPC has already completed Phase 1 of its Exhibit H Geological Hazards and Soil Stability studies. Exhibit H relies on published data, and also field and literature information compiled by IPC's geotechnical consultants. The Engineering and Seismic Hazards Supplement (Attachment H-1) presents the regional geologic and tectonic setting, seismic hazards, and non-seismic geologic hazards that could affect the Project. The Engineering Geology and Seismic Hazards Supplement was based on review of literature and existing mapping, referenced throughout Attachment H-1 and in Attachment H-1, Section 9 – References.

The Engineering and Seismic Hazards Supplement describes a reconnaissance-level survey that examined the proposed transmission line route from its starting point at Longhorn Station, near Boardman, Oregon, to its end point at the Hemingway Substation in Owyhee County, Idaho. IPC recognizes that any desktop analysis or regional study is generally useful for regional applications and should not be used as an alternative to site-specific studies in critical areas.

As described further in Section 3 of Attachment H-1, IPC proposes to conduct a Phase 2 site-specific geotechnical investigation, which will be conducted prior to final design and construction. Phase 2 will support final design, engineering, and construction specifications and will be used to avoid or mitigate site-specific geologic hazards. Following completion of Phase 2, IPC will develop a Phase 2 Site-Specific Geotechnical Report following the 2014 Guidelines for Preparing Engineering Geological Reports (OSBGE 2014). IPC will submit the Phase 2 Site-Specific Geotechnical Report to the DOGAMI and the Oregon Department of Energy (ODOE) prior to construction.

Consistent with the direction provided by DOGAMI, the most up-to-date building and structural codes that apply to transmission line projects will be used during the final design and construction of the Project. Current codes will be used to meet reliability standards and other external regulations. It is specifically assumed that current requirements embedded in structural, electrical building, and other codes meet or exceed the requirements of prior codes.

3.3 Geologic Report

> OAR 345-021-0010(1)(h): Information from reasonably available sources regarding the geological and soil stability within the analysis area, providing evidence to support findings by the Council as required by OAR 345-022-0020, including: (A) A geologic report meeting the Oregon State Board of Geologist Examiners geologic report guidelines. Current guidelines shall be determined based on consultation with the Oregon Department of Geology and Mineral Industries, as per (B).

OAR 345-021-0010(1)(h)(A) directs applicants to consult with DOGAMI to identify the relevant guidelines for developing the geologic report called for under that provision. For this Project, DOGAMI has directed IPC to rely on DOGAMI's *Guidelines for Engineering Geologic Reports* (DOGAMI Guidelines). The DOGAMI Guidelines provide general guidance for completing engineering geology reports in Oregon. Adopted by the Oregon State Board of Geologist Examiners in 2004, it contains a suggested guide for the preparation of engineering geologic reports in Oregon. The DOGAMI Guidelines state that "the engineering geologic report should include sufficient facts and interpretation of the suitability of the site for the proposed use. Because of the wide variation in size and complexity of projects and scope of work, the guidelines are intended to be flexible and should be tailored to the specific project." As such, the guidelines do not provide rigid requirements for every engineering geologic report.

The DOGAMI Guidelines include general types of information that may be considered in an engineering geology report. All of these may or may not be included, depending on the Project, or additional information may be necessary not mentioned in the DOGAMI Guidelines. General project information may include client, supervising geologist, project location and setting, purpose of report, topography, earth materials present, reference sources, geologic hazards, locations of test holes and excavations, field and laboratory test methods, statement of geologist's financial information if applicable, and signature and seal of certified engineering geologist. Geologic maps and cross-sections may be necessary to define the geologic conditions present. Geologic descriptions are typically found in an engineering report including bedrock rock types, relative age or formation names, distribution and thickness, and physical characteristics, structural features, surficial deposits, surface and subsurface hydrologic conditions, and seismic considerations. The geologic factors observed are typically discussed in the context of suitability for proposed land use to identify geologic conditions that may result in risk to land use, recommendations for site grading, drainage considerations, and limitations of study. Recommendations for additional investigations or hazard mitigations are also a part of typical engineering geology and seismic hazard reports.

Attachment H-1 includes an introduction, summary of topographical and geological features, general description of the scope of the proposed site-specific investigation, and summaries and mitigation strategies for seismic and non-seismic hazards. In turn, Exhibit H supplements the data contained in Attachment H-1.

To support the detailed design, IPC will carry out the Phase 2 program of site-specific geological and geotechnical work to investigate subsurface soil and geologic conditions following site certificate approval and apply site-specific geotechnical design recommendations. The geotechnical investigation will emphasize areas that require engineering design and areas identified as potential geologic hazards in the Engineering Geology and Seismic Hazards Supplement, including seismicity, slope failure, liquefaction, and subsidence. The site-specific geotechnical investigation will be performed prior to final design and construction.

Using the results of the geotechnical investigation, IPC will prepare a final engineering geologic report, the Phase 2 Site-Specific Geotechnical Report, prior to final design and construction to assess site-specific hazards in conformance with the DOGAMI Guidelines. As described in the DOGAMI Guidelines, the Phase 2 Site-Specific Geotechnical Report will include additional facts and site-specific interpretation regarding geologic materials, processes, and history to allow evaluation of the suitability of specific affected sites for the proposed Project uses.

IPC has responded to many portions of the DOGAMI Guidelines in Exhibit H and Exhibit I, and will respond to the remaining applicable guidelines in the Phase 2 Site-Specific Geotechnical Report and related studies.

3.4 Consultation with DOGAMI

OAR 345-021-0010(1)(h)(B): A summary of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate methodology and scope of the seismic hazards and geology and soil-related hazards assessments, and the appropriate site-specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.

OAR 345-021-0010(1)(h)(B) requires consultation with DOGAMI on the geotechnical work. Regarding the Project, DOGAMI and the ODOE were consulted at an in-person meeting on April 4, 2011, in Portland, Oregon. Based upon comments made during this meeting by Mr. Bill Burns, Engineering Geologist for DOGAMI, IPC responded with a letter to DOGAMI (Attachment H-2). Excerpts from the letter are as follows:

1) *The SLIDO (Statewide Landslide Inventory Database for Oregon) was being updated based on new LIDAR data, and you requested that the updated SLIDO 2 data should be incorporated into the geotechnical hazard assessment and engineering design prior to construction.*
2) *Geological and soil hazard analysis is not required at each tower location. The degree of investigation should be contingent on the type of hazards present, facility to be constructed, and potential danger to human safety. The degree of analysis will vary across the Project corridor.*
3) *The most recent IBC and Oregon Structural Specialty Code (OSSC) requirements should be used although current Oregon Administrative Rules reference historical IBC requirements.*
4) *You were aware that in transmission line construction, design for wind and ice forces is more than sufficient to account for typical seismic forces.*
5) *A detailed geotechnical plan may be submitted concurrently with the Application for Site Certification (ASC) and the Engineering Geologic Report for the Project may be submitted after filing the ASC.*
6) *Exhibit H should contain as much detail as possible. DOGAMI will only review Exhibit H and its Attachment so reference should not be made to other documents.*
7) *You indicated that the April 2011 meeting would satisfy the requirements of DOGAMI consultation.*

Attachment H-2 contains a letter to DOGAMI, confirming DOGAMI's acknowledgement of the bulleted items listed above. The Engineering Geology and Seismic Hazards Supplement was attached to the letter to DOGAMI for the agency's review and evaluation.

In September 2017, the Council amended the Structural Standard at OAR 345-022-0020 and the Exhibit H application requirements at OAR 345-021-0010(1)(h). On October 5, 2017, IPC met with DOGAMI via teleconference to discuss the rule amendments. During that meeting, DOGAMI indicated that IPC should continue to rely on DOGAMI's Guidelines for preparing the geologic report required under OAR 345-021-0010(1)(h)(A). DOGAMI also indicated that the Exhibit H material provided in IPC's June 2017 Amended Preliminary Application for Site Certificate satisfied the requirements of the amended rules, with the only exceptions being that new information would need to be provided to address (1) disaster resilience under OAR 345-021-0010(1)(h)(E) and OAR 345-021-0010(1)(h)(F)(i), and (2) future climate conditions under OAR 345-021-0010(1)(h)(F)(ii). Following the October 5, 2017 meeting, IPC had several conversations with DOGAMI to ensure the disaster-resilience and future-climate-condition information provided in this application met the requirements of the amended rules.

3.5 Site-specific Geotechnical Work

OAR 345-021-0010(1)(h)(C): A description and schedule of site-specific geotechnical work that will be performed before construction for inclusion in the site certificate as conditions.

OAR 345-021-0010(1)(h)(C) requires a description and schedule of pre-construction geotechnical work. Here, site-specific geologic and geotechnical investigations will include more detailed geologic field reconnaissance to identify faults and landslides and geologic data acquisition for soil, seismic, slope stability, and flood analyses.

Based on the geologic reconnaissance performed to date, IPC's geotechnical engineers have identified a preliminary list of proposed geotechnical boring locations for the Proposed Route (see Attachment H-1, Section 3.0 and Appendix C of Attachment H-1). Appendix A of Attachment H-1 includes maps of these proposed borehole locations and Appendix C (Table C-1) of Attachment H-1 includes a summary of proposed boring locations. Section 3 of the Attachment H-1 provides an overview of the proposed site-specific geotechnical work, including right-of-way considerations, access and disturbance, and exploration methods.

Boring locations will occur at a spacing of approximately 1 mile along the alignments at:

- dead-end structures;
- any corners or changes in alignment heading (angles);
- crossings of highways, major roads, rivers, railroads, and utilities such as power transmission lines, natural gas pipelines, and canals; and
- locations necessary to verify lithologic changes and/or geologic hazards such as landslides, steep slopes, or soft soil areas.

Additional borings may be obtained prior to construction in areas where we have not yet been granted access.

Reconnaissance and test borings, trenching techniques, and collection of rock and soil samples will be employed to help assess subsurface conditions. Collected rock and soil samples will be field classified and tested to determine geotechnical behaviors. Upon completion of soil and rock sampling, further laboratory tests will be conducted to measure physical and engineering properties of the soil and rock. Laboratory tests may include natural water content, particle size analysis, liquid and plastic limits, and moisture-density relationship. All testing will be performed in accordance with ASTM International (ASTM) or U.S. Army Corps of Engineers (USACE) testing requirements for consistency. Depending upon the materials encountered, additional testing in general accordance with ASTM or USACE testing procedures may be required to evaluate swell or settlement potential, direct shear, unconfined compressive strength, specific gravity and corrosion.

The results of the initial geotechnical investigation may identify data gaps that could result in additional investigation until sufficient information is received to ensure that the Project can be designed, engineered, and constructed. As detailed in Attachment H-1, it is anticipated that boring depths will generally be no more than 50 feet below the designed finish grade of the transmission center line. Subsurface investigation will be accomplished by hollow-stem auger in unconsolidated areas above the groundwater level and by mud rotary methods below groundwater level. In areas where rock is encountered, the rock will be cored using HQ triple-tube rock-coring techniques. Soil and bedrock samples will be collected for analysis of geotechnical properties. Rock-coring methods will be used in an attempt to obtain continuous samples of rock, where encountered during drilling. Other standard sample collection methods are described in Attachment H-1.

Depth to groundwater will also be measured in the borings. If seasonal high groundwater is anticipated to interact with foundations, piezometers may be installed to assess groundwater fluctuations.

For proposed structures (such as stations or communication stations) near identified faults or within historical and pre-historic landslide areas, additional geotechnical investigation will be conducted to acquire necessary data for seismic and slope stability analysis. The degree of analysis will be contingent on hazard present, facility to be constructed, and potential danger to human safety and infrastructure.

IPC will obtain the necessary detailed information through invasive field and laboratory studies essential for the design, engineering, and constructing of the proposed facilities. When appropriate, IPC may use geophysical methods to investigate the underlying soils and rock. Typical indirect methods would include, but not be limited to, seismic refraction and resistivity methods.

Based on the results of the geotechnical field work, other studies employing alternative investigation methods may be required to expand design knowledge necessary to assess seismic hazards and failure-prone slopes. For example, preliminary seismic sources and maximum probable ground shaking were analyzed and are presented in Attachment H-1. However, during the field investigation, faults that cross the Project will be evaluated to confirm location and assess activity. Additional investigative methods may include field geomorphic and geologic investigation, followed by trenching where towers would need to be relocated to avoid active faults.

In known landslide-prone areas, steep slopes will also be evaluated to examine the potential for slope failure. Subsurface investigations will examine soil/rock properties, depth to slide planes, groundwater depths, groundwater fluctuations, or depth to bedrock or specific soil horizons. Investigation methods may include borings, trenches, geophysical surveys, inclinometer installation and monitoring, and laboratory testing of soil/rock. Site modifications and mitigation strategies will be developed and implemented for each unstable area as required. IPC's preferred mitigation strategy will be to construct towers in stable locations and avoid unstable areas.

Geotechnical field investigations will commence when IPC obtains access and permission to proposed field investigation sites. The results will inform the final design and siting of the transmission line and related and supporting facilities: station, fly yards, stream crossings, roadway intersections, laydown yards, and multi-use yards. Table H-1 describes the general timeframe for detailed geotechnical work by facility and location. IPC will submit the results of the site-specific geotechnical investigation in the Phase 2 Site-Specific Geotechnical Report, which will be provided to DOGAMI and ODOE prior to construction.

Table H-1. Schedule of Site-Specific Geotechnical Work

Facility	Location	General Timeframe
Station	Morrow County	Summer and Fall 2020[1]
Transmission Line Spread 1	Morrow, Umatilla, and Union counties	Summer and Fall 2020[1]
Transmission Line Spread 2	Baker and Malheur counties	Summer and Fall 2020[1]

[1] Actual schedule will depend upon federal access approvals to conduct geotechnical investigations.

3.6 Locations of Geotechnical Work

OAR 345-021-0010(1)(h)(D): For all transmission lines, and for all pipelines that would carry explosive, flammable or hazardous materials, a description of locations along the proposed route where the applicant proposes to perform site specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, dead ends (for transmission lines), corners (for transmission lines), and portions of the proposed route where geologic reconnaissance and other site specific studies provide evidence of existing landslides, marginally stable slopes or potentially liquefiable soils that could be made unstable by the planned construction or experience impacts during the facility's operation.

OAR 345-021-0010(1)(h)(D) requires identification of geotechnical investigation sites. Here, sites for geotechnical investigation shall include indicative tower or substation locations and the following:

- dead-end structures;
- any corners or changes in alignment heading (angles);
- crossings of highways, major roads, rivers, railroads, and utilities such as power transmission lines, natural gas pipelines, and canals; and
- locations necessary to verify lithologic changes and/or geologic hazards such as landslides, steep slopes, or soft soil areas.

Attachment H-1, Appendix C presents a summary table with the approximate locations and rationale for the proposed boring locations. Additional borings may be necessary to fill data gaps from the initial drilling program. Appendix A of Attachment H-1 presents a series of geologic maps, showing the transmission line indicative alignment, and geologic features.

3.7 Earthquakes and Seismic Hazards

OAR 345-021-0010(1)(h)(E): An assessment of seismic hazards, in accordance with standard-of-practice methods and best practices, that address all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries under (B), and an explanation of how the applicant will design, engineer, construct, and operate the facility to avoid dangers to human safety and the environment from these seismic hazards. Furthermore, an explanation of how the applicant will design, engineer, construct and operate the facility to integrate disaster resilience design to ensure recovery of operations after major disasters. The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring and emergency measures for seismic hazards, including tsunami safety measures if the site is located in the DOGAMI-defined tsunami evacuation zone.

3.7.1 National Electric Safety Code

OAR 345-021-0010(1)(h)(F) requires an assessment of seismic hazards. The detailed seismic evaluation is presented in Attachment H-1. IPC is governed by the National Electric Safety Code (NESC) and is required to apply various weather-related structural loading cases while designing transmission lines. IPC will apply all NESC-required, weather-related loading cases as well as additional cases identified to be important to the integrity of the lines.

Notably, NESC Section 250.A.4 indicates that by designing for the required line and tower loading cases, nothing further is required to resist earthquake loads. It states, "The structural capacity provided by meeting the loading and strength requirements of Sections 25 (Loadings for Grades B and C) and 26 (Strength Requirements) provides sufficient capability to resist earthquake ground motions."

Additionally, the American Society of Civil Engineers (ASCE) *Guidelines for Electrical Transmission Line Structural Loading* (Wong and Miller 2010) states the following:

> *Transmission structures need not be designed for ground-induced vibrations caused by earthquake motion because, historically, transmission structures have performed well under earthquake events, and transmission structure loadings caused by wind/ice combinations and broken wire forces exceed earthquake loads. This may not be the case if the transmission structure is partially erected or if the foundations fail due to earth fracture or liquefaction.*
>
> *Transmission structures are designed to resist large, horizontal loads of wind blowing on the wires and structures. These loads and the resulting strengths provide ample resistance to the largely transverse motions of the majority of earthquakes. Decades of experience with lines of all sizes has shown that very infrequent line damages have resulted from soil liquefaction or when earth failures affect the structural capacity of the foundation.*

Generally, NESC-mandated combined ice and loading cases have been determined by the industry to be sufficient to address seismic hazards from earthquakes.

We understand that the common practice in the industry to design transmission tower structures against lateral loads is to consider the wind and ice forces. Transmission structures need not be designed for ground-induced vibrations caused by earthquake motion because, historically, transmission structures have performed well under earthquake events, and transmission structure loadings caused by wind/ice combinations and broken wire forces exceed earthquake loads. This may not be the case if the transmission structure is partially erected or if the foundations fail due to earth fracture or liquefaction. Decades of experience with lines of all sizes has shown that very infrequent line damages have resulted from soil liquefaction or when earth failures affect the structural capacity of the foundation (ASCE manual no. 74).

Although seismic-specific design criteria above the NESC are not generally required for transmission structures, IPC discusses seismic hazards as required in the OAR. The detailed seismic hazards evaluation is presented in Attachment H-1. For the purposes of this preliminary evaluation, the seismic sources are not mapped sufficiently to perform a deterministic evaluation of ground motions along a several- hundred-mile-long powerline alignment. Therefore, probabilistic peak ground acceleration (PGA) estimates for a 500- and 5,000-year return period have been included in this evaluation and are shown in Attachment H-1.

For geo-seismic hazard evaluations and corresponding mitigations for these geo-seismic hazards, as necessary, we will rely on the seismic requirements prescribed by American Society of Civil Engineers (ASCE) 7-16 code. The ASCE 7-16 design ground motion values, if necessary, will be obtained to use for these type of the evaluations (e.g., liquefaction, lateral spreading, seismic settlements, and other soil related issues).

We will use International Building Code (IBC) 2015 for seismic design of auxiliary buildings and facilities other than transmission towers along the power line. The IBC (2015) is an updated standard for the 2012 edition of the IBC, which was amended by the current Oregon Structural Specialty Code (OSSC) 2014.

3.7.2 Maximum Considered Earthquake Ground Motion

Seismic hazards are evaluated in Attachment H-1 according to the 2015 International Building Code (IBC), the most-recent version of the IBC. This evaluation provides PGA, short- and long-period (0.2 and 1.0 second) spectral accelerations. The 2015 IBC provides Maximum Considered Earthquake ground motions (MCE_R) that correspond to a 2 percent probability of exceedance in 50 years, or a 2,500-year return period. The PGA, short- and long-period (0.2 and 1.0 second) spectral accelerations are shown in Attachment H-1.

3.7.3 Earthquake Sources

Evaluation of source specific probabilistic ground motions along the 272.8-mile alignment has been provided using U.S. Geological Survey (USGS) 2002 and 2014 PGA and spectral accelerations on rock. Site class determinations and site specific hazard evaluations for structure locations will be determined during geotechnical design studies.

The four sources of earthquakes and seismic activity in Oregon are crustal, interplate, intraplate, and volcanic (DOGAMI 2010). The Project is not located on a plate boundary and the nearest is over 80 miles from the Project. However the Project may experience ground shaking from any of the earthquake types. The most significant earthquake sources near the Project are intraplate or crustal earthquakes; however, intraplate earthquakes may rarely occur and are located hundreds of miles from the Project.

- **Crustal earthquakes** are generally shallow (<30 kilometers [km] depth), resulting from active faulting in the upper North American Plate. Crustal earthquakes typically have a maximum magnitude near 7.0, and recurrence intervals are dependent on stress accumulation and release but can range from tens to hundreds of years.
- **Interplate earthquakes** are those that occur between two plate boundaries. Interplate seismicity in Oregon is generated from the convergence of the Juan de Fuca Plate and the North American Plate at the Cascadia Subduction Zone (CSZ) just off the coast of Washington and Oregon (USGS 2009a). These plates converge at a rate of 1 to 2 inches per year and accumulate large amounts of stress that are released abruptly in earthquake events. The CSZ and similar plate boundaries are capable of producing large, 9.0 magnitude subduction zone earthquakes. Recurrence intervals are typically on the order of 300 to 500 years.
- **Deep Intraplate earthquakes** occur deep (50-70 km depth) in the CSZ and have a maximum magnitude potential near 7.0. Recurrence intervals for deep intraplate earthquakes are generally between 500 to 600 years.

Because of their proximity, crustal faults represent the most significant seismic hazard to the proposed transmission alignment. A map of Quaternary faults is presented in Attachment H-1, Appendix D, Figure D9. The map presents the locations of known and inferred faults.

Table H-2 is a summary table of significant faults considered capable of generating a large earthquake within 5 miles of the Proposed Route and Alternative Route by county. These faults are potentially capable of producing a PGA greater than 0.05 g along the Proposed Route and Alternative Route. Of the youthful Quaternary faults identified by USGS (Table H-2), faults less than 15,000 years old are recent by geologic standards and likely pose the greatest potential for future earthquakes. These faults are assumed to be active.

Table H-2. USGS Quaternary Faults within 5 Miles of Project by County

County	Fault Name	Approximate Milepost	Age (years)	Active?
Morrow	None	N/A	N/A	N/A
Umatilla	Hite Fault System, Thorne Hollow Section[1]	80[1]	<130,000	No
	Hite Fault System, Agency Section	63.5	<1,600,000	No
Union	West Grande Ronde Valley Fault Zone (includes Mount Emily, La Grande, and Craig Mountain Sections)[2]	89–119.5[2]	<15,000	Yes
	South Grande Ronde Valley Fault Zone[1]	115-126[1]	<750,000	No
Baker	Unnamed East Baker Valley Faults[2]	140–148[2]	<750,000	No
	West Baker Valley Faults[2]	149.5-152.5[2]	<130,000	No
Malheur	Cottonwood Mountain Fault	224.5	<15,000	Yes
	Faults Near Owyhee Dam[1]	246–258.5[1]	<1,600,000 Class B[3]	No

1 Faults do not intersect the Project centerline; milepost (MP) reflects its closest location to the Project centerline.

2 The West Grande Ronde Valley Fault Zone intersects the Project centerline near approximately MP 109. The Unnamed East Baker Valley Faults intersect the Project centerline at multiple locations near approximately MPs 141, 143, and 148. The West Baker Valley Fault intersects the Project centerline at multiple locations near approximately MPs 150, 151, and 152.

3 Class B Faults are faults of uncertain origin that may be older than Quaternary.

3.7.4 Recorded Earthquakes

Due to the large areas of impact from earthquakes, the analysis area for recorded earthquakes was larger than the Site Boundary, and chosen by a variable buffer distance around epicenters, or groups of epicenters, of historical earthquakes. The seismology department at University of Nevada at Reno states that earthquakes of Richter magnitude 6.1 to 6.9 may affect areas up to 100 km from the epicenter (UNR 1996). Given that estimate, an analysis area radius of 25 miles was selected for earthquakes less than magnitude 6. A radius of 50 miles was assumed for earthquakes of magnitude 6 to less than 7, and the analysis area was extended out to 100 miles for earthquakes of magnitude 7 or greater. The distance of 100 miles was chosen because, above that distance, the effect on the proposed transmission line from even the strongest recorded past earthquakes would be minimal. The locations of historical earthquake epicenters were also reviewed relative to the Proposed Route and Alternative Routes. Earthquake data for Idaho and Oregon were obtained from the applicable state geologic survey departments. None of the recorded earthquakes within the Site Boundary exceeded Richter magnitude 6.0. The recommended design earthquake magnitudes of 6.0 to 6.2 appear realistic, given the maximum magnitude of historic earthquakes.

Historical earthquakes recorded by the USGS Earthquake Search Database (USGS 2016), the National Geophysical Data Center (NGDC 1985), and the Pacific Northwest Seismic Network (2008) are presented in Appendix D of Attachment H-1. A map of recorded earthquakes with magnitudes of 2 or greater within 50 miles of the Project is shown as Attachment H-1, Appendix D, Figure D10.

The NGDC reports 40 records of earthquakes measured at Modified Mercalli Intensity (MMI) III or greater within 50 miles of the Project. MMI values within the 50-mile route ranged from IV to VII. Attachment H-1, Appendix D, Table D2 lists these earthquakes, the date of occurrence, the earthquake magnitude, the MMI, and the city where it was felt. For earthquakes that were reported in terms of magnitude only, a MMI was estimated. The USGS (2009) provides the following descriptions of MMI values (abbreviated from the 12 levels of MMI):

> *III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.*
>
> *IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.*
>
> *V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.*
>
> *VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.*
>
> *VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.*

Based on the number of historical earthquakes that have occurred within 50 miles of the Project, it is assumed that earthquakes will occur during the life of the Project. However, the Project will be designed to withstand weather-related forces; according to the NESC, the structural capacity provided by meeting the loading and strength requirements for weather-related stresses provide sufficient capability to resist earthquake ground motions.

3.7.5 Median Ground Response, MCE and MPE

The MPE is the largest earthquake that a fault is predicted capable of generating under the known tectonic framework within a 500-year return period while the MCE is the largest earthquake that an active or potentially active fault is capable of generating. For this preliminary evaluation, the seismic sources are not mapped sufficiently to perform deterministic evaluations of ground motions along a several hundred-mile-long power line alignment. The location, length, and age of offset for credible fault ruptures are not sufficiently documented to determine magnitude and minimum epicentral distance. Therefore, as discussed in Attachment H-1, Section 4.1, probabilistic PGAs for a 500- and 5,000-year return period have been evaluated.

The ground motions provided in Attachment H-1 correspond to a Site Class B/C (soft rock) soil profile. To develop ground motions that correspond to other Site Class types, Site Coefficients that consider site soil type and level of ground shaking are required. The Site Class definitions and Site Coefficients can be obtained from ASCE 7-16. Subsurface explorations along the alignment have not been performed. Therefore, site-specific design criteria for structures will be prepared upon completion of the geotechnical investigations program.

3.7.6 Seismic Hazards Resulting from Seismic Events

The Project may be subject to ground shaking, ground failure, landslides, liquefaction, fault displacement, and subsidence from reasonably probable seismic events. The Project is well above sea level and far from the Pacific Coast; therefore, tsunami inundation was not considered.

Interplate events occur between two tectonic plates, such as the CSZ where the Juan de Fuca Plate subducts beneath the North American Plate. Interplate events include subduction earthquakes that have the potential to be the largest earthquakes that may occur in the Pacific Northwest. Intraplate events are seismic events that occur within a tectonic plate. The Nisqually earthquake of 2001 was identified as an intraplate seismic event. Crustal earthquakes typically occur within 10 miles of the surface along shallow faults and are considered the most likely source to impact the Project. IPC identified known significant faults near the facility (see Attachment H-1, Section 4.2).

Ground Motion or Seismic Shaking

Ground shaking will be evaluated after subsurface explorations are performed and soil site classes can be determined. IPC's engineers have relied on the seismic results from Attachment H-1 to perform initial designs, and as additional information is collected during the site-specific geotechnical investigation, designs will be modified if necessary to construct facilities to avoid dangers to human safety presented by seismic hazards.

Ground Failure

Ground failure and fault displacement can occur from fault rupture in an active fault zone. Known Quaternary faults located within 5 miles of the Proposed Route that could be considered active include the Cottonwood Mountain fault and segments of the West Grande Ronde Valley fault zone (see Table H-2). Of these active faults, the Hite Fault System, Agency Section, West Grande Ronde Valley Fault Zone, Unnamed East Baker Valley Faults, West Baker Valley Fault, and the Cottonwood Mountain fault crosses the Proposed Route and should be considered during final design. Ground failure including landslide, lateral spreading, liquefaction, and surface rupture or settlement will be evaluated once ground accelerations and subsurface conditions are known.

A preliminary seismic risk assessment was conducted from a review of earthquake hazard zones included in Federal Emergency Management Agency (FEMA) data, prepared for the U.S. Department of Transportation, Office of Pipeline Safety (OPS, 1996). The OPS data provide earthquake hazard rankings for the United States, including those portions of Idaho and Oregon near the proposed transmission lines. The OPS report utilized information from the USGS National Earthquake Hazards Reduction Program. The USGS compiled a large database of past earthquake magnitudes and locations. Based on those data, earthquake hazards were assigned to all parts of the country. Based on historical earthquake magnitudes and locations, geographic areas were assigned an earthquake hazard ranking, ranging from zero (no earthquake hazard) to 100 (highest earthquake hazard). For this earthquake hazard assessment, a high earthquake hazard was assigned for areas with earthquake hazard rankings of 85 to 100. Locations with earthquake hazard rankings between 70 and 84 were considered as medium risk, and rankings less than 70 were considered low risk. To identify existing earthquake conditions the mileage crossed for each earthquake hazard risk (low, medium, or high) was mapped and expressed as a percent for each county. To disclose overall hazard risk, the mileage crossed by the Proposed Route and alternative route in each county was identified.

Table H-3 presents the percent of low, medium, and high earthquake risk (in miles) along the Proposed Route and alternative routes by county. The OPS data indicate that earthquake risk is greatest in the northern portion of the Proposed Route, with all 82 percent of Morrow County in medium earthquake risk. The OPS data indicate the remainder of the Proposed Route contains low risk of earthquakes. The West of Bombing Range Road Alternatives 1 and 2 contains medium risk. The Morgan Lake and Double Mountain Alternatives contain a low risk of earthquakes.

Table H-3. OPS Earthquake Hazard Risk – Proposed Route and Alternative Route

Facility	County	Miles Crossed[1]	Earthquake Hazard Risk by Centerline Miles Crossed/Percent of Miles Crossed – Proposed Route and Alternative Route		
			Low < 70	Medium 70 to 85	High 85 to 100
Proposed Route	Morrow	47.5	8.5/18	39.0/82	0
	Umatilla	40.9	40.9/100	0	0
	Union	39.9	39.9/100	0	0
	Baker	69.2	69.2/100	0	0
	Malheur	75.2	75.2/100	0	0
Total Proposed Route		***272.8***	***257.5/87***	***39.0/13***	0
Alternative Routes					
West of Bombing Range Road Alt. 1	Morrow	3.7	0	3.7/100	0
West of Bombing Range Road Alt. 2	Morrow	3.7	0	3.7/100	0
Morgan Lake	Union	18.5	18.5/100	0	0
Double Mountain	Malheur	7.4	7.4/100	0	0

[1] Column may not sum exactly due to rounding.

Landslides

Appendix E of Attachment H-1 contains a summary of each landslide that was identified along the Proposed Route and alternative routes that could potentially affect the stability of proposed tower foundations or associated work areas. The review includes site photographs and preliminary maps of unstable or landslide surfaces. Appendix E of Attachment H-1 was compiled through review of the DOGAMI 2014 SLIDO, version 3.2 database, published geologic maps, aerial imagery, Digital Terrain Model data, DOGAMI light detection and ranging (LiDAR) data, and limited site reconnaissance. The data were used to map landslides within 1 mile of the Proposed Route. IPC's engineers will collect Project-specific LiDAR data prior to final design and will use it to identify historic and prehistoric landslides, as possible. IPC's engineers will include the areas of soil instabilities in the site-specific geotechnical analysis.

Liquefaction

Liquefaction is a phenomenon in which saturated, primarily cohesionless soils temporarily lose their strength when subjected to dynamic forces such as intense and prolonged ground shaking and seismic activity. All portions of the Site Boundary have the potential for ground shaking from earthquakes. Areas that are most susceptible to liquefaction have a combination of thick unconsolidated sediments, and a shallow water table (within 50 feet of the surface). Because the majority of the transmission line crosses relatively stable terrain with shallow bedrock and deep groundwater, the majority of the Site Boundary has a low susceptibility to liquefaction.

Prior to the development of final engineering design, liquefaction studies will be conducted for susceptible areas, including areas that cross or approach rivers and areas where thick unconsolidated sediments are encountered in the field. Additional evaluation of liquefaction also may be needed as the final alignment and tower locations are chosen. The geotechnical engineer will recommend additional exploration and/or analysis as applicable to assess liquefaction hazards in the geotechnical design report for the transmission line.

Subsidence

Subsidence is the sinking or the gradual downward settlement of the land surface, and is often related to groundwater drawdown, compaction, tectonic movements, mining, or explosive activity. Seismic activity in the area could lead to the settling of sediment and could also exacerbate potential subsidence associated with groundwater withdrawal in more populous regions. No historical cases of subsidence in the Site Boundary have been identified, and the majority of the site has a low susceptibility to subsidence. At this time, there are no specific locations where subsidence studies will be performed. However, if subsidence-prone areas are identified during the Phase 2 geotechnical investigation, the transmission line will be designed and located to avoid subsidence hazards.

Lateral Spreading

Lateral spreading is the permanent horizontal movement of a liquefiable soil deposit due to the presence of initial shear stresses on horizontal planes within the soil during a seismic event. It occurs predominantly within gradual slopes or on flat sites situated near riverbanks, shorelines, bulkheads, or wharves. For locations where liquefaction poses a risk, an assessment will be made to determine if lateral spreading would be an additional hazard.

3.7.7 Tsunami Evacuation Zones

There are not DOGAMI-defined tsunami evacuation zones in or near the Site Boundary for this Project. Therefore, no tsunami safety measures are required.

3.8 Soil-Related and Geologic Hazards

OAR 345-021-0010(1)(h)(F): An assessment of geology and soil-related hazards which could, in the absence of a seismic event, adversely affect or be aggravated by the construction or operation of the facility in accordance with standard-of-practice methods and best practices, that addresses all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries under (B). An explanation of how the applicant will design, engineer, construct and operate the facility to adequately avoid dangers to human safety and the environment presented by these hazards, as well as: (i) An explanation of how the applicant will design, engineer, construct and operate the facility to integrate disaster resilience design to ensure a rapid recovery of operations after major disasters. (ii) An assessment of future climate conditions for the expected life span of the proposed facility and the potential impacts of those conditions on the proposed facility.

3.8.1 Mass Wasting and Landslides

Mass wasting is a generic term for landslides, rockslides, rockfall, debris flows, soil creep, and other processes that include the downslope movement of masses of soil and rock. Mass wasting can be initiated by precipitation events, sometimes in conjunction with land use. Slope stability is a function of moisture content, slope gradient, rock and soil type, slope aspect, vegetation, seismic conditions and ground-disturbing activities. Appendix E Attachment H-1 contains a detailed reconnaissance of the Site Boundary showing the locations of known landslides and soil instabilities. Additional information will be collected on unstable areas during the site-specific, Phase 2 geotechnical investigation. Those data will assist in design of a transmission line that either avoids unstable areas or is built to withstand the effects of land movements to avoid dangers to human safety.

3.8.2 Flooding

FEMA's National Flood Hazard Layer (NFHL) data (2017) was reviewed to evaluate flooding potential within the Site Boundary. However, FEMA NFHL data was only available for Umatilla and Morrow Counties, and was not available for any of the remaining counties crossed by the Site Boundary including Union, Baker, Malheur, or Owyhee Counties. Because FEMA floodplain maps typically provide coverage for use by insurers in populated areas, and FEMA data are scarce away from populated areas, more comprehensive data also were evaluated. To evaluate flood hazards, DOGAMI Statewide Flood Hazard Database for Oregon – FEMA Flood Insurance Study inundation zones (2015) were compared to the temporary and permanent disturbance areas associated with the preliminary design (Table H-4). Project work areas, which include multi-use areas, pulling and tensioning sites, and structure work areas, would be temporary features and have temporary impacts in flood zones. Temporary flood zone impacts would occur in Morrow County (4.8 acres), in Baker County (30.3 acres), and in Malheur County (10 acres). Work areas for alternative routes would be the same as those for the Proposed Route.

Project roads would be permanent features and have permanent impacts in the flood zones. Permanent impacts would occur where access roads cross flood zones in Morrow County (0.5 miles) and Malheur County (0.8 mile). Access roads for alternative routes would cross flood zones in Morrow County (0.1 mile) and Malheur County (0.2 mile). See Exhibit K, Figures K-19 and K-20 for Morrow County locations, Figure K-42 for Union County locations, and Figure K-55 for Malheur County locations.

Table H-4. Flood Zone Impacts for Work Areas[1] and Access Roads[2] – Proposed Route and Alternative Routes

Facility	County	100-year Flood Zone Crossed	
		Temporary Work Areas[1] (acres)	Permanent Roads[2] (miles)
Proposed Route	Morrow	4.8	0.5
	Umatilla	0	0
	Union	0	0
	Baker	30.3	0
	Malheur	10.0	0.8
Total Proposed Route		***45.1***	***1.3***
Alternative Routes			
West of Bombing Range Road Alternative 1	Morrow	0	0.1
West of Bombing Range Road Alternative 2	Morrow	0	0.1
Morgan Lake	Union	0	0
Double Mountain	Malheur	0	0.2

[1] Work Areas include multi-use areas, pulling and tensioning sites, and structure work areas. Work areas for Alternative Routes would be the same as those for the Proposed Route.
[2] Access Roads are existing roads with improvements and new roads.
Source: Oregon Spatial Data Library (DOGAMI 2015)

3.8.3 Erosion

Erosion is a continuing natural process that can be accelerated by human disturbances. Factors that influence soil erosion include soil texture, structure, length and slope steepness, vegetative cover density, and rainfall or wind intensity. Soils most susceptible to erosion by wind and water are typically non-cohesive soils with low infiltration rates, residing on moderate to steep and sparsely vegetated slopes. Non-cohesive soils include silty, sandy, or gravelly soils, with little to no clay-sized particles. Wind erosion processes are less affected by slope angles but highly influenced by wind intensity. The potential for soil erosion within the Site Boundary varies based on the erosion mechanism and soil characteristics.

The erosion potential was analyzed using three factors: soil K factor, wind erodibility, and slope. The Phase 2 geotechnical analysis will provide further evaluation of soil erosion potential, based on both additional review of soil properties and laboratory testing of soil samples collected during geotechnical drilling. Soil erodibility will be considered in design of the Project to avoid dangers to human safety.

Soil K Factor

Soil erosion hazards were mapped throughout the Site Boundary based on the soil's K factor, the soil-erodibility factor. The standard measurement condition is the unit plot. The unit plot is 72.6 feet (22.1 meters) long on a 9 percent slope, maintained in continuous fallow, tilled up and down hill periodically to control weeds and break crusts that form on the surface of the soil. The plots are plowed, disked, and cultivated the same for a row crop of corn or soybeans except that no crop is grown on the plot.

Soils high in clay have low K values, because they are resistant to detachment. Coarse-textured soils, such as sandy soils, have low K values, because of low runoff even though these soils are easily detached. Medium-textured soils, such as the silt loam soils, have a moderate K values, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having a high silt content are the most erodible of all soils. They are easily detached, tend to crust, and produce high rates of runoff.

The State Soil Geographic (STATSGO) database was used to characterize soil erosion factors. The U.S. Department of Energy, Pacific Northwest National Laboratory website (DOE 2003) guideline was used to segregate the mapped soils into low, moderate, or high K Factor soils. Low K values ranged from 0.05 to 0.15, moderate K values were from 0.25 to 0.4, and high K values were greater than 0.4. However, the closest category in the Natural Resources Conservation Service (NRCS) geographic information system data file to 0.4 was 0.37. As such, a K factor of 0.37 was used to define soils mostly likely to erode. Appendix B of Attachment H-1 presents further information concerning soil erosion potential. Areas of soils with high K factor that could be affected during construction and operations are contained in Exhibit I, Table I-5 and Table I-9.

Wind Erosion

The potential for soil erosion by wind was evaluated using NRCS wind erodibility group data, which are based on the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion. Project construction activities that could expose soils particularly erodible to wind erosion include any surface disturbance (e.g., road construction and improvements, vegetation clearing).

Slope

In general, steep slopes possess a greater potential for erosion by water or mass movements than flat areas. Areas containing greater than 25 percent slope were considered to have greater erosion potential.

3.8.4 Disaster Resilience

3.8.4.1 Transmission Line

As discussed above in Section 3.7.1, NESC-mandated engineering and construction standards are designed to protect transmission lines from severe wind and ice loading disasters. Moreover, those same NESC standards are also sufficient to protect the transmission line from earthquake hazards, as “historically, transmission structures have performed well under earthquake events, and transmission structure loadings caused by wind/ice combinations and broken wire forces exceed earthquake loads” (Wong and Miller 2010). Therefore, by building and operating the transmission line to the NESC standards, the Project will be designed, engineered, constructed, and operated to adequately avoid dangers to human safety and the environment. In the unlikely event the transmission line is damaged by a geology- or soil-related hazard, IPC has in place policies and procedures designed to ensure its transmission lines are quickly and safely returned to service. IPC practices industry standard operations and maintenance plans to maintain their transmission lines in a safe and reliable operating condition.

IPC also maintains a “Transmission Emergency Response Plan”. This plan guides in the response to natural disasters and outage events that disrupt the transmission system.

In the case of a localized event, IPC maintains key materials and equipment to restore power in the event of a transmission outage. IPC also maintains a number of “Lindsay Emergency Restoration System” towers that can be quickly erected to temporarily replace damaged transmission towers. IPC will also maintain lattice tower repair kits to be used to replace/repair damaged lattice towers. Spools of spare conductors are also maintained for emergency repairs.

For large scale events, IPC is a member of the Edison Electric Institute (EEI), an association that represents all US investor-owned electric companies. EEI member companies have established and implemented a Mutual Assistance Agreement, an effective system whereby member companies may receive and provide assistance in the form of personnel and equipment to aid in restoring and/or maintaining electric utility service when such service has been disrupted by acts of the elements, equipment malfunctions, accidents, sabotage, or any other occurrence for which emergency assistance is deemed to be necessary or advisable (“Emergency Assistance”).

3.8.4.2 Access Roads

Idaho Power will locate new Project access roads away from areas of high geology- or soil-related hazard. In the unlikely event an access road is damaged by a geology- or soil-related event, IPC’s response will depend on the nature and ownership of the road. For example, certain access roads are public roads under the authority of the local county or municipality, which is responsible for maintenance and repair of the roads. To the extent such a public road is damaged by a geology- or soil-related event unrelated to IPC’s use of the road, IPC likely would defer to the relevant county or city to make the necessary repairs to the road. But if the access road is located on private land IPC would repair the road as soon as possible and necessary. Pending access road repairs, transmission line structures can be accessed via alternative access roads, by foot, by overland travel, or using a helicopter, if necessary.

3.8.4.3 Communication Stations and Longhorn Station

The Project communication stations and the Longhorn Station will be located to avoid areas of high geology- or soil-related hazard, and will be constructed to relevant building codes which are adequate to avoid dangers to human safety and the environment. Also, in the unlikely event a communication station or the Longhorn Station is affected by a geology- or soil-related event, Idaho Power's policies and procedures discussed above in Section 3.8.4.1 will ensure the communication station or Longhorn Station is quickly and safely returned to service. Further, with respect to the communication stations, the communications system for the line is designed to be redundant and geographically diverse, so if any of the communication stations along the route are damaged, then we will still have full communications through a geographically diverse redundant path.

3.8.5 Future Climate Change Conditions

Future climate change conditions that could potentially affect areas within the Site Boundary were determined through review of the Third Oregon Climate Assessment Report (Dalton et al. 2017), and relevant information that relates to soil and geologic resources is summarized herein.

In Oregon, climate change is expected to cause warmer temperatures year round (2.1° F-10.7° F by the 2080s) resulting in precipitation that falls more as rain and less as snow. This in turn will cause reduced winter snowpack, earlier spring peak snowmelt, and diminished streamflow and water supply in the summer months. While overall annual precipitation is expected to increase modestly (1.9%-2.7% by the 2050s), changes in seasonal precipitation patterns will be more noticeable—with summer months becoming drier (summer precip. down by -6.3% to -8.7% by the 2050s) and spring, fall, and winter months becoming wetter (winter precip. up by 4.9% to 7.9% by the 2050s).

The effect of altered precipitation patterns on groundwater recharge is uncertain. Changes in recharge dynamics could shift the timing of groundwater discharge in some streams, reducing late summer baseflows, although streamflow sensitivity to climate change depends on the hydrogeologic setting.

Extreme heat and precipitation events are expected to become more frequent, intense, and long-lasting. In winter, spring, and fall, higher rainfall will increase the risk for flooding and erosion hazards. Conversely, summer months are expected to be warmer and drier, with an increased risk of wildfire activity and drought.

Climate change is expected to affect each region of the state slightly differently due to varying ecosystems, water needs, and land use priorities. In eastern Oregon, where the site boundary occurs, the primary concerns include increased drought, reduced summertime water supply, increased wildfires and increased forest disturbance from disease, drought, and wildfire. Model simulations for eastern Oregon predict that the fire return interval, or the average number of years between fires, may decrease by approximately 80 percent by the 21st century, with the area burned increasing by 36 percent. These increases assume that fire suppression techniques would be employed successfully; without fire suppression, wildlife size and frequency is projected to increase by even larger percentages.

Projected increases in extreme precipitation events are also expected to cause an increased risk of flooding, runoff, soil erosion, landslides and mass wasting events. Rates of runoff and soil erosion are expected to increase in response to increased rainfall and intensity (Nearing et al, 2004). Erosion rates may also increase in response to increased wildfires and forest disturbances that reduce vegetative biomass on steep slopes, leaving them exposed to runoff and erosion. The likelihood of these events happening depends on the site-specific soil properties, biomass, and topography, as well as the intensity and duration of the antecedent extreme precipitation event. One study found that rates of soil erosion are expected to increase by approximately 1.7-2 percent for every 1 percent increase in precipitation (Nearing et al. 2004).

Although the future rates of soil erosion, food risk, or other geologic hazards may increase as a result of increased precipitation, proper land management techniques can be implemented, as needed, to address future soil and erosion issues. Here, the SPCC, ECP, and other mitigation measures set forth below in Section 3.9 are sufficient to address any climate-change-induced increases in soil erosion or geology hazards.

3.9 Mitigation

3.9.1 Geologic Hazard Mitigation

The following section discusses anticipated Project design, engineering, and construction measures to avoid or mitigate dangers to human safety and the environment resulting from the geologic hazards described above.

3.9.1.1 Seismic Hazard Mitigation

In general, transmission towers are designed for large wind and tension loads, which results in ample capacity to resist seismic loads. Towers will be designed in accordance with the NESC C2 (IEEE 2006), ASCE Standard 10-97 (ASCE 1997), ASCE Standard 7, Chapters 13 and 16 (ASCE 2017), and ASCE Manual of Practice (MOP)-74 (Wong and Miller 2010). Substation structures will be designed in accordance with applicable portions of the Oregon Structural Specialty Code (OSSC; ICC 2014).

All towers and facilities for the Project will be designed to meet or exceed the 2014 OSSC. The codebook contains the amendments to the 2015 IBC as adopted by the State of Oregon and local agencies. A qualified engineer will assess and review the seismic, geologic, and soil hazards associated with the construction of the towers and facilities. The Project will be designed to withstand wind and ice loads, which are greater than typical seismic forces. All designs and subsequent construction requirements may be modified based on the site-specific characterization of seismic, geologic and soil hazards. By following the appropriate codes; NESC C-2, OSSC Section 1604, 2015 IBC, ASCE 10-97, ASCE 7-13, ASCE 7-16, and ASCE MOP-74, the Project will be designed, engineered, and constructed to adequately avoid potential dangers to human safety presented by seismic hazards.

The Project facilities are generally unmanned and located in sparsely populated areas. Therefore, the risks to human safety due to seismic hazards are minimal due to the low probability of human presence. All Project facilities will be constructed in accordance with the 2014 OSSC and 2015 IBC, or the more recent standards applicable at the time of detailed design. To ensure compliance with the relevant building codes and to provide the Project is designed to address seismic hazards, IPC proposes that the Council include the following conditions in the site certificate:

> ***Structural Standard Condition 2:*** *During construction, the certificate holder shall construct the facility in accordance with the versions of the International Building Code, Oregon Structural Specialty Code, and building codes adopted by the State of Oregon.*
>
> ***Mandatory Condition 8 [OAR 345-025-0006(12)]:*** *The certificate holder shall design, engineer and construct the facility to avoid dangers to human safety and the environment presented by seismic hazards affecting the site that are expected to result from all maximum probable seismic events. As used in this rule "seismic hazard" includes ground shaking, ground failure, landslide, liquefaction triggering and consequences (including flow failure, settlement buoyancy, and lateral spreading), cyclic softening of clays and silts, fault rupture,*

> *directivity effects and soil-structure interaction. For coastal sites, this also includes tsunami hazards and seismically-induced coastal subsidence.*

Additional work will be necessary to complete the final seismic hazard assessment and identify all the areas that will require mitigation due to seismic hazards. As discussed in Attachment H-1, this will include the geotechnical field exploration program, laboratory testing, and detailed site reconnaissance. A qualified engineer will assess the seismic, geologic, and soil hazards associated with the construction of each tower and each facility. The Project will be designed to withstand wind and ice loads, which are typically greater than seismic loads from ground shaking. All designs and subsequent construction requirements will be modified based on the site-specific characterization of seismic, geologic, and soil hazards. Some specific mitigation techniques for earthquake-induced landslide and liquefaction hazards are presented below. The principal mitigation strategy for surface rupture hazards is modification of structure locations. Additional mitigation strategies will be developed and refined following completion of future geotechnical investigations. To ensure IPC conducts the additional geological and geotechnical investigations and develops any necessary mitigation and that IPC provide notification if site-specific investigations identify conditions significantly different from what's described in this ASC, IPC proposes that the Council include the following conditions in the site certificate:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *a. Subsurface soil and geologic conditions within the site boundary;*
> *b. Geotechnical design criteria and data for the facility's project features;*
> *. . .*
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*
>
> ***Mandatory Condition 9 [OAR 345-025-0006(13)]:*** *The certificate holder shall notify the Department, the State Building Codes Division and the Department of Geology and Mineral Industries promptly if site investigations or trenching reveal that conditions in the foundation rocks differ significantly from those described in the application for a site certificate. After the Department receives the notice, the Council may require the certificate holder to consult with the Department of Geology and Mineral Industries and the Building Codes Division to propose and implement corrective or mitigation actions.*

3.9.1.2 Earthquake-Induced Landslide Mitigation

Hazards and mitigation measures related to landslides in general are discussed in Section 3.10.2 under Mitigation of Slope Instability. To the extent landslides may be triggered by earthquakes in particular, IPC will investigate active faults within the Site Boundary as part of the Site-Specific Geological and Geotechnical Report and will propose mitigation measures specific to earthquake-induced landslides, if necessary. To ensure IPC conducts landslide potential investigations and develops any necessary mitigation, IPC proposes that the Council include the following condition in the site certificate providing for the same:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *. . .*

> *c. Description of potentially active faults that may affect the facility and their potential risk to the facility;*
> *d. LiDAR or field survey investigation of the site boundary to assess the potential for slope instability and landslide hazards;*
> *. . .*
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*

3.9.1.3 Liquefaction Mitigation

For structures or towers that are located in areas with a risk of liquefaction, a number of methods are available to either adequately reduce the risk of liquefaction or improve the performance of the structure (or improve resiliency), if liquefaction were to occur. Specific methods to reduce the liquefaction potential are ground densification to increase the soil's natural resistance to liquefaction, installation of drains to prevent excess ground water pore pressure build-up during a seismic event, and installation of soil-cement shear cells which reduce the seismic shearing demands on the soil. As an alternative, the structure foundations can be designed to account for a layer of soil that may liquefy—e.g., deep foundations can be designed to bypass the liquefiable layer, being founded on deeper layers. IPC proposes that the Council include the following conditions in the site certificate providing that the Site-Specific Geological and Geotechnical Report addresses liquefaction potential and any necessary mitigation measures and that IPC provide notification if site-specific investigations identify certain hazards:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *. . .*
> *e. Evaluation of potential liquefaction hazards;*
> *. . .*
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*
>
> ***Mandatory Condition 10 [OAR 345-025-0006(14)]:*** *The certificate holder shall notify the Department, the State Building Codes Division and the Department of Geology and Mineral Industries promptly if shear zones, artesian aquifers, deformations or clastic dikes are found at or in the vicinity of the site. After the Department receives notice, the Council may require the certificate holder to consult with the Department of Geology and Mineral Industries and the Building Codes Division to propose and implement corrective or mitigation actions.*

3.9.2 Soil-Related Hazard Mitigation

The following section discusses anticipated Project design, engineering, and construction measures to avoid or mitigate dangers to human safety and the environment resulting from the soil-related hazards described above.

3.9.2.1 Mitigation of Slope Instability

Slope instability hazards should be thoroughly evaluated to assess the potential for failure. At locations where landslides, debris flows, or marginally stable slopes are identified, the hazard will be mapped and adequately characterized during the field exploration. All roads and transmission facilities will be designed to meet structural and zoning requirements. Structural requirements should adhere to soil lateral load requirements in the 2014 OSSC (Section 1610).

In general, structures should be located to avoid potential slope instability hazards wherever possible, and newly constructed slopes should be designed with an adequate safety factor against failure. Appropriate mitigation methods should be selected based on site characteristics and the structure to be constructed. If feasible, structures should be located with sufficient setback from slopes to mitigate the potential for slope instability during construction and operation. Where structures cannot be moved or realigned, slope instability mitigation techniques may include modification of slope geometry, hydrogeological mitigation, and slope reinforcement methods.

Slope geometry may be altered by grading or removing soil in order to provide a sufficient factor of safety. Hydrogeological mitigation may include surface drainage, shallow drainage, and deep drainage. These drainage mechanisms vary in intensity; however, all mechanisms attempt to reduce the soil's water content. This decreases both the soil's pore pressures and the overall driving force, thereby decreasing landslide risk. Types of drains may include trench drains, horizontal drain wells, siphon drains, or micro drains.

Reinforcement measures may be implemented when geometric slope modifications or drainage improvements are not sufficient or practical. Reinforcement modifications can involve the use of anchors or tieback systems, geofabric installation, buttressing, and cellular and crib face installation.

The use of vegetation may also be combined with the methods described above to help prevent shallow slides by intercepting rainfall, decreasing runoff, and providing root stabilization.

To ensure IPC conducts slope stability investigations and develops any necessary mitigation, IPC proposes that the Council include the following condition in the site certificate providing for the same:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *. . .*
> *c. Description of potentially active faults that may affect the facility and their potential risk to the facility;*
> *d. LiDAR or field survey investigation of the site boundary to assess the potential for slope instability and landslide hazards;*
> *. . .*
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*

3.9.2.2 Mitigation of Erosion

A desktop analysis of soil conditions was conducted prior to initial Project siting (Shaw 2012). This analysis incorporated data from many sources as previously described. The transmission line siting was based partly on engineering constraints related to known geologic hazards, soil stability, water crossings, and areas of steep topography. By considering soil and slope conditions throughout the siting and design process, IPC has avoided soil impacts to the extent possible.

The Project will use existing roads to access Project sites to the extent practicable. Where needed, existing roads will be improved to reduce sediment generation and minimize impacts to soils. Results of further engineering evaluations will be used to provide micrositing and design of Project structures that protect the public and minimize construction on unstable soil surfaces. Additional soil data will be collected during the site-specific geotechnical evaluation to further evaluate soil conditions and to assist in preparing detailed foundation designs and erosion and sediment control measures.

Localized impacts to soils at and around tower locations, access roads, light-duty fly yards, and facility footprints in the temporary disturbance area will be minimized though the use of best management practices (BMP) and restoration efforts to restore soil surfaces and vegetation following disturbances.

Impacts to soils at and around tower locations, access roads, and facility footprints will be avoided or minimized through the use of BMPs and restoration measures to restore soil surfaces and vegetation following disturbances. IPC will meet design standards for new roads as required by the Bureau of Land Management, United States Forest Service (USFS), and Oregon Department of Transportation and will implement BMPs described below and in the Erosion and Sediment Control Plan (ESCP) and National Pollutant Discharge Elimination System (NPDES) permits to reduce potential soil erosion during the construction process. Construction of roads, facilities, and towers will be regulated by the NPDES 1200-C Stormwater Construction Permit and the associated ESCP. To minimize soil erosion, where practical IPC will implement revegetation procedures, such as recontouring, scarification, soil replacement, seedbed preparation, fertilization, seed mixtures, seeding timing, seeding methods, supplemental wetland and riparian plantings, and supplemental forest plantings.

Once the roads, towers, and other facilities have been constructed to the designed specifications, operations will have minimal potential for soil erosion. Slopes and cut banks will be stabilized with riprap and/or planted or seeded with vegetation as practical, and Project facilities will be maintained as required to prevent erosion. Temporary access road sites and other compacted soils will be mechanically loosened where necessary, and where required previously salvaged topsoil will be replaced and non-cropped areas will be revegetated.

Vegetation management methods employed during maintenance operations will not result in soil erosion.

Mitigation for Soil Erosion by Water

Erosion control measures will be designed with attention to the mapped soil erosion hazards described above, with particular attention to areas with medium and high hazard ratings. Work on access roads will include grading and re-graveling of existing roads and construction of new roads. Soil erosion will be minimized by constraining traffic, heavy equipment and construction to existing roads where possible. Where new road construction is required, road widths will be limited to the width necessary to accommodate construction equipment. New roads will be located to avoid steep areas as much as possible.

Areas affected by construction will be reseeded with vegetation to minimize future erosion and to restore the systems to their natural state. Erosion and sediment control measures will be designed to remain intact until natural vegetation is sufficient to protect against erosion. The station operational footprint areas will be graveled to prevent erosion. The area outside the station fence may also be graveled where practical to prevent soil erosion during operations.

The Project has applied for and will obtain a 1200-C permit (see Exhibit I, Attachment I-3). Specific erosion and sediment control measures and BMPs to be implemented during the project construction and operations include the following BMPs:

- Avoid Highly Erodible Areas: Initial mitigation measures should include avoiding highly erodible areas, such as steep slopes, where possible, and rerouting impacted drainages to natural drainages to minimize erosion and sedimentation from runoff. Areas impacted by construction should be reseeded and sediment fences, check dams, and other BMPs will remain in place until impacted areas are well vegetated and the risk of erosion has subsided.
- Stabilize Road Entrance/Exit: A stabilized construction entrance/exit should be installed at locations where dirt (exposed, disturbed land) or newly constructed roads intersect existing paved roads. Stabilized entrances should also be installed at the construction laydown areas. The stabilized construction entrance/exits should be inspected and maintained for the duration of the Project life.
- Preserve/Restore Vegetation: To the extent practicable, existing vegetation should be preserved. In the event that vegetation is destroyed in temporary road locations or laydown areas, stockpiled topsoils should be replaced and recontoured. Vegetation should be reseeded to prevent erosion using an approved seed mixture specified by the NRCS or the USFS as being capable of surviving in local conditions (see the Vegetation Management Plan attached to Exhibit P1, Attachment P1-4).
- Control Dust: Dust should be controlled during construction through water application to the disturbed grounds and access roads where necessary. Application of excess water that could lead to erosion or sedimentation should be avoided. Other methods of dust control may include the use of poly sheeting, vegetation, or mulching. Speed limits should be kept to a minimum to prevent pulverization of road substrate.
- Install Silt Fencing: Silt fencing or an equivalent control measure should be installed at various locations along the transmission line. The fencing should be installed on contours downgradient of excavations, fill areas, or graded areas where necessary. Silt fencing or an equivalent control measure should be installed around the perimeters of material stockpiles and construction laydown areas.
- Install Straw Wattles: Straw wattles should be installed to decrease the velocity of sheet flow from stormwater. The wattles should be used along the downgradient edge of access roads adjacent to slopes or sensitive areas.
- Apply Gravel and Mulching: Gravel should be used where soil becomes wet or muddy to prevent erosion and working of the soil. Mulch should be provided to immediately stabilize soil exposed as a result of land disturbing activities. The mulch reduces the potential for wind and raindrop erosion.
- Install Stabilization Matting: Jute mesh, straw matting, or turf reinforcement matting should be used to stabilize slopes that could become exposed during installation of access roads, during rainfall events, or to stabilize intermittent streams disturbed during construction of road crossings. Erosion control matting should be combined with revegetation techniques.
- Control Concrete Washout Area: Concrete washout should be appropriately managed to prevent concrete washout water from impacting soils, water bodies, or wetlands.
- Manage Stockpiles: Soils excavated may be temporarily stockpiled. While the material is stockpiled, perimeter controls should be established and the stockpiled material should

be covered as necessary with mulch, plastic sheeting, and/or other appropriate means to prevent erosion and sedimentation.

- Install Check Dams, Sediment Traps, and Sediment Basins: Check dams and sediment traps should be used during construction near tributaries and existing drainages. The check dams and sediment traps will minimize downstream disturbances and sedimentation of creeks. A sediment basin is a constructed temporary pond, built to capture eroded soils that wash off from larger construction sites during rain storms. The sediment-laden soil settles in the pond before the runoff is discharged.

To ensure the protective measures set forth in the draft ESCP are incorporated into the final ESCP and to ensure compliance with the final ESCP, IPC proposes that the Council include the following conditions in the site certificate providing for the same:

> ***Soil Protection Condition 3:*** *Prior to construction, the certificate holder shall submit to the department a copy of an ODEQ-approved construction-related final Erosion and Sediment Control Plan (ESCP). The protective measures described in the draft ESCP Plan in ASC Exhibit I, Attachment I-3, shall be included as part of the construction-related final ESCP, unless otherwise approved by the department.*

> ***Soil Protection Condition 6:*** *During construction, the certificate holder shall conduct all work in compliance with the final ESCP referenced in Soil Protection Condition 3.*

Mitigation for Soil Erosion by Wind

To mitigate the risk of accelerating soil erosion by wind in areas rated with wind erodibility groups 1 through 4, IPC will implement reseeding efforts, apply mulch, and use water for dust control. Areas that are susceptible to aeolian processes that will be disturbed by construction activities and not permanently covered by aboveground facilities will be vegetated using a seed mixture specified by the applicable agencies as being capable of surviving in local conditions, and withstanding burial and deflation from aeolian processes. Disturbed areas susceptible to wind erosion may be hydroseeded when temperatures and moisture levels are conducive to seed germination. Vegetation protection actions and activities will be presented as part of the Project's Vegetation Management Plan (see Exhibit P1, Attachment P1-4). To ensure the protective measures set forth in the draft Vegetation Management Plan are incorporated into the final Vegetation Management Plan and to ensure compliance with the final Vegetation Management Plan, IPC proposes that the Council include the following conditions in the site certificate providing for the same:

> ***Fish and Wildlife Condition 5:*** *Prior to construction, the certificate holder shall finalize, and submit to the department for its approval, a final Vegetation Management Plan. The protective measures described in the draft Vegetation Management Plan in ASC Exhibit P1, Attachment P1-4, shall be included as part of the final Vegetation Management Plan, unless otherwise approved by the department.*

> ***Fish and Wildlife Condition 18:*** *During construction, the certificate holder shall conduct all work in compliance with the final Vegetation Management Plan referenced in Fish and Wildlife Condition 5.*

> ***Fish and Wildlife Condition 28:*** *During operation, the certificate holder shall conduct all work in compliance with the final Vegetation Management Plan referenced in Fish and Wildlife Condition 5.*

3.9.2.3 Mitigation of Expansive Soils

Expansive soils swell when exposed to moisture and shrink when dried. This change in volume can be detrimental to structure foundations. The selection of appropriate mitigation techniques will depend on the specific properties of site soils and foundation requirements of proposed structures. In general, mitigation techniques for expansive soils include removal, bypass, isolation, and treatment. If only a thin layer of expansive soil is present at a site, it may be feasible to strip and remove it. For thicker layers of expansive soil, it is common practice to extend foundations deep enough to effectively bypass the zone where moisture content is likely to change. Another mitigation alternative is to isolate the soil from changes in moisture content, through the use of enhanced drainage and/or coverings. Where only shallow foundations are practical, another mitigation alternative is to treat the expansive soils with lime or some other material that reduces their expansive properties. IPC proposes that the Council include the following condition in the site certificate providing that the Site-Specific Geological and Geotechnical Report addresses the potential of expansive soil impacts and any necessary mitigation measures regarding the same:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *. . .*
> *f. Evaluation of potential soil expansion hazards;*
> *. . .*
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*

3.9.2.4 Mitigation of Groundwater

The first step in mitigation of hazards posed by groundwater is to understand where and when it is present. Groundwater levels can vary significantly from one location to another and from one season to another. The geotechnical investigation will help to determine where groundwater will be relevant along the proposed alignments. Where groundwater plays a role in slope instability, the hydrogeological mitigation measures discussed in above should be considered. As discussed in Attachment H-1, groundwater can also complicate construction, particularly where excavations extend below the water table. This will most likely be applicable to the proposed alignment where drilled shafts are required for tower foundations. If a shaft is excavated in good quality rock or firm fine-grained soils below the water table, groundwater may not be a significant concern. However, if shaft foundations extend below the water table in granular soils, casing and/or slurry may be necessary to prevent soil heave and maintain shaft integrity. IPC proposes that the Council include the following condition in the site certificate providing that the Site-Specific Geological and Geotechnical Report addresses affected groundwater and any necessary mitigation measures regarding the same:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *. . .*

> *g. Description of groundwater detections and any related potential risk to the facility;*
>
> *. . .*
>
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*

3.9.2.5 Mitigation of Corrosive Subsurface Conditions

Where soil conditions are identified that may be corrosive to metals, potential mitigation alternatives may include application of protective coatings, such as coal tar enamel. Another mitigation alternative is to increase the metal thickness to provide a "sacrificial" layer that is thick enough to manage the amount of corrosion anticipated to occur over the structure's design life. Where sulfates are present and corrosion of concrete is a concern, mitigation alternatives may include use of sulfate-resistant cement, such as type II low-alkali cement, coating the concrete with an asphalt emulsion, or reducing the water-cement ratio to reduce the hydraulic conductivity of the concrete and slow the reaction processes. IPC proposes that the Council include the following condition in the site certificate providing that the Site-Specific Geological and Geotechnical Report addresses corrosive soils and any necessary mitigation measures regarding the same:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
>
> *. . .*
>
> *h. Description of corrosive soils detections and any related potential risk to the facility; …*
>
> *. . .*
>
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*

3.9.2.6 Flood Mitigation

Flood hazard mitigation goals are to avoid and reduce damage to constructed tower and facility locations, prevent construction that could exacerbate flooding, minimize economic losses associated with repair of structures influenced by flooding hazards and avoid dangers to human safety. Federal and state policies related to development in flood-prone areas were developed according to FEMA requirements and guidelines. These policies include zoning ordinances found in local regulations and building code ordinances in the OSSC Section 1612. This code establishes flood protection standards for all construction, including criteria to ensure that the foundation will withstand flood forces.

There are very few miles of access roads (permanent Project features) within the 100-year flood zone within the Site Boundary. Results of further engineering evaluations will be used to provide micrositing and design of Project structures that protect the public and minimize construction in flood zone areas. To reduce flood hazards, Project structures and towers will be set back from areas of high flood risks during final design. Where structures cannot be set back, a site-specific structural and erosion hazard assessment will be conducted and coordinated with local flood-zone managers to determine mitigation requirements.

Standards for protecting foundations against flood damage include requirements for soil testing and prepared fill. Building code provisions impose conditions to ensure that structures built in flood zones meet minimum standards. The primary structural code in Oregon is the OSSC, Section 1612 (ICC 2014). This code establishes flood protection standards for all construction, including criteria to ensure that the foundation will withstand flood forces and that all portions of the structures subject to damage are above, or otherwise protected from, flooding. IPC proposes that the Council include the following condition in the site certificate providing that the Site-Specific Geological and Geotechnical Report addresses flood hazards and any necessary mitigation measures regarding the same:

> ***Structural Standard Condition 1:*** *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
> *. . .*
> *i. Description of Project features within the 100-year flood zone and any related potential risk to the facility; and*
> *j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.*

4.0 IDAHO POWER'S PROPOSED SITE CERTIFICATE CONDITIONS

IPC proposes the following site certificate conditions to ensure compliance with the relevant EFSC standards:

Generally Applicable

> ***Mandatory Condition 8 [OAR 345-025-0006(12)]:*** *The certificate holder shall design, engineer and construct the facility to avoid dangers to human safety and the environment presented by seismic hazards affecting the site that are expected to result from all maximum probable seismic events. As used in this rule "seismic hazard" includes ground shaking, ground failure, landslide, liquefaction triggering and consequences (including flow failure, settlement buoyancy, and lateral spreading), cyclic softening of clays and silts, fault rupture, directivity effects and soil-structure interaction. For coastal sites, this also includes tsunami hazards and seismically-induced coastal subsidence.*

> ***Mandatory Condition 9 [OAR 345-025-0006(13)]:*** *The certificate holder shall notify the Department, the State Building Codes Division and the Department of Geology and Mineral Industries promptly if site investigations or trenching reveal that conditions in the foundation rocks differ significantly from those described in the application for a site certificate. After the Department receives the notice, the Council may require the certificate holder to consult with the Department of Geology and Mineral Industries and the Building Codes Division to propose and implement corrective or mitigation actions.*

> ***Mandatory Condition 10 [OAR 345-025-0006(14)]:*** *The certificate holder shall notify the Department, the State Building Codes Division and the Department of Geology and Mineral Industries promptly if shear zones, artesian aquifers, deformations or clastic dikes are found at or in the vicinity of the site. After the Department receives notice, the Council may require the certificate holder to*

consult with the Department of Geology and Mineral Industries and the Building Codes Division to propose and implement corrective or mitigation actions.

Prior to Construction

Structural Standard Condition 1: *Prior to construction, the certificate holder shall conduct a site-specific geological and geotechnical investigation, and shall submit to the department for its approval a Site-Specific Geological and Geotechnical Report. The investigation and/or report shall address the following:*
a. Subsurface soil and geologic conditions within the site boundary;
b. Geotechnical design criteria and data for the facility's project features;
c. Description of potentially active faults that may affect the facility and their potential risk to the facility;
d. LiDAR or field survey investigation of the site boundary to assess the potential for slope instability and landslide hazards;
e. Evaluation of potential liquefaction hazards;
f. Evaluation of potential soil expansion hazards;
g. Description of groundwater detections and any related potential risk to the facility;
h. Description of corrosive soils detections and any related potential risk to the facility;
i. Description of Project features within the 100-year flood zone and any related potential risk to the facility; and
j. Define and delineate geological and geotechnical hazards to the facility, and means to mitigate the identified hazards.

Soil Protection Condition 3: *Prior to construction, the certificate holder shall submit to the department a copy of an ODEQ-approved construction-related final Erosion and Sediment Control Plan (ESCP). The protective measures described in the draft ESCP in ASC Exhibit I, Attachment I-3, shall be included as part of the construction-related final ESCP Plan, unless otherwise approved by the department.*

Fish and Wildlife Condition 5: *Prior to construction, the certificate holder shall finalize, and submit to the department for its approval, a final Vegetation Management Plan. The protective measures described in the draft Vegetation Management Plan in ASC Exhibit P1, Attachment P1-4, shall be included as part of the final Vegetation Management Plan, unless otherwise approved by the department.*

During Construction

Structural Standard Condition 2: *During construction, the certificate holder shall construct the facility in accordance with the versions of the applicable International Building Code, Oregon Structural Specialty Code, and building codes adopted by the State of Oregon.*

Soil Protection Condition 6: *During construction, the certificate holder shall conduct all work in compliance with the final ESCP referenced in Soil Protection Condition 3.*

Fish and Wildlife Condition 18: *During construction, the certificate holder shall conduct all work in compliance with the final Vegetation Management Plan referenced in Fish and Wildlife Condition 5.*

During Operation

Fish and Wildlife Condition 28: *During operation, the certificate holder shall conduct all work in compliance with the final Vegetation Management Plan referenced in Fish and Wildlife Condition 5.*

5.0 CONCLUSIONS

Exhibit H includes the application information provided for in OAR 345-021-0010(1)(h). Further, the evidence set forth in Exhibit H shows the Project will meet the Structural Standard at OAR 345-022-0020.

6.0 COMPLIANCE CROSS-REFERENCES

Table H-5 identifies the location within the application for site certificate of the information responsive to the application submittal requirements in OAR 345-021-0010(1)(h), the Structural Standard at OAR 345-022-0020, and the relevant Second Amended Project Order provisions.

Table H-5. Compliance Requirements and Relevant Cross-References

Requirement	Location
OAR 345-021-0010(1)(h)	
(h) Exhibit H. Information from reasonably available sources regarding the geological and soil stability within the analysis area, providing evidence to support findings by the Council as required by OAR 345-022-0020, including:	
(A) A geologic report meeting the guidance in Oregon Department of Geology and Mineral Industries open file report 00-04 "Guidelines for Engineering Geologic reports and Site-Specific Seismic Hazard Reports."	Exhibit H, Section 3.3 and Attachment H-1
(B) A description and schedule of site-specific geotechnical work that will be performed before construction for inclusion in the site certificate as conditions.	Exhibit H, Section 3.4 and Attachment H-1
(C) Evidence of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate site specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.	Exhibit H, Section 3.5 and Attachment H-2
(D) For all transmission lines, a description of locations along the proposed route where the applicant proposes to perform site specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, dead-ends, corners, and portions of the proposed route where geologic reconnaissance and other site specific studies provide evidence of existing landslides or marginally stable slopes that could be made unstable by the planned construction.	Exhibit H, Section 3.6 and Attachment H-1

Requirement	Location
(E) For all pipelines that would carry explosive, flammable or hazardous materials, a description of locations along the proposed route where the applicant proposes to perform site specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings and portions of the proposed alignment where geologic reconnaissance and other site specific studies provide evidence of existing landslides or marginally stable slopes that could be made unstable by the planned construction.	Exhibit H, Section 3.7. Not Applicable because the Project does not contain pipelines.
(F) An assessment of seismic hazards. For the purposes of this assessment, the maximum probable earthquake (MPE) is the maximum earthquake that could occur under the known tectonic framework with a 10 percent chance of being exceeded in a 50 year period. If seismic sources are not mapped sufficiently to identify the ground motions above, the applicant shall provide a probabilistic seismic hazard analysis to identify the peak ground accelerations expected at the site for a 500 year recurrence interval and a 5000 year recurrence interval. In the assessment, the applicant shall include:	Exhibit H, Section 3.8
(i) Identification of the Maximum Considered Earthquake Ground Motion under the 2009 International Building Code.	Exhibit H, Section 3.8.1 and Attachment H-1
(ii) Identification and characterization of all earthquake sources capable of generating median peak ground accelerations greater than 0.05g on rock at the site. For each earthquake source, the applicant shall assess the magnitude and minimum epicentral distance of the maximum credible earthquake (MCE).	Exhibit H, Section 3.8.2 and Attachment H-1
(iii) A description of any recorded earthquakes within 50 miles of the site and of recorded earthquakes greater than 50 miles from the site that caused ground shaking at the site more intense than the Modified Mercalli III intensity. The applicant shall include the date of occurrence and a description of the earthquake that includes its magnitude and highest intensity and its epicenter location or region of highest intensity.	Exhibit H, Section 3.8.3 and Attachment H-1
(iv) Assessment of the median ground response spectrum from the MCE and the MPE and identification of the spectral accelerations greater than the design spectrum provided in the 2010 Oregon Structural Specialty Code. The applicant shall include a description of the probable behavior of the subsurface materials and amplification by subsurface materials and any topographic or subsurface conditions that could result in expected ground motions greater than those characteristic of the Maximum Considered Earthquake Ground Motion identified above.	Exhibit H, Section 3.8.4
(v) An assessment of seismic hazards expected to result from reasonably probable seismic events. As used in this rule “seismic hazard” includes ground shaking, ground failure, landslide, lateral spreading, liquefaction, tsunami inundation, fault displacement and subsidence.	Exhibit H, Section 3.8.5
(G) An assessment of soil-related hazards such as landslides, flooding and erosion which could, in the absence of a seismic event, adversely affect or be aggravated by the construction or operation of the facility.	Exhibit H, Section 3.9 and Attachment H-1

Requirement	Location
(H) An explanation of how the applicant will design, engineer and construct the facility to avoid dangers to human safety from the seismic hazards identified in paragraph (F). The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring for seismic hazards.	Exhibit H, Section 3.10.1 and Attachment H-1
(I) An explanation of how the applicant will design, engineer and construct the facility to adequately avoid dangers to human safety presented by the hazards identified in paragraph (G).	Exhibit H, Section 3.10.2
OAR 345-022-0020	
To issue the requested Site Certificate, the Council must find that: (a) The applicant, through appropriate site-specific study, has adequately characterized the site as to the Maximum Considered Earthquake Ground Motion as shown for the site in the 2009 International Building Code and maximum probable ground motion, taking into account ground failure and amplification for the site specific soil profile under the maximum credible and maximum probable seismic events; and	Exhibit H, Section 3.8.1 through Section 3.8.4, and Attachment H-1
(b) The applicant can design, engineer, and construct the facility to avoid dangers to human safety presented by seismic hazards affecting the site that are expected to result from maximum probable ground motion events. As used in this rule "seismic hazard" includes ground shaking, ground failure, landslide, liquefaction, lateral spreading, tsunami inundation, fault displacement, and subsidence;	Exhibit H, Section 3.8 and Section 3.10.1
(c) The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and	Exhibit H, Section 3.9 and Section 3.10.2
(d) The applicant can design, engineer and construct the facility to avoid dangers to human safety presented by the hazards identified in subsection (c).	Exhibit H, Section 3.8, Section 3.10.1, and Section 3.10.2
Second Amended Project Order Provisions	
The Department understands that detailed site-specific geotechnical investigation for the entire site boundary is not practical in advance of completing the final facility design and obtaining full site access. However, OAR 345-021-0010(h) requires evidence of consultation with the Oregon Department of Geology and Mineral Industries (DOGAMI) prior to submitting the application if the applicant proposes to base Exhibit H on limited pre-application geotechnical work. Exhibit H shall include written evidence of consultation with DOGAMI regarding the level of geologic and geotechnical investigation determined to be practical for the application submittal.	Exhibit H, Section 3.5 and Attachment H-2

Requirement	Location
Any geotechnical reports included in Exhibit H as supporting evidence that the proposed facility will meet the Council's structural standard shall meet the Oregon State Board of Geologist Examiners geologic report guidelines, as determined based on consultation with DOGAMI. In 2017, the Council underwent rulemaking amending the Oregon Administrative Rules (OARs) 345-021-0010, 345-022-0020, and 345-050-0060 to address rule language for structural, geologic, and seismic related issues and hazards. The amended rule language focuses on the requirements of Exhibit H and the Structural Standard to site-specific issues and risks, and allow for the appropriate consideration of evolving science of seismic risk and hazard based on consultation with DOGAMI.	Exhibit H, Section 3.3, Section 3.4, Section 3.5, Attachment H-1, and Attachment H-2

7.0 RESPONSE TO NOTICE OF INTENT AND SCOPING MEETING COMMENTS

ODOE received over 450 comments based on the Notice of Intent and the related scoping meetings. ODOE summarized those comments in the First Amended Project Order (December 2014) and then removed the summaries from the Second Amended Project Order "to reduce the risk of misinterpreting the intention of the individual comment."[2] Although ODOE eliminated the requirement that IPC address the comment summaries, IPC nonetheless voluntarily addresses those summaries here in Table H-6, identifying the location within the ASC of the information responsive to the comments summarized in the First Amended Project Order.

Table H-6. Responses to Comment Summaries

Requirements	Location
Geological hazards, including seismic hazards, steep terrain, and landslides, should be addressed in Exhibit H.	See Exhibit H, Section 3.3
A commenter expressed concern about "thermal vents" on Lindsey Mountain—if the proposed route is in the area and might be impacted by such vents, it should be addressed in Exhibit H.	The Project is not in the vicinity of Lindsey Mountain.
A commenter expressed concern about "27 recognized fault lines" present in the John Day Valley. The applicant should address identified fault lines in Exhibit H.	The Project is not in the vicinity of the John Day Valley.

8.0 REFERENCES

ASCE (American Society of Civil Engineers). 1997. Design of Latticed Steel Transmission Structures (ASCE Standard 10-97). Reston, VA, 71pp.

ASCE. 2013. Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE Standard 7). Reston, VA, 593pp.

ASCE. 2017. Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE Standard 7-16). Reston, VA.

Burns, Bill. 2011. DOGAMI staff member discussions during meeting of April 4, 2011.

[2] Second Amended Project Order, Section VI(a).

Dalton, M.M, K.D. Dello, L. Hawkins, P.W. Mote, and D.E. Rupp. 2017. The Third Oregon Climate Assessment Report, Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR.

DOGAMI (Oregon Department of Geology and Mineral Industries). 2010. Oregon's Earthquake Risk and Resiliency. *Cascadia Newsletter*. Winter.

DOGAMI. 2015. Statewide Flood Hazard Database for Oregon – FEMA Flood Insurance Study inundation zones. Available online at: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BF2CC36DE-1F0A-42D2-9B8D-FDD71721A7D3%7D (accessed December 2016).

DOE (Department of Energy, Pacific Northwest National Laboratory). 2003. 5.3.2 Soil Erodibility Factor. Available online at: http://mepas.pnl.gov/mepas/formulations/source_term/5_0/5_32/5_32.html (Accessed April 2011).

FEMA (Federal Emergency Management Agency). 2017. National Flood Hazard Layer (NFHL), published November 30, 2017. Downloaded from https://msc.fema.gov/portal on January 18, 2018.

ICC (International Code Council). 2014. 2014 Oregon Structural Specialty Code: Chapter 16 Structural Design. May. ISBN: 978-1-60983-517-0.

IEEE (Institute of Electrical and Electronics Engineers). 2006. NESC National Electrical Safety Code C2-2007.

Nearing, M.A., F.F. Pruski, and M.R. O'Neal. 2004. Expected Climate Change Impacts on Soil Erosion Rates: A Review. Available online at: file:///C:/Users/DIS0485/AppData/Local/Microsoft/Windows/INetCache/IE/6QWB7RNB/1542.pdf (Accessed June 2018).

NGDC (National Geophysical Data Center). 1985. Earthquake Intensity Database Search, 1683 – 1985, NOAA Satellite and Information Service. Available online at: http://www.ngdc.noaa.gov/cgi-bin/hazard/util/ffq_result.pl (Accessed February 2011).

OPS (Office of Pipeline Safety). 1996. National Pipeline Mapping System, 1996, U.S. DOT Pipeline Safety. Available online at: https://www.npms.phmsa.dot.gov/ (Accessed March 2016).

OSBGE (Oregon State Board of Geologist Examiners). 2014. Guideline for Preparing Engineering Geologic Reports, Second Edition, May 30, 2014. Available online at: https://www.oregon.gov/osbge/pdfs/Publications/EngineeringGeologicReports_5.2014.pdf.Pacific Northwest Seismic Network. 2008. Earthquake Catalogs and Data. Available online at http://www.pnsn.org/HIST_CAT/catalog.html (Accessed February 2001).

Shaw (Shaw Environmental & Infrastructure, Inc.). 2012. Desktop Geotechnical Report, Proposed 500kV Transmission Line, Boardman, Oregon to Hemingway, Idaho. January.

UNR (University of Nevada, Reno, Nevada Seismological Laboratory). 1996. What is Richter Magnitude? Available online at: http://www.bing.com/search?q=UNR%2C+earthquake+magnitude&FORM=LENIE. (Accessed April 2011).

USGS (U.S. Geological Survey). 2009. The Modified Mercalli Intensity Scale. Available online at http://earthquake.usgs.gov/learn/topics/mercalli.php (Accessed December 2016).

Wong, C.J., and M.D. Miller, eds. 2010. Guidelines for Electrical Transmission Line Structural Loading (ASCE Manual of Practice MOP-74). ISBN-10: 0784410356. ASCE. Reston, VA.

ATTACHMENT H-1
ENGINEERING GEOLOGY AND SEISMIC HAZARDS SUPPLEMENT

Attachment H-1 Engineering Geology and Seismic Hazards Supplement to Exhibit H
Boardman to Hemingway 500kV Transmission Line Project
Boardman, Oregon to Hemingway, Idaho

January 25, 2018

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

**Attachment H-1 Engineering Geology and Seismic Hazards Supplement to Exhibit H
Boardman to Hemingway
500kV Transmission Line Project
Boardman, Oregon
to Hemingway, Idaho**

January 25, 2018

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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BOARDMAN, OREGON TO HEMINGWAY, IDAHO

1.0 INTRODUCTION

1.1 General

This report supplements Exhibit H of the Idaho Power Company (IPC) Application for Site Certificate (ASC) to the Energy Facility Siting Council (EFSC) for the Boardman to Hemingway 500kV Transmission Line Project, in accordance with Oregon Administrative Rule (OAR) sections 345-021 and 345-022. The project location is shown on the Vicinity Map, Figure 1.

The basis for Exhibit H and this Attachment H-1 is OAR 345-021-0010(1)(h) and OAR 345-022-0020. With this document, Shannon & Wilson, Inc., presents information regarding geologic conditions as well as soil and rock stability, as required by EFSC Exhibit H, along the proposed alignments of the Boardman to Hemingway 500kV Transmission Line. The following sections present the requirements outlined in OAR 345-022-0020(1)(h), which generally states that the applicant must provide evidence that they will design, engineer, and construct the proposed facility in such a way as to adequately avoid danger to human safety. Specifically, OAR 345-022-0020(1) states that the applicant must be able to demonstrate the following:

a) *The applicant, through appropriate site-specific study, has adequately characterized the seismic hazard risk of the site; and*
b) *The applicant can design, engineer, and construct the facility to avoid dangers to human safety and the environment presented by seismic hazards affecting the site, as identified in subsection (1)(a);and*
c) *The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and*
d) *The applicant can design, engineer and construct the facility to avoid dangers to human safety and the environment presented by the hazards identified in subsection (c).*

The following discussion of information provided in Exhibit H and this supplemental Attachment H-1 is in accordance with OAR 345-021-0010(1)(h) and is intended to provide evidence of compliance with OAR 345-022-0020.

The document OAR 345-021-0010(1)(h)(A) requires, "*A geologic report meeting the Oregon State Board of Geologist Examiners geologic report guidelines. Current guidelines shall be determined based on consultation with the Oregon Department of Geology and Mineral Industries, as described in paragraph (B) of this subsection.*" Furthermore, the document OAR 345-021-0010(1)(h)(B) requires, "*A summary of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate methodology and scope of the seismic hazards and geology and soil-related hazards assessments, and the appropriate site-specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.*"

Consultation with Oregon Department of Geology and Mineral Industries (DOGAMI) is discussed in the main text in Exhibit H. A previous version of this Attachment H-1 has been provided to DOGAMI for their review. They have made comments and we understand that the previous version, along with the updates included in this document, addresses the requirements of OAR 345-021-0010(1)(h)(A) and (B). Discussions of geology, geo-seismic hazards, and other geologic hazards are a result of original Attachment H-1 or stem from the consultation with DOGAMI.

2.0 TOPOGRAPHIC AND GEOLOGIC FEATURES

This section presents the overall topographic and geologic framework for the proposed transmission alignments. Subsequent sections discuss potential geologic hazards within these geomorphic regions and categorization of these conditions/hazards for preliminary geotechnical design purposes.

Topographic and geologic information provided in this section is based on readily available reports and maps from DOGAMI, geographic information system (GIS)-based maps, Idaho Department of Water Resources (IDWR) GIS-based maps, and other geologic literature, including reports from the U.S. Geological Survey (USGS), as listed in the references section of this report.

The proposed transmission alignments are located within four general physiographic provinces. From north to south along the alignment, the provinces are the Deschutes-Columbia Plateau, the Blue Mountains, the Owyhee Plateau, and the Snake River Plain (refer to Figure 2, Physiographic Province Page Index). The following discussion presents a brief description of the topographic characteristics of each province; major stream drainage systems (with an emphasis on those streams that will be crossed by the proposed transmission alignments); a description of the general geologic environment; and a brief description of surface soils mantling the bedrock units in each province.

2.1 Deschutes-Columbia Plateau

2.1.1 Topography

The northernmost portion of the IPC Proposed Route and the entirety of the West of Bombing Range Road Alternatives 1 and 2 are located within the Deschutes-Columbia Plateau province. The Deschutes-Columbia Plateau is predominantly a volcanic province covering approximately 63,000 square miles in Oregon, Washington, and Idaho. The plateau is surrounded on all sides by mountains. For the purpose of this study, we will describe only the portion of the province that lies in Oregon.

The Deschutes-Columbia Plateau is located in the northern portion of Oregon. For the purposes of this study, the province is bounded on the west by the Cascade Range, on the southwest by the High Lava Plains, on the south and east by the Blue Mountains, and artificially on the north by the Columbia River. The northernmost portion of the IPC Proposed Route and the entirety of the West of Bombing Range Road Alternatives 1 and 2 cross the Deschutes-Columbia Plateau as shown on Figure 2 and on Figure 3, Deschutes-Columbia Plateau Topography and Drainage. The region of the Deschutes-Columbia Plateau crossed by the alignments is known as the Umatilla Basin and slopes gently northward toward the Columbia River, with elevations as high as 3,000 feet along the southern margins and as low as a few hundred feet along the river.

2.1.2 Drainage

Primary rivers within the province that are near the project area include the west-flowing Columbia River and its tributaries, the Umatilla River, and Willow Creek. McKay Creek and Butter Creek are major tributaries of Umatilla River. These streams have cut intricate, deep canyons across the plateau, but broad, flat plains remain between them within the Umatilla Basin. The IPC Proposed Route crosses the North Fork of Butter Creek three times, and the South Fork of Butter Creek once. In the foothills of the adjacent Blue Mountains province, the route also crosses McKay Creek and several smaller tributaries of the Umatilla River.

2.1.3 Geologic Overview

The Deschutes-Columbia Plateau province was created on a grand scale. Its formation has been described by Orr and Orr (2000), and is summarized in the following paragraphs. Immense outpourings of lavas during the Miocene epoch created one of the largest flood basalt provinces in the world, second only to the Deccan Plateau in India. Erupting from multiple fissures in central and northeast Oregon, as well as in southeast Washington and northwest Idaho, flow after flow of basalt lava filled a gradually subsiding basin, creating a broad, featureless plateau.

Even as the lavas were still erupting, regional stresses in the earth's crust began to warp the basalt surface into a complicated pattern of folds and faults. The Umatilla Basin is a down-warp or depression in the basalt surface. Upper Miocene- to Pliocene-age sediments (eroded from the geologically older Blue Mountains province) were deposited into this depression (refer to Figure 4, Deschutes-Columbia Plateau Geology, for province-wide general geology and Appendix A for geologic strip maps and rock unit descriptions). These sediments consist of partly indurated cobble-gravel and tuffaceous sand and silt, which now form terraces and alluvial fan deposits that lie between the basin floor and the basalt highlands along the southern margin of the basin. In the early Pleistocene, wind-blown silt called "loess" was deposited across the basalt uplands around the margins of the Umatilla Basin.

During the ice ages of the late Pleistocene, numerous lakes developed behind ice dams in northern Washington and western Montana. The largest of these, Glacial Lake Missoula, occupied the Clark Fork River Valley and much of western Montana. Glacial Lake Missoula grew steadily deeper until the ice dam failed and the lake emptied catastrophically. Once the lake had drained, the ice slowly reoccupied its position across the valley and the lake developed anew. This process of filling and emptying catastrophically was repeated numerous times. The resulting floods overpowered the landscape, eroding soil and scouring bedrock surfaces across southeastern Washington and through the Columbia River Gorge. The deluge back-flooded up stream valley tributaries to the Columbia River, including the Umatilla River, where the floodwater became temporarily impounded in the Umatilla Basin, forming a short-lived lake known as Lake Condon. As the energy of the flood waters dissipated in the area of Lake Condon, its sediment load, consisting of silt, sand, cobble-gravel, and boulders, was deposited across the floor of the basin. The geology of the Deschutes-Columbia Plateau Province is shown in Figure 4; strip maps and rock unit descriptions from the area are included in Appendix A.

2.1.4 Soils

Soils data have been compiled by the National Resources Conservation Service (NRCS) in a series of county-wide reports. The following summary of soil conditions is discussed similarly by county from north to south along the IPC Proposed Route. Soil data tables and strip maps of soil units within a one-half-mile radius of the IPC Proposed Route, rebuild sections, the alternative alignments, and associated multi-use areas are provided for reference in Appendix B, Soils Data Tables and Maps.

Morrow County soils, from the substation at the northern end of the alignment to approximately milepost 12 (MP12), are largely derived from sediments deposited during the late Pleistocene in former Lake Condon, which temporarily occupied the Umatilla Basin during the periods of catastrophic flooding from Glacial Lake Missoula. These soils are relatively uniform, consisting of well-drained silt loam to fine sandy loam with rare gravelly silt loam. The sandy soils are generally greater than 5 feet thick over the underling basalt bedrock; they are well drained, and have a moderate to severe erosion potential. A few sand dunes are present between MP7 and MP12.

South of MP12, the land surface begins to rise gradually in elevation and the sandy water deposited soils are replaced by wind-blown silt, or “loess.” The loess is thickest on broad uplands. On narrow ridges, steep slopes, and along streams, such as Butter Creek, the loessal soils are subject to erosion and are often mixed with stony colluvium derived from the underlying basalt bedrock. A few isolated rock outcrops are present along Butter Creek where the soils have been eroded along the stream channel. Scattered rock outcrops and silt loam soils mixed with stony colluvium and residuum are common south of MP27 and on into Umatilla County.

As the IPC Proposed Route continues into Umatilla County, it crosses terraces south of the Umatilla Basin and then begins climbing the basalt highlands. Soils become gradually thinner, but are still composed largely of loess, which consist of fine sandy silt loam to silty fine sandy loam. The soils vary from about 20 to 40 inches deep and are commonly mixed with stony basalt colluvium and residuum, or overlie cemented alluvial terrace deposits. The soils are generally well-drained and the erosion hazard remains moderate to severe.

2.2 Blue Mountains Province

2.2.1 Topography

The IPC Proposed Route continues toward the southeast through the Blue Mountains physiographic province. The Blue Mountains province is located largely in northeastern Oregon and is bounded on the east by the Snake River Canyon, the Columbia River Plateau, and an Accreted Terrane; on the north and west by the Deschutes-Columbia Plateau; and on the south by the High Lava Plains and the Owyhee Plateau provinces. The Blue Mountains province is made up of a cluster of smaller ranges of various orientations and relief. Their multiple origins are evident in the topography. The western portion of the province is part of a wide, uplifted plateau; while the Wallowa Mountains on the east contain a striking array of glacially sculpted mountain peaks, deep canyons, and broad valleys.

The IPC Proposed Route traverses the Blue Mountains just west of the Grande Ronde Valley, and then along the low hills that rise above the eastern margin of Baker Valley, which is drained by the Powder River (refer to Figure 5, Blue Mountains Topography and Drainage). The Morgan Lake Alternative parallels the IPC Proposed Route, farther west of the Grande Ronde Valley. The Proposed 230-kV Rebuild Route parallels the IPC Proposed Route northeast of Baker City. The alignments are generally situated between the Elkhorn Mountains to the west, and the Wallowa Mountains to the east.

The IPC Proposed Route continues in a southwesterly direction across relatively low rolling hills that form the southeastern margin of the Baker Valley, and then south over Lone Pine Mountain, until reaching the Sutton Creek Valley. The alignment then turns toward the southeast, up the Sutton Creek Valley, and in a direction that approximately parallels the Interstate 84 highway. Topography south of the Baker Valley consists of low, steep-sided mountains and ridges with narrow intervening valleys. Most valleys are either dry or occupied by small ephemeral streams. Small springs are often present at the heads of the valleys.

The IPC Proposed Route reaches a drainage divide near Pleasant Valley. From here, the route continues southeasterly down Alder Creek. Before it reaches Durkee Valley, it turns south, crosses Alder Creek, then crosses the foothills to the northwest of Durkee Valley. It continues across the Burnt River where it turns southeast along the mountains to the west of the Burnt River Canyon. At Dixie, the alignment begins to follow the canyon until Huntington. This canyon is narrow with rocky, steep-sided valley margins. Adjacent mountain ridges and peaks rise 2,000 feet or more above the valley floor.

About 4 miles south of Huntington, the Proposed 138-kV Rebuild parallels the IPC Proposed Route. Here, near its closest approach to the Snake River, the IPC Proposed Route turns south. The route then crosses the southeastern foothills of the Blue Mountains. Formed primarily of fine-grained sedimentary rocks, the peaks and ridges are lower in elevation, more rounded, and eroded by a more finely divided drainage network than the hard rock peaks along the Burnt River Canyon. Most canyons are dry or contain only small seasonal streams.

About 8 miles north of the town of Vale, Oregon, the route swings southwestward, then south again, crosses the Willow Creek Valley, then swings south again and crosses the Malheur River about 10 miles west-southwest of Vale. The valleys of Willow Creek and the Malheur River are intensely cultivated; vegetables and other crops are made possible in this area of sparse precipitation by extensive irrigation systems. In contrast to the green valley floors, the surrounding hills are dry, brown, and sparsely vegetated. After crossing the Malheur River, the Double Mountain Alternative provides an option to cut off a northward curve in the IPC Proposed Route, which then enters the Owyhee Plateau physiographic province.

2.2.2 Drainage

The Blue Mountain Range consists of several extensive watersheds, draining into rivers including the Grande Ronde, Imnaha, Wallowa, and John Day. The Grande Ronde River is the principal watershed of the Blue Mountain Range. With headwaters approximately 20 miles southwest of La Grande, the Grande Ronde River intersects the proposed alignment approximately 7 miles west of La Grande. The Grande Ronde River flows through the mountains, generally trending north until it passes La Grande and begins to trend northeast, meandering through the Grande Ronde Valley. Little Catherine Creek flows in a northwesterly direction, passes east of Union, and joins the Grande Ronde River just east of La Grande. Continuing south and east through the Blue Mountains province, the IPC Proposed Route crosses through the semi-arid Powder Basin.

The main streams of the Powder Basin are the Powder River and the Burnt River. The Powder River originates in the Elkhorn Mountains and trends to the north through the city of North Powder and then east to the Snake River. The Burnt River originates in the Blue Mountains (the east slope of the uplands between the Elkhorn Mountains and the Strawberry Range) from the confluence of North, West, Middle, and South Forks of Burnt River, which converge at Unity Lake. The Burnt River trends east to a confluence with the Snake River near Huntington. The Malheur River and its tributary Willow Creek drain the southeastern portion of the Blue Mountains Province; they flow eastward to the Snake River near Ontario.

2.2.3 Geologic Overview

The IPC Proposed Route runs through the central portion of the Blue Mountains Province, crossing the northern portion of the Elkhorn Mountains, and then continuing south through the Baker Valley. From there, the alignment generally runs along a portion of the Burnt River Canyon, then southwest over the southeastern foothills, across the Willow Creek drainage basin, and finally southward across the Malheur Valley. This area through the Blue Mountain province contains some of the oldest rocks in Oregon. Permian, Triassic, and Jurassic rocks were scraped off of a subducting oceanic plate and accreted to the Mesozoic shoreline, which at that time was positioned near the present Idaho border with Washington and Oregon. Metamorphism, intrusion, and volcanic activity cemented these exotic blocks onto the North American continent, where they became the foundation of northeast Oregon (Orr and Orr, 2000).

The IPC Proposed Route crosses groups of rocks that have been designated as the Baker, Wallowa, and Olds Ferry Terranes. Within the Baker Terrane, the alignment encounters Burnt River Schist and Elkhorn Ridge Argillite. The Wallowa Terrane portion consists of igneous rocks including the Clover Creek Greenstone. The Olds Ferry Terrane consists primarily of sedimentary rocks, including those of the Weatherby Formation (Jet Creek Member). The southeastern foothills of the Blue Mountains Province (the areas drained by Willow Creek and the Malheur River) are largely composed of Miocene- to Pliocene-age tuffs and tuffaceous sedimentary rocks. The geology of the Blue Mountains Province is shown in Figure 6, Blue Mountains Geology; strip maps and rock unit descriptions from the area are included in Appendix A.

2.2.4 Soils

Beginning about 15 miles west of the Union County line, and just after crossing Birch Creek (near MP65), the IPC Proposed Route passes out of the Umatilla Basin and enters the Blue Mountains Province. Elevation continues to increase, and the predominantly loessal silt loam soils gradually grade to residual (developed in-place) silt loams and clay loams that are often mixed with volcanic ash and gravel- to cobble-sized rock clasts (colluvium) derived from the underlying basalt lava and andesitic tuff parent materials. The soils vary from a few inches to a few feet thick over weathered bedrock, are generally well-drained, and are typically characterized as having a severe erosion hazard. Similar soil conditions are also present along the Morgan Lake Alternative. Soil data tables and strip maps of the soil units within a one-half-mile radius of the IPC Proposed Route, rebuild sections, and the alternative alignments are provided for reference in Appendix B.

The IPC Proposed Route continues toward the southeast and passes through the Glass Hill area west of La Grande. The IPC Proposed Route traverses areas underlain by silt loam soils derived from a mixture of basalt colluvium and surficial deposits of loess and volcanic ash. These soils mantle ridge crests and mountain slopes and are often stony, i.e., they grade with depth to more rocky colluvial debris derived from the underlying basalt bedrock. Although bedrock exposures are rare, the soil cover is relatively thin: commonly less than 5 feet thick over weathered basalt bedrock. The soils are well-drained and are associated with a severe erosion hazard.

The IPC Proposed Route descends gradually in elevation toward the south and southeast, and then finally leaves the highlands. It crosses the Powder River and enters Baker County and the northern portion of the Baker Valley southwest of Union, Oregon. Valley soils consist predominantly of silt loam soils developed from loess and volcanic ash that grade with depth to stony colluvium, that was derived from residual soils weathered out of the underlying basalt and tuff parent materials. These soils are generally less than 10 feet thick over the underlying bedrock surface, moderately- to well-drained, and have a moderate to severe erosion hazard. Alluvial silt and sand with local accumulations of gravel and cobbles are present along stream channels and across adjacent floodplains.

The IPC Proposed Route continues southeastward and up onto the low range of hills that flank the eastern side of the Baker Valley. Soils continue to consist predominantly of silt loam derived from loess and volcanic ash; which overlie colluvial and/or residual soils derived from underlying basalt and tuffaceous volcanics, as well as some intrusive and metamorphic rocks. The route continues southeast past North Powder, Haines, and Baker City. The short Proposed 230-kV Rebuild section is included here, just east of Baker City and south of Highway 86. Stony silt loam colluvial soils developed on the underlying bedrock are mixed with loess, volcanic ash, alluvial and lacustrine sediments, and older alluvial terrace and alluvial fan deposits. These soils are generally well-drained silt loams, which often contain gravel and cobbles, and have a moderate to severe erosion hazard. Surface soils are generally less than 5 feet thick over the underlying consolidated parent materials.

Approximately 3 miles southeast of Baker City, the IPC Proposed Route approaches Sutton Creek and Interstate 84. At this point, the route turns southeastward and continues up Sutton Creek, crosses a drainage divide near Pleasant Valley, and then continues down Alder Creek, turning south about 6 miles from its confluence with the Burnt River near Durkee. The route then continues southeastward following the western ridge of the Burnt River canyon.

Although it crosses Alder Creek once, the Burnt River once, and Dixie Creek once, the route generally keeps to steep slopes between hilltops and ridges above the valley floor. Soils in this section are stony to gravelly silt loams and gravelly clay loams mixed with colluvium. The colluvium is derived from mixed alluvial and lacustrine sedimentary rocks, basalt, greenstone, argillite, schist, and metamorphosed volcanic rocks. These soils are present on hill slopes; they are well-drained, have a severe erosion hazard, and generally range between 5 and 10 feet thick over the underlying consolidated parent materials.

About 3 miles south of Huntington, the IPC Proposed Route crosses the Baker-Malheur County line. Available soils data in Malheur County is limited to areas along Willow Creek and the Malheur River, where the alluvial soils will support agricultural pursuits. However, geologic mapping is available (refer to Appendix A); and where soil data is unavailable, we have used the geologic mapping along with a comparison of similar rock types, and associated soils, in Baker County to infer generalized soil conditions that are likely to develop from the underlying bedrock parent materials.

From the Malheur County line (near MP197), the IPC Proposed Route trends southwestward to the Willow Creek Valley, then turns southeastward. Between the Baker-Malheur County line and the Willow Creek Valley, the route crosses principally consolidated fine-grained tuffaceous sedimentary rock. We infer that surface soils from near the County line to near Willow Creek will consist principally of silt loam to fine sandy loam; hill slopes might be stony. Soils will be thickest on lower slopes and across the intervening valleys, intermediate depth on hilltops and ridge crests, and thinnest on upper and middle slopes. These fine-grained soils will likely be well-drained, except in the intervening valleys and in closed basins where excessive fines may be present. We expect that soils are probably not more than 10 feet thick over consolidated materials, and the erosion hazard rating will likely be severe.

In the Willow Creek Valley, soils on the IPC Proposed Route are dominated by silt loam and fine sandy loam derived from alluvial parent materials. The erosion hazard is slight to moderate, and the soils are deep, i.e., exceeding 10 feet. After crossing the Willow Creek Valley, the route makes a large loop to the west, then south and east around Vale. After crossing the Malheur River, the Double Mountain Alternative would cut off a short northward curve in the IPC Proposed Route. No soils mapping is available in this area. These alignments cross a variety of geologic units, including unconsolidated sediments, consolidated sedimentary rocks, and igneous rock. We infer that the soils are largely fine sandy to silty loams, locally stony or gravelly, and that the soils are generally well-drained with a moderate to severe erosion hazard rating. Just south of the Malheur River Valley, the IPC Proposed Route crosses into the Owyhee Plateau province.

2.3 Owyhee Plateau

2.3.1 Topography

The Owyhee Plateau straddles the Oregon-Idaho border near the southeastern end of the IPC Proposed Route and extends southward into north-central Nevada. The Owyhee Plateau is a subset of the much larger Basin and Range province that is found extensively throughout Nevada and even in parts of California. The Owyhee Plateau differs from the rest of the Basin and Range in that it is a flat, deeply dissected plateau with little interior drainage; and its fault-block topography, which is a characteristic of the Basin and Range, is less pronounced. The Owyhee Plateau rises from about 2,100 feet above sea level, where the Malheur River enters the Snake River, to about 6,500 feet at the top of Mahogany Mountain. The Owyhee River, the Malheur River, and the Snake River, as well as many smaller creeks and streams, have cut deeply into the plateau surface. The topography and drainage of the Owyhee Plateau is shown in Figure 7.

2.3.2 Drainage

The drainage basin of the Owyhee River encompasses the southern portion of the IPC Proposed Route near Lake Owyhee. Due to steep gradients, the Owyhee River and its tributaries provide well-defined drainage patterns and deeply incised canyons, with intermittent small streams flowing in from the surrounding hills. The Owyhee River is a tributary of the Snake River. In addition to the Owyhee River, Succor Creek drains the last watershed in this province and also flows into the Snake River.

2.3.3 Geologic Overview

The IPC Proposed Route continues south and east from the Malheur Valley through the Owyhee Plateau physiographic province, crossing into Idaho about 32 miles south of Ontario, Oregon. Shortly after crossing into Idaho, the IPC Proposed Route leaves the Owyhee Plateau and passes into the Snake River Plain physiographic province. The Owyhee Plateau was formed by volcanic eruptions of ash and basalt lava beginning in the middle Miocene (about 15 million years ago). Much of the ash was eroded and re-deposited in stream valleys. The earlier ash and lava was covered over by additional periodic eruptions of lava. A period of erosion followed, as regional uplift began to raise the area into low mountains. Basaltic eruptions continued, and from late Miocene into the Pliocene epoch, fault blocks developed, creating basins where ashrich sediments were deposited by streams. Alternating basalt flows, ash deposits, and stream sediments accumulated up to 2,000 feet in thickness (refer to Figure 8, Owyhee Plateau Geology and Appendix A for strip maps and rock unit descriptions). By the early Pliocene (about 4 to 3 million years ago), as the climate became drier, the Owyhee River had established its present channel. Uplift of the region continued and the streams cut even deeper into their canyons (Orr and Orr, 2000).

2.3.4 Soils

The IPC Proposed Route enters the Owyhee Plateau geomorphic province near MP245. As stated earlier, soils data in Malheur County are limited to areas along major streams and rivers where the alluvial soils will support agricultural pursuits. However, the entire county is covered by geologic mapping (refer to Appendix A), and it has been used to infer generalized soil conditions that are likely to develop from the underlying bedrock parent materials.

From near MP245 to near MP250, the IPC Proposed Route crosses primarily terraced alluvial gravel and fine-grained lacustrine sedimentary deposits. Based on the NRCS soils data, these parent materials have developed silt loam to gravelly silt loam soils that range from about 4 to 10 feet thick, are well-drained, and have a moderate to severe erosion hazard rating.

From about MP250 to MP255, the IPC Proposed Route crosses alternating areas underlain by lacustrine sedimentary deposits, described above, and basalt bedrock. The basalt parent materials are likely to have produced stony loam soils that are less than 5 feet thick and which are well-drained with a moderate to slight erosion hazard rating. Bare rock outcrops may occur locally.

Local soils mapping is available near the IPC Proposed Route adjacent to the Owyhee River (refer to Appendix B for soil tables and maps). Soils adjacent to the river crossing (near MP255) are silt loam and gravelly silt loam developed on terraced fluvial and lacustrine sedimentary parent materials. These soils are relatively deep, i.e., greater than 5 feet, and well-drained with a moderate to severe erosion hazard rating.

After crossing the Owyhee River (between MP255 and MP256) the IPC Proposed Route continues toward the southeast as it gradually descends from the Owyhee Plateau to the Snake River Plain. At the ground surface, the eastern slope of the Owyhee Plateau is largely composed of tuffaceous lacustrine sediments, tuff, and ash flow deposits, but basalt rock protrudes through the fine-grained materials locally. The area is intricately eroded, and alluvial deposits and associated terraced alluvium and alluvial fan deposits of sand and gravel are also present locally. Soils developed from the tuffaceous materials are silty to fine sandy loams; gravelly loams have developed over the alluvial materials. The fine-grained soils are generally greater than 5 feet thick, well-drained, and have a moderate to severe erosion hazard rating. Where basalt rock is exposed, stony loam soils have developed and may be mixed with or grade with depth to colluvium and residuum. These coarse soils tend to be greater than 5 feet thick and well- to somewhat excessively-drained with a moderate erosion hazard rating.

2.4 Snake River Plain

2.4.1 Topography

The IPC Proposed Route passes into the edge of the Snake River Plain physiographic province less than 2 miles after crossing the border into Idaho. The Snake River Plain is a broad, relatively flat, topographic depression that extends across southern Idaho. The proposed alignment follows the southwestern margin of the Snake River Plain all the way to the Hemingway Substation. As the alignment follows the border between the Snake River Plain and the Owyhee Plateau, it experiences variable topographic relief that reflects the transition between the two provinces. While the terrain is less rugged than what is typical in the deeply dissected Owyhee Plateau, there is greater relief than is found throughout most of the Snake River Plain. The topography and drainage of the Snake River Plain is shown in Figure 7, Owyhee Plateau Topography and Drainage.

2.4.2 Drainage

The portion of the project area within the Snake River Plain generally drains to the northeast, toward the Snake River, which lies northeast of and sub-parallel to the IPC Proposed Route. In the vicinity of the project, the Snake River flows toward the northwest, turning north at the Oregon-Idaho border and joining with its tributary, the Boise River. The Snake River ultimately drains into the Columbia River, near Kennewick, Washington.

2.4.3 Geologic Overview

While the entire Snake River Plain appears to be topographically continuous, there are significant geologic and structural differences between the eastern and western portions. The western Snake River Plain, where the IPC Proposed Route is located, is thought to be a northwest-trending, fault-bound graben. Surface topography and geologic strata in the region dip toward the axis or middle of the plain (Shervais, et al., 2005; Bonnichsen and Godchaux, 2002).

Rocks of the western Snake River Plain include Miocene rhyolitic tuffs and ash flows of the Idavada Volcanic Group, as well as fluvial and lacustrine sediment interbedded with basalt flows of the Idaho Group (Pierce and Morgan, 1992; Bonnichsen and Godchaux, 2002). The geology of the Snake River Plain province is shown in Figure 8, Owyhee Plateau Geology; strip maps and rock unit descriptions from the area are included in Appendix A.

2.4.4 Soils

About 15 miles east of the Owyhee River crossing (about MP271), the IPC Proposed Route crosses the Oregon-Idaho border and enters Owyhee County, Idaho. At approximately MP273, the route passes into the Snake River Plain physiographic province. Complete soils mapping is available for Owyhee County, Idaho.

From the state boundary, soils are principally silt loam with some fine sandy loam from mixed alluvial and lacustrine deposits, volcanic ash, residual and colluvial materials derived from welded tuff, basalt, and rhyolitic lavas. These soils occur on alluvial fans, alluvial terraces, valley floors, foothills, and hill slopes. They tend to be well-drained with a moderate to severe erosion hazard. These soils also tend to be relatively deep, varying from about 4 to more than 15 feet thick over the underlying consolidated materials.

3.0 PROPOSED SITE-SPECIFIC GEOTECHNICAL WORK

The document OAR 345-021-0010(1) requires the following:

- OAR 345-021-0010(1)(h)(B): "*A summary of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate methodology and scope of the seismic hazards and geology and soil-related hazards assessments, and the appropriate site-specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.*"
- OAR 345-021-0010(1)(h)(C): "*A description and schedule of site-specific geotechnical work that will be performed before construction for inclusion in the site certificate as conditions.*"
- OAR 345-021-0010(1)(h)(D): "*For all transmission lines, and for all pipelines that would carry explosive, flammable or hazardous materials, a description of locations along the proposed route where the applicant proposes to perform site specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, dead ends (for transmission lines), corners (for transmission lines), and portions of the proposed route where geologic reconnaissance and other site specific studies provide evidence of existing landslides, marginally stable slopes or potentially*

> *liquefiable soils that could be made unstable by the planned construction or experience impacts during the facility's operation.*"

The following sections provide a generalized exploration program for the proposed alignments and describe proposed geotechnical exploration methods based on anticipated geologic conditions. The proposed schedule for site-specific geotechnical work, as required by OAR 345-021-0010(1)(h)(C), is provided in the main Exhibit H text, along with evidence of consultation with the DOGAMI regarding the appropriate site-specific geotechnical work, as required by OAR 345-021-0010(1)(h)(B).

3.1 Geotechnical Exploration Plan

Shannon & Wilson reviewed the proposed project alignments with respect to aerial photographs, topographic maps, existing geologic mapping, soils mapping, landslide mapping, and limited reconnaissance data (compiled by Shannon & Wilson and Shaw) to select preliminary proposed boring locations. Some proposed boring locations were adjusted slightly away from proposed tower locations based on known access or permitting considerations communicated to us by Tetra Tech, via HDR. Preliminary locations of the proposed borings are summarized in Table C1 in Appendix C. These locations are also shown on the Geologic Map sheets in Appendix A and the Landslide Inventory maps in Appendix E. In general, criteria for boring placement included borings at the following:

- A maximum spacing of approximately 1 mile along the alignments in areas anticipated to have variable ground conditions, and a maximum spacing of approximately 2 miles along the alignments in areas anticipated to have uniform ground conditions;
- Dead-end structures;
- Corners or significant changes in alignment heading (angle points);
- Crossings of highways, major roads, rivers, railroads, and utilities such as power transmission lines, natural gas pipelines, and canals;
- Locations necessary to verify anticipated lithologic changes and/or geologic hazards such as landslides, steep slopes, or soft soil areas;
- Locations of towers nearest to where Quaternary faults cross the alignment; and
- Locations for potential geo-seismic hazards such as liquefaction, lateral spreading, and seismic slope instability.

The desired boring locations were compared with areas that have already been surveyed for cultural, biological, or environmental sensitivity; and where the necessary right of entry permits have already been granted by land owners. Where complete access clearance at a borehole location was not expected by the year 2019, the desired borehole location was removed from this preliminary exploration list.

The preliminary summary table provided in Appendix C presents 342 proposed boring locations, as well as information regarding the anticipated subsurface geology, anticipated drilling rig type, and justification for each boring. This information will need to be verified during a detailed field reconnaissance of the entire alignment, to be performed prior to drilling. The list of proposed borings currently includes 315 boreholes along the IPC Proposed Route; 3 boreholes for the West of Bombing Road Alternative 1; 2 boreholes for the West of Bombing Road Alternative 2; and 22 boreholes for the Morgan Lake Alternative.

The current list of proposed borings is preliminary and will change as the project progresses. Borings may be added, repositioned, or removed from the list based on future site reconnaissance, conditions encountered as the exploration program is performed, and site access constraints. Current borehole designations, based on the designation of the nearest tower, are also preliminary and subject to future revision. It should be expected that an initial phase of drilling will not have as many borings as currently shown in Table C1.

The depth of each boring will generally be no more than 50 feet below the designed finish grade of the transmission line centerline. Depths for drilling into hard soil or competent rock will vary depending on the information needed for design. Borings may be terminated at shallower depths if the blow counts (the number of blows required to advance a split-spoon sampler 12 inches) in soil materials exceed 50 blows per foot for a minimum of three consecutive samples taken at 5-foot intervals (a total depth interval of 15 feet). Borings may also be terminated at less than 50 feet when they have been advanced 10 feet into unweathered, competent rock, as determined by a field representative from examination of the recovered rock core.

3.1.1 Geotechnical Drilling Methods

The purpose of the geotechnical drilling will be to evaluate the foundation conditions for the proposed transmission towers and substations. Geotechnical drilling will be accomplished using a variety of drilling methods, which will vary depending on the type of soil and rock expected within the anticipated completion depth of each boring. Some of the various methods anticipated to be implemented are discussed below.

3.1.1.1 Hollow Stem Auger Drilling

Hollow Stem Auger (HSA) drilling consists of rotating and pushing a hollow drill stem with a continuous helical fin on the outside into the subsurface. The lead auger has a toothed bit at the bottom with a hole in the middle. During drilling, a center rod with a plug at the bottom is left inside the auger drill string to keep the center free of cuttings. The cuttings are brought to the surface on the outside of the augers by rotation of the helical fin. For sampling, the internal rod is withdrawn, and the plug is removed from the end of the rod and replaced with a soil sampler. The sampler is then inserted through the hollow auger stem and placed at the bottom of the borehole.

HSA drilling does not require water or drilling mud, making it ideal for work in remote areas where available water is scarce. It is also easier to determine the depth to groundwater, if it is encountered, as compared with other drilling methods. Another advantage is that the hole is essentially cased during drilling, so loose or caving materials do not inhibit drilling progress or sample quality. Augers can be used as casing in combination with mud rotary drilling or rock coring to temporarily support a borehole across loose materials. The principal disadvantage of HSA drilling is the potential for soil heave into the augers and/or unreliable blow counts when sampling in soft or loose soils below the water table. Under such conditions, mud rotary drilling is preferable. HSA generally cannot penetrate very dense gravels, large cobbles, or hard rock.

3.1.1.2 Mud Rotary Drilling

Mud rotary borings are typically advanced using a smooth-walled hollow drill stem and a tri-cone bit, through which a fluid bentonite drilling mud is pumped. The drilling mud serves to cool the bit, keep the borehole open, and flush the cuttings to the surface. Returning drilling mud is typically passed through a screen and into a tub over the borehole. The screen collects the cuttings and the tub collects the mud for recirculation back into the hole. If a borehole cannot be kept open using mud alone, casing (such as a hollow stem auger) may be set to facilitate advancement of the hole. Mud rotary drilling requires a water source or a supply vehicle which may have difficulty accessing some boring locations. Also, due to the presence of drilling fluid, groundwater levels are often difficult to discern during drilling.

3.1.1.3 Rock Coring

Rock core drilling is typically used to advance a borehole through rock and, at the same time, retrieve sample cores of the rock. This can be done using a conventional coring system, where the core barrel with a diamond-impregnated bit is attached to a string of smaller diameter drilling rods. To retrieve the core sample, the entire string of drill rods must be pulled from the borehole. Today, wireline systems are more commonly used for rock coring. The wireline system also advances a core barrel behind a diamond-impregnated bit, but differs from the convention system in that the drill rods have a larger inside diameter and the core barrel contains an inner barrel. This inner barrel is inserted and retracted through the string of drill rods using a winch and a wireline system, while the rods and outer core barrel remain in the borehole. Clean water or water mixed with polymer is used to lubricate the casing, cool the bit, and flush fine cuttings from the hole.

3.1.2 Types of Drill Rigs

The drilling techniques described above can be performed using rigs mounted on road-legal trucks, tracked vehicles, or mobile platforms. Truck-mounted drilling rigs will be used at all locations not inhibited by access restrictions. The other drilling rigs are proposed for areas where the truck-mounted drilling rigs cannot be used due to steep terrain and/or difficult access. Other vehicles and equipment may also be mobilized to each boring location and could include a water truck or support vehicle, an air compressor, the field representative's pickup truck or utility vehicle, and possibly another support pickup truck. In some areas, a dozer or grading equipment may be required to assist with access to boring locations.

3.1.2.1 Truck-Mounted Drilling Rigs

Truck-mounted drilling rigs are road-legal, heavy trucks that require access to be relatively flat (5 percent grade or less). They travel on existing roadways and two-track trails as close as possible to boring locations and then overland on firm ground. Truck rigs are typically 30 feet long, 8.5 feet wide, 12 feet high with mast down, and 25 to 35 feet high with the mast up. The gross vehicle weight of a truck rig is typically about 30,000 to 40,000 pounds.

3.1.2.2 Track-Mounted Drilling Rigs

Track-mounted drilling rigs are another alternative drill rig type for borings where there are softer ground conditions and/or up to 20 percent grade. These rigs are approximately 8,000 to 15,000 pounds with rubber tracks, resulting in approximately 10 psi ground pressure. This type of rig yields the lowest relative ground disturbance for mobile rigs on soft ground. Tracked rigs are typically 12 to 24 feet long, 6 to 8 feet wide, and 12 to 28 feet high with mast up. They are transported as close as possible to exploration sites on low-boy trailers, using existing roadways and two-track trails. From there, they track overland to boring locations.

While these rigs can traverse steeper terrain than truck rigs, most models still require a relatively flat area to set up for drilling. In some areas along the proposed alignment, this may require some minor grading and site preparation using an excavator or dozer. Some drilling contractors have track-mounted water haulers available, which facilitates mud rotary drilling and rock coring on track rigs in remote areas, away from water sources.

3.1.2.3 Platform Drilling Rigs

Platform drilling rigs will be utilized to access areas that are too steep for the mobile drilling rigs (described above) to access. Platform rigs will generally be transported to the boring locations by helicopter, in 8 to 10 pieces, and assembled on site. Where tower sites are located high on steep slopes above existing roadways, platform drilling equipment can also be lifted into place using mobile cranes.

Platform rigs are approximately 6,000 to 7,000 pounds when assembled, and up to 32 feet high with the mast up. They generally have base dimensions on the order of 8 to 15 feet by 6 feet and have roughly 5-foot-long stabilizer legs that extend from all sides of the base to level the platform on slopes.

For helicopter transport, staging areas near existing roadways will be required to load the equipment to the helicopter.

For crane transport, staging areas will be required along roadways adjacent to the slopes where the rigs will be placed. Traffic control may be required if shoulder widths are insufficient.

3.1.3 Sampling Methods

During drilling operations, samples will generally be taken at 2.5- to 5-foot depth intervals. Most soil sampling will be performed using split-spoon samplers. Thin-walled tubes may be used to sample fine-grained or cohesive soils. HQ or NQ core will generally be used to advance through and sample rock. These sampling methods are described further in the following subsections.

3.1.3.1 Split-Spoon Sampling

Disturbed samples in borings are typically collected using a standard 2-inch outside diameter (O.D.) split spoon sampler in conjunction with Standard Penetration Testing. In a Standard Penetration Test (SPT, ASTM D1586), the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is defined as the standard penetration resistance, or N-value. The SPT N-value provides a measure of in situ relative density of granular soils (silt, sand, and gravel), and the consistency of fine-grained, cohesive soils (silt and clay). All disturbed samples are visually identified and described in the field, sealed to retain moisture, and returned to the laboratory for additional examination and testing. In some cases, it may be necessary to use a larger sampler, such as a 3.25-inch O.D. Dames & Moore sampler, to collect a representative quantity of soil that contains coarse gravels.

3.1.3.2 Thin-Walled Tubes

Relatively undisturbed samples of fine-grained and/or cohesive soils encountered in the borings may be obtained by pushing a 3-inch outside-diameter, thin-walled tube sampler (also known as Shelby tube sampler, ASTM D1587) a distance of approximately 2 feet into the bottom of the borehole using a hydraulic ram. After a thin-wall tube sample is recovered from the boring, it is sealed at both ends to prevent moisture loss and carefully transported back to the laboratory. Care is taken to keep the sample upright and to avoid dropping, jarring, or rough handling.

3.1.3.3 Coring

HQ or NQ coring is typically used to advance through and sample rock. Core runs are typically 5 feet long. Core samples are photographed in a split tube immediately after extraction from the core barrel. The core is evaluated in the field to determine the percentage of the run recovered, as well as the Rock Quality Designation (RQD), defined as the sum of the length of core pieces 4 inches or more in length and divided by the total length of the drilled core run. The degree of weathering, soundness, joints and structural discontinuities, and other rock characteristics are documented on the boring logs. Rock core samples which are sensitive to moisture loss may be individually wrapped in the field with plastic wrap. All core is stored in waxed cardboard or plastic corrugated boxes which are labeled with the boring designation and depth intervals.

3.1.4 Boring Logs

A field representative will be present during all drilling activities. The field representative will locate the boreholes, collect samples, and maintain logs of the materials encountered. The logs will include sample locations and types, sample descriptions, and notes regarding drilling methods, drill action, fluid loss, problems encountered during drilling, and the depth to groundwater (if observed). The boring logs will present a description of the soil and rock materials encountered at each boring and the approximate depths at which material changes were observed. Soil samples will be described and identified visually, in general accordance with ASTM D2488, the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

3.1.5 Laboratory Testing

Laboratory testing will be performed on soil and rock samples obtained from the borings to refine field descriptions and to provide index properties for use in engineering design. Laboratory tests for soils may include natural water content and density analyses, Atterberg Limits tests, particle-size analyses, and analytical testing for corrosivity potential. Testing on rock may include point load, unconfined compressive strength testing, and slake durability testing. All laboratory testing will be performed in accordance with applicable ASTM International (ASTM) or U.S. Army Corps of Engineers (USACE) standard test procedures.

3.1.6 Geophysical Surveys

In addition to geotechnical drilling, non-invasive geophysical surveys may be conducted at substation expansion areas and remote areas that cannot be accessed by the previously described drilling equipment. Geophysical survey techniques may include electrical resistivity testing for grounding design or seismic refraction surveys, often used to profile depths to bedrock contacts.

3.2 Geotechnical Reporting

Once the field explorations and laboratory testing are completed and engineering evaluation of the acquired data has been accomplished, a geotechnical report will be prepared in accordance with *Guidelines for Preparing Engineering Geologic Reports* (Oregon State Board of Geologist Examiners, 2014).

4.0 SEISMIC HAZARDS

OAR 345-021-0010(1)(h)(E) states, "*An assessment of seismic hazards, in accordance with standard-of-practice methods and best practices, that addresses all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries described in paragraph (B) of this subsection, and an explanation of how the applicant will design, engineer, construct, and operate the facility to avoid dangers to human safety and the environment from these seismic hazards. Furthermore, an explanation of how the applicant will design, engineer,* *construct and operate the facility to integrate disaster resilience design to ensure recovery of operations after major disasters. The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring and emergency measures for seismic hazards, including tsunami safety measures if the site is located in the DOGAMI-defined tsunami evacuation zone.*"

The following section provides information and discussion to satisfy the requirements provided in the aforementioned OAR, as well as the consultation with DOGAMI.

4.1 Seismic Ground Motion Parameters

During future design and analysis for the project, seismic ground motion parameters will be derived using the code-based approaches contained in Oregon Structural Specialty Code (OSSC) 2014, International Building Code (IBC) 2015, and American Society of Civil Engineers (ASCE) 7-16. Typical seismic ground motion parameters used in design are spectral response acceleration for short and long periods and the Peak Ground Acceleration (PGA). The short- and long-period spectral response accelerations are typically used to design structures, while the PGA is used to assess geo-seismic hazards such as seismic slope stability and liquefaction.

Furthermore, ASCE 7-16 defines the Maximum Considered Earthquake Geometric Mean (MCE_G) Peak Ground Acceleration as, "*The most severe earthquake effects considered by this standard determined for geometric mean peak ground acceleration and without adjustment for targeted risk. The MCE_G is used in this standard for evaluation of liquefaction, lateral spreading, seismic settlements, and other soil-related issues.*" In general, for evaluation of geo-seismic hazards, and corresponding mitigations for these geo-seismic hazards, as necessary, we will utilize the PGA_M: the site-adjusted PGA derived from the MCE_G.

For the purposes of this preliminary evaluation, probabilistic PGA, short-, and long-period (0.2- and 1.0-second) spectral accelerations for the 2,500-year return period have been generated based on both the USGS 2002 and 2014 National Seismic Hazard Maps. Additionally, the probabilistic PGAs for the 500-year and the 5,000-year return periods have also been generated. The probabilistic evaluation method utilized by USGS to generate these hazard maps considers multiple specific sources and regional seismicity to predict the probability of an earthquake of a given ground motion occurring anywhere along the alignment within a given return period.

It should be noted that the governing code for evaluation of geo-seismic hazards for this project is ASCE 7-16. This code utilizes the USGS 2014 National Seismic Hazard Maps to derive the values for the PGA_M.

4.1.1 Ground Motions from 2002 USGS PSHA

The 2009 IBC, as amended by the 2010 OSSC, utilizes the uniform hazard ground motion values from the 2002 USGS Probabilistic Seismic Hazard Analysis (PSHA). The PGA that corresponds to a 500-year mean return period is shown in Figure D1 in Appendix D, which provides mapped contours of the 500-year PGA along the entire alignment. The PGA values are mapped assuming a shear wave velocity of 760 meters per second, which corresponds to the boundary between Site Class B and Site Class C (Site Class B/C).

The 2009 IBC defines the maximum considered earthquake (MCE) as having a 2 percent probability of being exceeded in 50 years. This is most accurately referred to as a 2,475-year return period earthquake; however, we refer to it as a 2,500-year return period herein for ease of use. Peak ground accelerations and short- and long-period (0.2- and 1.0-second) spectral accelerations for the 2002 USGS PSHA are provided in Figures D2 through D4. The acceleration values are mapped assuming a shear wave velocity of 760 meters per second (Site Class B/C).

The 5,000-year return period PGA has been calculated along the alignment using 2002 PSHA data. The 2002 PSHA data available through USGS was organized to produce contours of PGA. These contours are presented in Appendix D, Figure D5.

4.1.2 Ground Motions from 2014 USGS PSHA

The USGS publishes updated PSHA data every six years to incorporate the latest understanding of the seismic framework and seismic uncertainties. A significant change from the 2002 PSHA to the 2008 and 2014 PSHAs is the inclusion of uncertainty in seismic structural capacity (Luco, 2007). This resulted in a maximum considered earthquake (MCE_R) rather than a uniform hazard maximum considered earthquake (MCE) provided in the 2002 USGS PSHA (IBC, 2009).

The 2015 IBC utilizes the ground motion values from the 2008 USGS PSHA. However, ASCE 7-16 uses the more up-to-date data incorporated into the 2014 PSHA. We propose to use the ground motion values from the 2014 USGS PSHA for this project, in accordance with the guidance in ASCE 7-16.

The PGA that corresponds to a 500-year mean return period is shown in Figure D6 in Appendix D, which provides mapped contours of the 500-year PGA along the entire alignment. The PGA values are mapped assuming a shear wave velocity of 760 meters per second (Site Class B/C).

The 2015 IBC defines the maximum considered earthquake (MCE_R) as having a 2 percent probability of being exceeded in 50 years (i.e., approximately 2,500-year return period). Peak ground accelerations and short- and long-period (0.2- and 1.0-second) spectral accelerations from the 2014 USGS PSHA are provided in Figures D7 through D9. The acceleration values are mapped assuming a shear wave velocity of 760 meters per second (Site Class B/C).

Furthermore, the 5,000-year return period PGA has been calculated along the alignment using 2014 PSHA data. The 2014 PSHA data available through USGS was organized to produce contours of PGA. These contours are presented in Appendix D, Figure D10..

4.1.3 Comparison of 2002 and 2014 USGS Ground Motions

The 500-year return period PGA values for the 2002 and 2014 USGS PSHAs are shown on Figures D1 and D6. The PGA values from the 2002 PSHA range from 0.088g at the beginning of the alignment near Boardman, Oregon, to 0.053g at the end of the alignment near Hemingway, Idaho, with an average PGA of 0.066. The PGA values from the 2014 PSHA range from 0.074g at the beginning of the alignment, to 0.045g at the end of the alignment. The changes in PGA values from the 2002 to the 2014 PSHA ranged from -0.014g (-19 percent) to -0.005g (-9 percent), with an average change of -0.010g (-15 percent).

The 2,500-year return period PGA values are shown on Figure D2 and D7. The PGA values from the 2002 PSHA range from 0.200g at the beginning of the alignment to 0.111g at the end of the alignment, with an average PGA of 0.147. The PGA values from the 2014 PSHA range from 0.185g at the beginning of the alignment to 0.117g at the end of the alignment, with a local maximum of 0.159g near the Cottonwood Mountain Fault, and an average PGA of 0.148g. The changes in PGA values from the 2002 to the 2014 PSHA ranged from - 0.015g (-7 percent) to +0.019g (+14 percent), with an average change of +0.001g (+1 percent).

The 2,500-year short period (0.2-second) spectral response acceleration (s_s) values are shown on Figures D3 and D8. The s_s values from the 2002 PSHA range from 0.467g at the beginning of the alignment to 0.111g at the end of the alignment, with local maxima of 0.366g and 0.372g at mile posts 80 and 150, respectively. The average s_s from the 2002 PSHA is 0.147g. The s_s values from the 2014 PSHA range from 0.416g at the beginning of the alignment to 0.262g at the end of the alignment, with local maxima of 0.345g and 0.359g at mile posts 80 and 224 (near the Cottonwood Mountain Fault), respectively. The changes in s_s values from the 2002 to the 2014 PSHA range from -0.051g (-11 percent) to +0.023g (+7 percent), with an average change of -0.013g (-3 percent).

The 2,500-year long period (1.0-second) spectral response acceleration (s_1) values are shown on Figures D4 and D9. The s_1 values from the 2002 PSHA range from 0.144g at the beginning of the alignment to 0.091g at the end of the alignment, with an average s_1 of 0.112g. The s_1 values from the 2014 PSHA range from 0.137g at the beginning of the alignment to 0.082g at the end of the alignment, with an average s_1 of 0.105g. The changes in s_1 values from the 2002 to the 2014 PSHA range from -0.012g (-11 percent) to 0.000g (0 percent), with an average change of -0.007g (-7 percent).

The 5000-year return period PGA values are provided in Figures D5 and D10. The PGA values from the 2002 PSHA range from 0.276g at the beginning of the alignment to 0.154g at the end of the alignment with a local maximum of 0.216g near the Cottonwood Mountain Fault. The average PGA from the 2002 PSHA is 0.206g. The PGA values from the 2014 PSHA range from 0.261g the beginning of the alignment to 0.169g at the end of the alignment, with a local maximum of 0.272g near the Cottonwood Mountain Fault and an average PGA of 0.216g. The change in PGA values from the 2002 to the 2014 PSHA ranged from - 0.015g (-5 percent) to +0.056g (+26 percent) with an average change of +0.010g (+5 percent).

4.2 Seismic Sources

Evaluation of source-specific probabilistic ground motions along the proposed 300-mile alignment has been provided herein using USGS 2002 and 2014 PGA and spectral accelerations. Site class determinations and specific hazard evaluations for each tower will be determined in future design studies. The magnitude and minimum epicentral distance of the MCE is not evaluated as part of this preliminary study. Specific faults in close proximity to the alignment will be further evaluated during final design.

Potential seismic hazards along the proposed alignments can result from any of three seismic sources: interplate, intraslab, and crustal events. Interplate sources are those which occur between two plate boundaries. The major interplate source for the alignment is the Cascadia Subduction Zone (CSZ), along which the Juan de Fuca, Gorda, and Explorer Plates are subducting beneath the overriding North American Plate. The CSZ extends about 750 miles from northern California to southern British Columbia. Collision of the tectonic plates generates uplift along the coast and volcanism in the Cascade Range. Although extremely large earthquakes are anticipated along the CSZ, the substantial distance from the proposed alignment (about 280 miles or more) would attenuate ground shaking, causing this source not to represent the most significant earthquake hazard.

Intraslab earthquakes originate from within the subducting oceanic plates as a result of down-dip tensional forces and bending caused by mineralogical and density changes in the plates at depth. These earthquakes typically occur 28 to 37 miles beneath the surface. An example of an intraslab earthquake that occurred in the Pacific Northwest is the 2001 moment magnitude 6.8 Nisqually earthquake. Although relatively common in Washington State, significant intraslab earthquakes are historically rare in Oregon.

Shallow crustal earthquakes within the North American Plate have historically occurred in a diffuse pattern in Oregon, typically within the upper 4 to 19 miles of the continental crust. Because of their proximity, crustal faults represent the most significant seismic hazard to the proposed alignment. In accordance with guidance stemming from our consultation with DOGAMI, known significant faults near the proposed alignments associated with crustal earthquakes are outlined in the following sections.

4.3 Quaternary Faults

Quaternary faults are faults that are thought to have been active within the last 2.6 million years. Quaternary faults mapped in the USGS Quaternary Fault and Fold Database (USGS, 2006) that are within a 50-mile-radius of the IPC Proposed Route are shown in Appendix D, Figure D11. These USGS-mapped Quaternary faults are also shown on the geologic maps in Appendix A as blue dashed lines. Older or inactive faults are shown on the geologic maps in Appendix A as black lines that are solid (for confident), dashed (for approximate), or dotted (for concealed). Descriptions of USGS-mapped Quaternary faults within an approximate 5-mile radius of the proposed alignments are provided in the following sections. In the following sections, the discussed faults have a numerical identifier, such as 845, which corresponds with the fault ID provided by the USGS fault database (USGS, 2006). These Quaternary faults within an approximate 5-mile radius of the proposed alignments are also summarized in Appendix D, Table D1.

Quaternary faults in Oregon and Idaho have been subdivided by approximate age and include the following categories:

- Undifferentiated Quaternary – less than 1,600,000 years old
- Mid- to Late-Quaternary – less than 750,000 years old
- Late Quaternary – less than 130,000 years old
- Latest Quaternary – less than 15,000 years old
- Historic – less than 150 years old

4.3.1 Hite Fault System (845)

The Hite Fault System is a northeast trending system that runs parallel, and to the west, of the Blue Mountains. Total length of the Hite Fault System is about 87 miles, with an average dip direction of N70°W. The Hite Fault System is divided into four sections. However, only two of the sections are significant to the proposed transmission alignment (within 5 miles of proposed centerline): the Thorn Hollow section (845c) and the Agency section (845d).

4.3.1.1 The Thorne Hollow Section (845c)

The Thorne Hollow section consists of 27 miles of complex faulting that is expressed as co-linear streams, saddles, and notches in ridges within the Columbia River Basalt Group (CRB), as well as shallow linear depressions south of the Umatilla River. Movement is suggested to have occurred in the Quaternary period within the southern portion of the section, and middle to late Quaternary movement within the northern portion of the section. The sense of movement along faults located within the Thorn Hollow section has been described as normal, left-lateral, and right-lateral strike-slip. The faults have an average strike direction of N10°E and a dip of 80° to 90° NW. Total displacements in the Miocene-aged (~17 to 6 million-year old) CRB may be on the order of 260 to 1,500 feet (Personius and Lidke, 2003a).

4.3.1.2 The Agency Section (845d)

The Agency section consists of 17 miles of faults creating offsets within the CRB. Movement is suggested to have occurred in the Quaternary period in CRB rocks. The sense of movement along faults located within the Agency section has been described as normal, left-lateral, and right-lateral strike-slip. The faults have an average strike direction of N6°E and a dip direction to the NW (Personius and Lidke, 2003b).

4.3.2 West Grande Ronde Valley Fault Zone (802)

The West Grande Ronde Valley Fault Zone is a north and northwest trending system forming the western margin which confines the Grande Ronde Valley. Total length of the fault zone is approximately 30 miles. The fault zone is divided into three sections: the Mt. Emily section (802a), the La Grande section (802b), and the Craig Mountain section (802c). Each of the sections are part of a large graben system and have formed steep echelon range fronts containing tonal contrasts, linear depressions, springs, and scarps. Fault systems within this zone offset Miocene rocks of the CRB and Powder River Volcanic field, as well as Quaternary surficial deposits.

4.3.2.1 The Mt. Emily Section (802a)

The Mt. Emily section consists of 18 miles of fault, forming a steep range front from Thimbleberry Mountain to the mouth of the Grande Ronde River Canyon. Recent detailed mapping suggests the latest Quaternary displacement occurred on the southern half of the section. The sense of movement along the faults of this section has been described as normal and right-lateral. Faults located within the Mt. Emily section have an average strike direction of N2°W and an estimated dip of 60°E to 70°E. Vertical offsets of the Miocene CRB are estimated to be around 3,280 feet (Personius, 2002c).

4.3.2.2 The La Grande Section (802b)

The La Grande section consists of 9 miles of fault, forming steep range front from the mouth of the Grande Ronde River Canyon to the mouth of Ladd Canyon. The La Grande Section consists of two primary fault strands: one adjacent to La Grande and one parallel to Foothill Road. The La Grande strand is identified by small fault scarps on late Quaternary alluvial deposits in the mouths of canyons, and larger scarps in older landslide debris near the southern end of the strand, forming a steep linear range front. The Foothill strand is identified by linear topographic benches, springs, and vegetation along the range. Offsets of alluvial deposits and landslide deposits near the southern end of the La Grande strand are estimated to be late Quaternary. Latest Quaternary displacement has been inferred by the presence of scarps on the La Grande section. The sense of movement along the faults of this section has been described as normal and right-lateral. Faults located within the La Grande section have an average strike of N30°W and an estimated dip of 60°NE to 70°NE. Displacement along the Miocene CRB and Powder River volcanic field is estimated to be around 1,400 to 2,300 feet (Personius, 2002d).

4.3.2.3 The Craig Mountain Section (802c)

The Craig Mountain section consists of about 6 miles of fault, forming steep range front along the east flank of Craig Mountain. Craig Mountain is identified by linear fronts and numerous springs, with hot springs located at the northern end of the section. Latest Quaternary displacement has not been identified at this time; however, multiple landslide complexes located along the mountain front may be covering evidence of recent faulting. The sense of movement along the faults of this section has been described as normal and right-lateral. Faults in the Craig Mountain section have an average strike of N49°W and an estimated dip of 60°NE to 70°NE. Vertical offsets of the Miocene CRB are estimated to be around 2,400 feet southeast of Hot Lake hot springs (Personius, 2002e).

4.3.3 South Grande Ronde Valley Faults (709)

The South Grande Ronde Valley Faults bound several northwest trending fault blocks in Miocene volcanic rocks. The total length of the fault zone is 14 miles. Faults located within the fault zone have been described as high-angle normal faults, with an average strike of N39°W. Faults within this system offset Miocene volcanic rocks, with escarpments up to 650 feet high. The most recent movement is suggested to be middle and late Quaternary. Total displacements of 295 to 1,510 feet have been described in the High Valley, Catherine Creek, and Pyle Canyon faults (Personius, 2002a).

4.3.4 Unnamed East Baker Valley Faults (712)

The Unnamed East Baker Valley Faults are a northwest trending system that forms the eastern margin of Baker Valley. The total length of the fault zone is 17 miles. The sense of movement along the faults has been described as normal. The faults have an average strike of N40°W and dip to the SW. The faults juxtapose Miocene volcanic rocks, and Mesozoic and Paleozoic igneous and metamorphic rocks, against Quaternary alluvial deposits, forming escarpments less than 325 feet high. Late Quaternary displacement has been suggested on a small section of one of the faults, while Quaternary displacement has been described along the length of the faults. The most recent movement is suggested to be middle and late Quaternary (Personius, 2002b).

4.3.5 West Baker Valley Faults (804)

The West Baker Valley Fault is a northwest trending, down-to-the-northeast system forming a large, steep range along the western margin of Baker Valley. The faults are identified by linear range fronts, faceted spurs, benches, springs, tonal and vegetation lineaments, scarps observed in late Quaternary alluvial-fan deposits, and the exposed Mesozoic and Paleozoic igneous and metamorphic rocks of the uplifted Elkhorn Ridge. Total length of the fault zone is about 21 miles. The sense of movement along the faults has been described as normal. The faults have an average strike of N54°W and a dip of 40°NE to 70°NE. Lack of offset in middle to late Holocene deposits, along with large scarps in older Quaternary deposits, indicate late Quaternary surface-faulting and recurrent displacement (Personius, 2002f).

4.3.6 Cottonwood Mountain Fault (806)

The Cottonwood Mountain Fault is a northwest trending system located along the eastern margin of Cottonwood Mountain. The fault is approximately 26 miles long and identified by prominent fault scarps in the alluvial fans east of Cottonwood Mountain. The fault offsets Miocene and Pliocene ash-flow tuffs and tuffaceous lacustrine deposits. Small scarps on Holocene deposits and larger scarps in mid to late Pleistocene deposits indicate recurrent late Quaternary activity, at a recurrence rate of about 3,750 to 25,000 years. The sense of movement along the fault has been described as normal and left-lateral. The fault has an average strike of N33°W and an estimated dip of 40°NE to 70°NE (Personius, 2002g).

4.3.7 Faults Near Owyhee Dam (808)

The faults near Owyhee Dam are in a structurally complex region between the Blue Mountains, the Owyhee Plateau, and the Snake River Plain provinces. The faults are generally north to northwest trending and are identified by vegetation lineaments, scarps, and springs in Miocene sedimentary and volcanic rocks. Fault activity has been mapped as active in the Quaternary, with some debate over evidence of mid to late Quaternary activity. The total length of these faults is 23 miles. The sense of movement along the faults has been described as normal. The faults have an average strike of N13°W and an estimated dip of 60° to 70°E/W (Personius, 2002h).

4.3.8 Owyhee Mountain Faults (636)

The Owyhee Mountain Faults are northwest-trending faults that demarcate the border between the Owyhee Plateau and the Snake River Plain. The faults offset volcanic rocks of Miocene to Pliocene age, with the possibility of Quaternary activity. The majority of surficial faults are of undifferentiated Quaternary age, with the faults of the Halfway Gulch and Water Tank faults showing evidence of latest Quaternary activity. The total length of these faults is

128 miles. The sense of movement along the faults has been described as normal. The faults have an average strike of N50°W and an estimated dip of 65°NE to 70°NE.

4.4 La Grande Area Faults

As part of our study, we reviewed DOGAMI's open file report: Engineering Geology of the La Grande Area, Union County, Oregon, by Schlicker and Deacon (1971). The study identified several northwest-trending faults in the area west and south of La Grande. Faults shown on the Geologic Map sheets in Appendix A are based on more recent studies compiled in Ferns and others (2010). The fault locations shown in Ferns and others (2010) are similar to, although not exactly the same as, those mapped by Schlicker and Deacon (1971). The differences between the fault maps are due to improvements in the understanding of local stratigraphy over time. The only faults within the area mapped by Schlicker and Deacon (1971) that are recognized by the USGS as having been active within the Quaternary period are those of the West Grande Ronde Fault Zone, which is discussed in Section 4.2.3. Current mapping of the West Grande Ronde Fault Zone, consistent with Ferns and others (2010), is shown and labeled on the Geologic Map sheets in Appendix A.

4.5 Historical Earthquakes

The Advanced National Seismic System (ANSS) Comprehensive Catalog (ComCat) contains earthquake source parameters (e.g., hypocenters, magnitudes, phase picks, and amplitudes) and other products (e.g., moment tensor solutions, macroseismic information, tectonic summaries, maps) produced by contributing seismic networks. This comprehensive collection of seismic information will eventually replace the ANSS Composite Catalog currently being hosted by the Northern California Data Center. However, historic regional seismic network catalogs have not yet been fully loaded. Important digital catalogs of earthquake source parameters are currently being loaded into ComCat. New and updated data is added to the catalog dynamically as sources publish or update products; hence there is a need for searching multiple data sources. Currently, the most comprehensive source for northwest earthquake data is the USGS ANSS Database (USGS, 2016a). The best sources for historical northwest earthquake intensity data are the National Geophysical Data Center (NGDC, 1985) and Johnson and others (1994), although neither of these sources are current at the date of this report.

Shannon & Wilson reviewed historical earthquake data for recorded earthquakes from the USGS Earthquake Search Data Base (USGS, 2016), the National Geophysical Data Center (NGDC, 1985), and the Pacific Northwest Seismic Network (PNSN, 2008). Recorded earthquakes with magnitudes of 2 or greater, within a 50-mile radius of the proposed alignments, are shown in Appendix D, Figure D12.

Shannon & Wilson also collected Pacific Northwest earthquake intensity data from three sources: National Geophysical Data Center (NGDC, 1985), Johnson and others (1994), and the Advanced National Seismic System Comprehensive Catalog (ANSS, 2016). The resulting data was processed by geographic information system software (ArcGIS) to remove data points greater than 50 miles from the IPC Proposed Route centerline. The data was then edited to remove redundant entries.

The categories of data present in the original sources varied between the three data catalogs, and some categories (e.g., number of stations reporting, distance to nearest station) were removed to provide a consistent data set. Intensity is recorded at the location (usually the nearest city or town) where the earthquake was felt, which could be up to 50 miles from the IPC Proposed Route centerline. The ANSS data set did not include intensity values. Earthquake events for which no intensity was recorded are presented in a separate table, which includes an estimated intensity based on the event magnitude. Times of the earthquake events are expressed in Coordinated Universal Time, which is converted to Pacific Standard Time by subtracting eight hours.

The resulting intensity data includes a total of 123 earthquake events, which occurred between March 1893 and April 2015. The intensity data is included in Appendix D, Seismic Tables and Maps. Table D2, Earthquakes Reported to Cause Greater than Modified Mercalli Intensity (MMI) III, lists 40 earthquake events with intensities ranging from IV to VII; Table D3 lists 83 earthquake events estimated to have been capable of generating an intensity of at least MMI III. Abbreviated descriptions of the MMI values (USGS, 2016b) are as follows:

- III. Felt quite noticeably by persons indoors, especially on upper floors of buildings; many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibrations similar to the passing of a truck.; duration estimated.
- IV. Felt indoors by many; outdoors by few during the day; at night, some awakened; dishes, windows, doors disturbed; walls make cracking sound; sensation like heavy truck striking building; standing motor cars rocked noticeably.
- V. Felt by nearly everyone; many awakened; some dishes, windows broken; unstable objects overturned; pendulum clocks may stop.
- VI. Felt by all; many frightened; some heavy furniture moved; a few instances of fallen plaster; damage slight.

- VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

4.6 Effects of Site Class on Ground Motion Parameters

The ground motion parameters, shown on Figures D1 through D10, correspond to a Site Class B/C (soft rock) profile. To develop ground motion parameters that correspond to other Site Class types, Site Coefficients that consider site material type and level of ground shaking are required. The Site Class criteria are defined in Chapter 20 of ASCE 7-16. Site Coefficients for use on spectral response accelerations can be obtained from Section 1613 of IBC 2015. Site Coefficients for use on PGA can be obtained in Chapter 11 of ASCE 7-16. It should be noted that subsurface explorations along the alignment have not yet been performed. Code-based site specific ground motion parameters for use in evaluating geo-seismic hazards will be developed during design, upon completion of the subsurface exploration program.

4.7 Geo-Seismic Hazards

Ground failure, including landslide, lateral spreading, liquefaction, and surface rupture or settlement, will be evaluated on a case-by-case basis during design. In general, the seismic ground motion parameter (PGA_M) will be determined following a code-based approach consistent with ASCE 7-16. This will use the 2014 USGS hazard maps in conjunction with a site class. This site class will be determined by the subsurface conditions identified through the planned geotechnical exploration program.

Below, we discuss the various geo-seismic hazards and how the project will address each during future design phases. In most cases, geotechnical site exploration is required to better assess the potential for geo-seismic hazards prior to performing more in-depth analyses.

4.7.1 Ground Shaking

The magnitude of expected ground shaking for various probabilities of exceedance are discussed above, using a code-based approach based on the 2014 USGS hazard maps, assuming that the site class is borderline B/C. Once the subsurface exploration program is performed for final design, the site class should be evaluated at each tower and facility in order to select the appropriate site class. A code-based seismic acceleration response spectrum can then be developed in locations where this input will be used for structural evaluation.

4.7.2 Earthquake-Induced Landslides

Earthquake-induced landslides will be evaluated during final design on a case by case basis. Primarily, existing landslides will be reviewed as stated in Section 5.1.1, below, and will be reviewed for both static and seismic stability. Additionally, during detailed site reconnaissance, performed as part of the final design, existing or potential slope instabilities will be noted and studied. Slopes can be analyzed for seismic hazard by adding a pseudostatic force (acting in the horizontal direction) to standard slope stability analyses. This force represents the inertial force that would act on a soil wedge during an earthquake. Following the standard-of-practice, the pseudostatic force will be equal to one-half of the PGA_M (site adjusted PGA from ASCE 7-16) determined at a given site. Use of one-half of the PGA_M means that there will be some risk of displacement of the analyzed slope even with an appropriate factor of safety. If an existing or potential landslide is deemed to have an inadequate factor of safety, the project will either avoid or mitigate the hazard.

4.7.3 Liquefaction and Lateral Spreading

Liquefaction is the sudden loss of shear strength in soil caused from a rapid generation of excess groundwater pore pressure due to repeated shearing of the soil during shaking. Liquefaction is most common in loose clean sands below the water table, but may also occur in saturated silts and gravels. Soils must be saturated, meaning they must be below the water table for liquefaction to occur.

For many of the towers along the IPC Preferred Routes and alternative routes, the towers will be placed on ridges or slopes that border valleys. For these locations, it is assumed that there is little to no soil below the water table; therefore, the liquefaction hazard will be negligible.

The towers and structures located in areas covered in recent (Holocene) alluvial deposits, for instance those which cross valley floors, should preliminarily be considered to have a low risk of liquefaction. During the detailed site exploration program, borings will be sampled using the SPT method, as stated in Section 3.1.3.1, above. The N-values are required to perform liquefaction analysis of susceptible soils below the water table. Common analysis methods are proposed in Seed et al., 2003, Youd et al., 2001, and Idriss and Boulanger, 2006. We propose to utilize the reference *State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences* (National Academies of Sciences, Engineer, and Medicine, 2016). It should be noted that this reference is still in a draft state; but we anticipate that it will be finalized prior to moving forward with the site-specific analyses, and that it will be considered the state-of-the-practice for geotechnical assessment of liquefaction.

Lateral spreading may occur if liquefaction is triggered and if there is a free face or sloping ground. This causes significant ground displacement and severe cracking. For locations where liquefaction poses a risk, an assessment will be made to determine if lateral spreading would be an additional hazard.

Ground subsidence also may occur due to the densification of soils subjected to repeated cyclic shearing. In some cases, liquefaction is triggered which can exacerbate subsidence. Where there is a potential for ground subsidence that affects a structure, it will be evaluated and quantified. In some cases, mitigation may be required if it is not practical to move a structure or design it for this hazard.

4.7.4 Surface Rupture

The faults that are considered in this geologic and seismic hazard review are listed in Section 4.3 above. For faults that are directly crossed by the alignment, a detailed review of the fault location and characteristics may be necessary to accurately quantify this hazard during the detailed site reconnaissance for final design. If the associated risk from fault rupture is found to be too high for the project, the locations for some towers may need to be modified.

4.7.5 Tsunami Inundation / Seiche

The alignment is not in a mapped tsunami zone nor does it border any large lake or reservoir capable of producing a seiche. These hazards are considered negligible.

4.8 Regional Seismic Studies

As part of our study, we reviewed two regional seismic studies: the Hanford Sitewide Probabilistic Hazard Analysis (PNNL, 2014), and the Probabilistic Seismic Hazard Analysis for the Mid-Columbia Dams (URS and others, 2012). The Hanford Sitewide Probabilistic Hazard Analysis was prepared for the U.S. Department of Energy by the Pacific Northwest National Laboratory (PNNL). It updated a previous seismic hazard analysis for the Hanford Site and included collection of new field data, which PNNL used for seismic source characterization.

The Probabilistic Seismic Hazard Analysis for the Mid-Columbia Dams was prepared for the Public Utility Districts of Chelan, Douglas, and Grant Counties, Washington, by numerous consultants. The scope of the latter study did not include acquisition of new field data.

Both studies will be considered in the seismic hazard analysis for final design of the Boardman to Hemingway 500kV Transmission Line Project.

5.0 NON-SEISMIC HAZARDS

Regarding non-seismic geologic hazards, OAR 345-021-0010(h)(F) requires, "*An assessment of geology and soil-related hazards which could, in the absence of a seismic event, adversely affect or be aggravated by the construction or operation of the facility, in accordance with standard-of-practice methods and best practices, that address all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries described in paragraph (B) of this subsection. An explanation of how the applicant will design, engineer, construct and operate the facility to adequately avoid dangers to human safety and the environment presented by these hazards….*"

Five categories of potential geologic hazards were identified by this desktop study:

- Slope Instability
- Erosion
- Expansive Soil
- Groundwater
- Corrosion Potential

Descriptions of the potential hazards and the proposed hazard evaluation methods are discussed below. Future geologic reconnaissance and geotechnical investigations are planned to address these hazards on a site-specific basis.

5.1 Slope Instability

Slope instability is a generalized category of geologic hazards that includes landslides, debris flows, talus slopes, alluvial fans, and soil creep. The following sections discuss each of these subcategories.

5.1.1 Landslides

Landslides are mass movements with a distinct zone of weakness separating the slide material from the more stable underlying material. They occur either by translational movement of the landslide mass along a roughly planar surface or rotational movement in which the zone of weakness is curved concavely upward. Landslides are often identified by the presence of scarps at the top or head of the feature, topographic bulges at the bottom or toe, hummocky topography, and chaotic bedding attitudes. In some cases, changes in the type and orientation of trees and vegetation can also be indicative of landslide activity.

A literature review and limited field reconnaissance identified areas where landslide hazard assessments are needed for final design. An inventory of known landslides is summarized in Appendix E. Appendix E presents site maps of each landslide that was identified along the proposed alignments and considered potentially capable of affecting the stability of proposed tower locations or multi-use areas. Data sources for the inventory included the Statewide Landslide Information Database for Oregon (SLIDO), version 2 (Burns and others, 2011) and version 3.4 (Burns and Watzig, 2017), published geologic mapping, review of LiDAR data, review of aerial photographs, and limited site reconnaissance.

Where mapped landslides intersect or lay adjacent to proposed transmission line routes, the field exploration program will include field reconnaissance by a geotechnical engineer and/or engineering geologist. Where landslides are observed, the geotechnical team will evaluate the mechanics of why the landslide occurred and how stable these areas are expected to be in the future. For example, some landslide areas may have filled in a ravine in such a way as to render further movement unlikely. Some other landslide areas may be the result of recent sliding along a weak layer of soil or rock. Undercutting by erosion may cause additional mass sliding in the future and, therefore, may indicate against siting towers in these areas. Seismic triggering of slope failures may pose additional hazards, particularly for granular deposits, in areas of historic slope failures.

5.1.2 Debris Flow and Talus

A debris flow is a form of mass movement that can contain a combination of water, loose soil, rock fragments, and organic debris. Debris flows are typically caused by intense surface-water flow eroding the ground surface and mobilizing loose soil or rock on steep slopes. Debris flow source areas are often identified by the presence of debris fans at the mouths of gullies below them. Talus consists of broken, angular rock fragments accumulated at the base of crags, mountain cliffs, or valley shoulders. SLIDO data was used in GIS to overlay areas where debris flows and talus occur along the alignment. These areas are shown using specific hatch patterns on maps in the Landslide Inventory, Appendix E. Within the SLIDO database, debris flows are grouped with landslides, and talus is grouped with colluvium (mixed slope deposits).

Where mapped debris flows and talus slopes coincide with proposed transmission line routes, the field exploration program will include field reconnaissance by a geotechnical engineer and/or engineering geologist. Where debris flows or talus slopes are observed, the geotechnical team will evaluate the mechanics of how the deposits were emplaced, and how stable these areas are expected to be in the future. In areas prone to debris flows, intense surface-water flow caused by heavy precipitation or snow melt may lead to additional debris flows, and may indicate against siting transmission towers in these areas.

5.1.3 Alluvial Fans

Alluvial fans are fan-shaped accumulations of sediment at the downstream ends of natural drainages, such as canyons between mountain ridges. Alluvial fans may be considered geologic hazards if they are unconsolidated and/or steeply sloping. Slope failures are common in alluvial fan deposits, where transverse valley streams erode at the toe of the fan. Alluvial fans are also susceptible to ongoing erosion and periods of surface water flow. SLIDO data was used in GIS to identify areas where alluvial fans occur along the alignment. These areas are shown using specific hatch patterns on maps in the Landslide Inventory, Appendix E.

5.1.4 Soil Creep

Soil creep is a slow, downslope movement of soil under the influence of gravity. It is typically a shallow phenomenon involving the upper few feet of a colluvial or alluvial deposit, and is exacerbated by seasonal fluctuations in water levels and temperature. Soil creep can be identified by curved tree trunks, bent or leaning fences, tilted poles, small soil ripples or ridges, and the presence of colluvium.

5.2 La Grande Area Slope Instability

As part of our study, we reviewed DOGAMI's open file report: Engineering Geology of the La Grande Area, Union County, Oregon, by Schlicker and Deacon (1971). The study identified several landslides in the areas west and south of La Grande. The majority of the landslide features mapped by Schlicker and Deacon (1971) were similarly mapped as landslides or alluvial fans in Ferns and others (2010). The current SLIDO database uses the feature locations mapped in Ferns and others (2010). While the two map sets generally agree, there are differences in the mapped limits of some landslide and alluvial fan areas, and there is one landslide area in Schlicker and Deacon (1971), near towers 106/3 and 106/4, which is not included in SLIDO or Ferns and others (2010). The Landslide Inventory in Appendix E includes mapped landslide and alluvial fan limits from both SLIDO and Schlicker and Deacon (1971).

5.3 Erosion Potential

Erosion is the 'wearing away' of soil or rock by agents such as wind, water, or ice. Erosion of surface soils is influenced by factors such as climate (wind and rainfall), soil type, slopes, and land use. The National Soil Information System (NASIS) GIS-based information system provided soil maps for the proposed alignments, except where noted above in Section 2. These maps were used to determine the near-surface soils which may be encountered in the top 60 to 80 inches of the existing ground surface, and if shallow rock can be expected within this depth. Major units of surficial soils have been grouped into map units, which are a combination of General Soil Units (GSU's) identified within the individual counties. These map units are based on information provided in the Soil Survey of each individual county. The relative erosion potential of soils encountered along the alignments is indicated in the soil description tables and mapping presented in Appendix B.

5.4 Expansive Soils

Expansive soils owe their characteristics to the presence of swelling clay minerals. When they are exposed to moisture, the clay minerals absorb water molecules and expand; conversely, they shrink as they dry, leaving voids in the soil. Swelling clays can control the behavior of virtually any type of soil if the percentage of clay is more than about 5 percent by weight. Soils with smectite clay minerals, such as montmorillonite, exhibit the most profound swelling properties. Over time, the shrinking and swelling cycles can cause loss of foundation support.

Potentially expansive soils can typically be recognized in the lab by their plastic properties. Inorganic clays of high plasticity (generally those with liquid limits exceeding 50 percent and plasticity indices over 30) usually have high inherent swelling capacities. The levels of expansion in the soils are very site-specific and will be identified during the geotechnical investigation.

5.5 Groundwater

Groundwater can have dramatic implications on design, construction, and long-term performance of structure foundations. Groundwater must be considered in areas of steep terrain, where slope stability may be a hazard, and in loose alluvial deposits, where liquefaction may occur. The study of groundwater is essential for determining the best construction means and methods. Excavations that extend below the water table in granular soils may require specific construction techniques such as, casing, cut-off walls, or local dewatering to appropriately deal with groundwater. The depth to groundwater, including perched groundwater, will be identified wherever possible during the geotechnical exploration program.

5.6 Corrosion Potential

Corrosive soils can damage subsurface utilities and structures. There are several variables that have an influence on the corrosion rates in soils. The following laboratory testing will be performed to evaluate known risk factors for corrosion and to develop recommendations regarding general soil corrosion potential:

- pH - Soils usually have a pH range of 5 to 8. In this range, pH is generally not considered to be the dominant variable affecting corrosion rates. More acidic soils present an elevated corrosion risk to common construction materials such as steel, cast iron, and zinc coatings. Soil acidity is produced by mineral leaching, decomposition of acidic plants (such as coniferous tree needles), industrial wastes, acid rain, and certain forms of microbiological activity. Alkaline soils tend to have high sodium, potassium, magnesium, and calcium contents. The latter two elements tend to form calcareous deposits that protect buried structures against corrosion. The pH level can affect the solubility of corrosion-resistant products and also the nature of microbiological activity.
- Resistivity - Soil resistivity is a measure of the ground’s capacity to pass an electrical current. Soil resistivity generally decreases with increasing water content and the concentration of ions. While resistivity testing has historically been used as a broad indicator of soil corrosivity, where lower resistivity is associated with higher rates of corrosion, it is also useful for designing grounding systems for transmission towers and substations. Grounding systems provide a safe connection between an electrical circuit and the ground and are used for dissipation of electrical faults, grounding of lightning strikes, and maintenance of electrical equipment.
- Chloride level - Chloride ions generally increase corrosion rates, as they participate directly in anodic dissolution reactions of metals and tend to decrease soil resistivity.
- Sulfate level - Compared to the corrosive effect of chloride ions, sulfates are generally considered to be more benign in their corrosive action towards metallic materials. Concrete, however, may be attacked as a result of high sulfate levels. Sulfates can react with cement to form calcium sulfoaluminate crystals, which can crack and disintegrate concrete as they grow. The presence of sulfates also poses some risk for metallic materials in the sense that sulfates can be readily converted to highly corrosive sulfides by anaerobic sulfate-reducing bacteria.

Preliminary indications of soil corrosivity to concrete and steel were analyzed along the proposed alignment using the NRCS Soil Survey Geographic (SSURGO) Database in GIS. Susceptibility of concrete to corrosion when in contact with the on-site surficial soils is expected to be low, with a few instances where moderate susceptibility is anticipated. Susceptibility of uncoated steel to corrosion when in contact with the onsite surficial soils is expected to be moderate to high.

Analytical laboratory testing of soils for corrosion potential will be conducted during the geotechnical investigation. Tests will be conducted on each soil type and throughout the proposed route corridor to evaluate potential corrosion impacts on concrete and steel.

6.0 MITIGATION OF SEISMIC HAZARDS

As stated above, the document OAR 345-021-0010(h)(E) states specifically regarding designing for seismic hazards, "*…an explanation of how the applicant will design, engineer, construct, and operate the facility to avoid dangers to human safety and the environment from these seismic hazards. Furthermore, an explanation of how the applicant will design, engineer, construct and operate the facility to integrate disaster resilience design to ensure recovery of operations after major disasters. The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring and emergency measures for seismic hazards, including tsunami safety measures if the site is located in the DOGAMI-defined tsunami evacuation zones.*"

The project facilities are generally unmanned and located in sparsely populated areas. Therefore, the risks to human safety due to seismic hazards are minimal due to the low probability of human presence. All project facilities will be constructed in accordance with the 2014 OSSC, 2015 IBC, and ASCE 7-16.

Future work will be necessary to perform the geo-seismic hazard assessment at all sites where applicable and to identify all the areas that will require mitigation due to seismic hazards. As discussed in previous sections, this will include the geotechnical field exploration program, laboratory testing, and detailed site reconnaissance. A qualified engineer will assess the seismic, geologic, and soil hazards associated with the construction of each tower and each facility. Where risk of a geo-seismic hazard cannot be avoided, it will be mitigated. Specific mitigation techniques for geo-seismic risks, such as earthquake-induced landslide and liquefaction hazards, are presented below. As discussed in Section 4.7.4, the principal mitigation strategy for surface rupture hazards is modification of structure locations. Additional mitigation strategies will be developed and refined following completion of future geotechnical investigations.

6.1 Earthquake-Induced Landslide Mitigation

Where an unacceptable risk of earthquake-induced landslide cannot be avoided by realignment, engineered modifications to reduce risk will be necessary. Mitigation of earthquake-induced landslide would be the same techniques used to mitigate static landslide risks. These mitigation methods are discussed in Section 7.1, below.

6.2 Liquefaction Mitigation

For structures or towers which are located in areas that have a risk of liquefaction, there are a number of methods available to either adequately reduce the risk of liquefaction or to improve the performance of the structure (or improve resiliency), if liquefaction were to occur. Specific methods to reduce the liquefaction potential are ground densification to increase the soil's natural resistance to liquefaction; installation of drains to prevent excess ground water pore pressure build-up during a seismic event; and installation of soil-cement shear cells which reduce the seismic shearing demands on the soil.

Alternative to the methods which improve the soil's resistance to liquefaction described above, the foundations for structures may be designed to account for a layer of soil which may liquefy. Deep foundations can be designed to bypass the liquefiable layer, founding towers or critical structures on deeper layers.

7.0 MITIGATION OF NON-SEISMIC HAZARDS

The guidance documents require mitigation for non-seismic hazards be considered. OAR 345-021-0010(h)(F) specifically states, "…*An explanation of how the applicant will design, engineer, construct and operate the facility to adequately avoid dangers to human safety and the environment presented by these hazards…*"

Additional work during final design will be necessary to complete the non-seismic hazard assessment and identify areas that may require mitigation due to non-seismic hazards. As discussed in previous sections, this additional work will include geotechnical field explorations, laboratory testing, and detailed site reconnaissance. Generalized mitigation strategies for the identified non-seismic hazards are described below. Additional mitigation strategies will be developed, as needed, following completion of future geotechnical investigation program.

7.1 Mitigation of Slope Instability

Slope instability hazards will be thoroughly evaluated to assess the potential for failure. At locations where landslides, debris flows, or marginally stable slopes are identified, the hazard will be mapped and adequately characterized during the field exploration.

In general, structures should be located to avoid potential slope instability hazards wherever possible; and newly constructed slopes should be designed with an adequate safety factor against failure, for both static and seismic conditions. Appropriate mitigation methods should be selected based on site characteristics and the structure to be constructed. If feasible, structures should be located with sufficient setback from slopes to mitigate the potential for slope instability during construction and operation. Where structures cannot be moved or realigned, slope instability mitigation techniques may include modification of slope geometry, hydrogeological mitigation, and slope reinforcement methods.

Slope geometry may be altered by grading or removal of soil in order to provide a sufficient factor of safety. Hydrogeological mitigation may include surface drainage, shallow drainage, and deep drainage. These drainage mechanisms vary in intensity; however, all mechanisms attempt to reduce the soil's water content. These modifications will decrease both the soil's pore pressures and the overall driving force, thereby increasing a slope's factor of safety and decreasing landslide risk. Types of drains may include trench drains, horizontal drain wells, siphon drains, or micro drains.

Reinforcement measures may be implemented when geometric slope modifications or drainage improvements are not sufficient or practical. Reinforcement modifications can involve the use of anchors or tieback systems, soil nailing, geofabric installation, buttressing, cellular and crib face installation, cement deep soil mixing, stone columns, or jet grouting.

The use of vegetation may also be combined with the methods described above to help prevent shallow slides by intercepting rainfall, decreasing runoff, and providing root stabilization.

7.2 Mitigation of Erosion

A desktop review of soil conditions was conducted prior to initial project siting (Shaw, 2012). This review incorporated data from many sources, as previously described. The transmission line siting was based partly on engineering constraints related to known geologic hazards, soil stability, water crossings, and areas of steep topography. By considering soil and slope conditions throughout the siting and design process, IPC has avoided soil impacts to the extent possible.

The project should use existing roads to access construction sites to the extent practicable. Where needed, existing roads should be improved to reduce sediment generation and minimize impacts to soils. Site impacts to soils at and around tower locations, access roads, and facility footprints should be avoided or minimized through the use of best management practices (BMPs). Appropriate restoration measures should be used to restore soil surfaces and vegetation following disturbances. IPC should meet design standards for new roads by the Bureau of Land Management, U.S. Department of Agriculture Forest Service (USFS), and Oregon Department of Transportation, as required, and should implement BMPs described below to reduce potential soil erosion during the construction process. To minimize soil erosion, where practical, IPC should implement revegetation procedures, such as recontouring, scarification, soil replacement, seedbed preparation, fertilization, seed mixtures, seeding timing, seeding methods, supplemental wetland and riparian plantings, and supplemental forest plantings.

Once the roads, towers, and other facilities have been constructed to the designed specifications, operations will have minimal potential for soil erosion. Slopes and cut banks should be stabilized with riprap and/or planted or seeded with vegetation as practical; and project facilities should be maintained as required to prevent erosion. Where necessary, temporary access road sites and other compacted soils should be mechanically loosened. Previously salvaged topsoil should be replaced and non-cropped areas should be revegetated where required.

7.2.1 Mitigation for Soil Erosion by Water

Erosion control measures should be designed with attention to the mapped soil erosion hazards (described in Section 5.3), with particular attention to areas with medium and high hazard ratings. Work on access roads should include grading and re-graveling of existing roads and construction of new roads. Soil erosion should be minimized by constraining traffic, heavy equipment, and construction to existing roads, where possible. Where new road construction is required, road widths should be limited to the width necessary to accommodate construction equipment. New roads should be located to avoid steep areas as much as possible.

Areas affected by construction should be reseeded with vegetation to minimize future erosion and to restore them to their natural state. Erosion and sediment control measures should be designed to remain intact until natural vegetation is sufficient to protect against erosion. The station operational footprint areas should be graveled to prevent erosion. The area outside the station fence may also be graveled, where practical, to prevent soil erosion during operations.

Specific erosion and sediment control to be implemented during the project construction and operations may include the following BMPs:

Avoid Highly Erodible Areas: Initial mitigation measures should include avoiding highly erodible areas, such as steep slopes, where possible, and rerouting impacted drainages to natural drainages to minimize erosion and sedimentation from runoff. Areas impacted by construction should be reseeded and sediment fences, check dams, and other BMPs will remain in place until impacted areas are well vegetated, and the risk of erosion has subsided.

Stabilize Road Entrance/Exit: A stabilized construction entrance/exit should be installed at locations where dirt (exposed, disturbed land) or newly constructed roads intersect existing paved roads. Stabilized entrances should also be installed at the construction laydown areas. The stabilized construction entrance/exits should be inspected and maintained for the duration of the project life.

Preserve/Restore Vegetation: To the extent practicable, existing vegetation should be preserved. In the event that vegetation is destroyed in temporary road locations or laydown areas, stockpiled topsoils should be replaced and recontoured. Vegetation should be reseeded to prevent erosion using an approved seed mixture specified by the Natural Resources Conservation Service (NRCS) or the USFS as being capable of surviving in local conditions (see Vegetation Management Plan attached to Exhibit P).

Control Dust: Dust should be controlled during construction through water application to the disturbed grounds and access roads where necessary. Application of excess water that could lead to erosion or sedimentation should be avoided. Other methods of dust control may include the use of poly sheeting, vegetation, or mulching. Speed limits should be kept to a minimum to prevent pulverization of road substrate.

Install Silt Fencing: Silt fencing or an equivalent control measure should be installed at various locations along the transmission line. The fencing should be installed on contours downgradient of excavations, fill areas, or graded areas where necessary. Silt fencing or an equivalent control measure should be installed around the perimeters of material stockpiles and construction laydown areas.

Install Straw Wattles: Straw wattles should be installed to decrease the velocity of sheet flow from stormwater. The wattles should be used along the downgradient edge of access roads adjacent to slopes or sensitive areas.

Apply Gravel and Mulching: Gravel should be used where soil becomes wet or muddy to prevent erosion and working of the soil. Mulch should be provided to immediately stabilize soil exposed as a result of land-disturbing activities. The mulch reduces the potential for wind and raindrop erosion.

Install Stabilization Matting: Jute mesh, straw matting, or turf reinforcement matting should be used to stabilize slopes that could become exposed during installation of access roads, during rainfall events, or to stabilize intermittent streams disturbed during construction of road crossings. Erosion control matting should be combined with revegetation techniques.

Control Concrete Washout Area: Concrete washout should be appropriately managed to prevent concrete washout water from impacting soils, water bodies, or wetlands.

Manage Stockpiles: Soils excavated may be temporarily stockpiled. While the material is stockpiled, perimeter controls should be established and the stockpiled material should be covered as necessary with mulch, plastic sheeting, and/or other appropriate means to prevent erosion and sedimentation.

Install Check Dams, Sediment Traps, and Sediment Basins: Check dams and sediment traps should be used during construction near tributaries and existing drainages. The check dams and sediment traps will minimize downstream disturbances and sedimentation of creeks. A sediment basin is a constructed temporary pond, built to capture eroded soils that wash off from larger construction sites during rain storms. The sediment-laden soil settles in the pond before the runoff is discharged.

7.2.2 Mitigation of Soil Erosion by Wind

To mitigate the risk of accelerating soil erosion by wind in areas susceptible to wind erosion, IPC should implement reseeding efforts, apply mulch, and use water for dust control. Areas that are susceptible to eolian processes that will be disturbed by construction activities and not permanently covered by aboveground facilities should be vegetated using a seed mixture specified by the applicable agencies as being capable of surviving in local conditions, and withstanding burial and deflation from eolian processes. Disturbed areas susceptible to wind erosion may be hydroseeded when temperatures and moisture levels are conducive to seed germination.

7.3 Mitigation of Expansive Soils

Expansive soils swell when exposed to moisture and shrink when dried. This change in volume can be detrimental to structure foundations. The selection of appropriate mitigation techniques will depend on the specific properties of site soils and foundation requirements of proposed structures. In general, mitigation techniques for expansive soils include removal, bypass, isolation, and treatment. If only a thin layer of expansive soil is present at a site, it may be feasible to strip and remove it. For thicker layers of expansive soil, it is common practice to extend foundations deep enough to effectively bypass the zone where moisture content is likely to change. Another mitigation alternative is to isolate the soil from changes in moisture content, through the use of enhanced drainage and/or coverings. Where only shallow foundations are practical, another mitigation alternative is to treat the expansive soils with lime or some other material that reduces their expansive properties.

7.4 Mitigation of Groundwater

The first step in mitigation of hazards posed by groundwater is to understand where and when it is present. Groundwater levels can vary significantly from one location to another and from one season to another. The geotechnical investigation will help to determine where groundwater will be relevant along the proposed alignments. Where groundwater plays a role in slope instability, the hydrogeological mitigation measures discussed in Section 7.1 should be considered. As discussed in Section 5.5, groundwater can also complicate construction, particularly where excavations extend below the water table. This will most likely be applicable to the proposed alignment where drilled shafts are required for tower foundations. If a shaft is excavated in good quality rock or firm fine-grained soils below the water table, groundwater may not be a significant concern. However, if shaft foundations extend below the water table in granular soils, casing and/or slurry will likely be necessary to prevent soil heave and maintain shaft integrity.

7.5 Mitigation of Corrosive Subsurface Conditions

Where soil conditions are identified that may be corrosive to metals, potential mitigation alternatives may include application of protective coatings, such as coal tar enamel. Another mitigation alternative is to increase the metal thickness to provide a ‘sacrificial’ layer that is thick enough to manage the amount of corrosion anticipated to occur over the structure’s design life. Where sulfates are present and corrosion of concrete is a concern, mitigation alternatives may include use of sulfate-resistant cement, such as type II low-alkali cement, coating the concrete with an asphalt emulsion, or reducing the water-cement ratio to reduce the hydraulic conductivity of the concrete and slow the reaction processes.

8.0 LIMITATIONS

This report was prepared for the exclusive use of HDR, Inc. (HDR), and the Idaho Power Company (IPC) design team for the Boardman, Oregon to Hemingway, Idaho 500kV Transmission Line Project. This report represents preliminary design considerations consisting of generalized geology, geologic hazard characterization, and geotechnical considerations. The purpose for this report is to assist IPC and HDR in preparing exhibits required by the Oregon Energy Facility Siting Council (EFSC) prior to obtaining their approval to complete design and initiate construction of the Boardman to Hemingway Project. No final design geotechnical recommendations are included herein. Instead, the report presents an assessment of conditions and recommends further geotechnical investigations and design support as planning of the project proceeds. Within the limitations of scope, schedule, and budget, the conclusions, and recommendations presented herein were prepared in accordance with generally accepted professional engineering geology and geotechnical engineering principles and practice in this area at the time this report was prepared. We make no other warranty, either express or implied. These conclusions and recommendations were based on our understanding of the project as described in this report and the site conditions as described in the references cited herein.

The conclusions and recommendations contained in this report are based primarily on available published information, with very limited field reconnaissance. No subsurface explorations were conducted for this study. We have assumed that the referenced data is factual, accurate, and representative of conditions throughout the project alignments. This report is intended to assist in project planning, permitting and preliminary design. This report is not suitable for final design. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of separated portions of this report.

The scope of our present work did not include environmental assessments or evaluations regarding the presence or absence of wetlands, or hazardous or toxic substances in the soil, surface water, groundwater, or air, on or below or around this site, or for the evaluation or disposal of contaminated soils or groundwater should any be encountered.

Shannon & Wilson, Inc. has prepared and included in Appendix F, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of our reports.

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9.0 REFERENCES

Advanced National Seismic System (ANSS), 2016, Composite Catalog: accessed November, 2016: Available: http://earthquake.usgs.gov/earthquakes/search/ and http://www.quake.geo.berkeley.edu/anss/catalog-search.html.

American Society of Civil Engineers (ASCE), 2010 with 2013 errata, Minimum Design Loads for Buildings and Other Structures (Standards ASCE/SEI 7-10): Reston, VA, ASCE, 636 p.

American Society of Civil Engineers (ASCE), 2017, Minimum Design Loads and Associated Criteria for Buildings and Other Structures (Provisions ASCE/SEI 7-16): Reston, VA.

Ashley, R.P., 1966, Metamorphic Petrology and Structure of the Burnt River Canyon Area, northeastern Oregon: Palo Alto, California, Stanford University, Ph.D. dissertation, 236 p., scale 1:21,100.

Barrash, Warren, John G. Bond, John D. Kauffman, and Ramesh Venkatakrishnan, 1980, Geology of the La Grande Area, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 6.

Bela, J.L. (Compiler), 1982, Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1^0 x 2^0 quadrangle: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-027, scale 1:250,000.

Bonnichsen, B., and Godchaux, M.M., 2002, Late Miocene, Pliocene, and Pleistocene Geology of Southwestern Idaho With Emphasis on Basalts in the Bruneau-Jarbidge, Twin Falls, and Western Snake River Plain Regions, *in* Bill Bonnichsen, C.M. White, and Michael McCurry, eds., Tectonic and Magmatic Evolution of the Snake River Plain Volcanic Province: Idaho Geological Survey Bulletin 30, p. 233-312.

Boore, D.M., Atkinson, G.M., 2008, Ground Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods between 0.01 s and 10.0 s: Earthquake Spectra, v. 24, p. 99-138.

Brooks, H.C., 2006, Geologic and mineral resources map of the Mormon Basin quadrangle, Baker and Malheur Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-2006-25, 25 p., scale 1:24,000.

Brooks, H.C., 1991, Geology and Mineral Resources Map of the Vines Hill Quadrangle, Malheur County, Oregon: Oregon Department of Geology and Mineral Industries, Geologic Map Series, GMS-063, scale 1:24,000.

Brooks, H.C., 1979, Geologic Map of the Huntington and Part of the Olds Ferry Quadrangles, Baker and Malheur Counties, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-013, scale 1:62,500.

Brooks, H.C., McIntyre, J.R., and Walker, G.W., 1976, Geologic Map of the Oregon part of the Baker 1 degree by 2 degree Quadrangle: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-007, scale 1:250,000.

Burns, W.J., and Watzig, R.J., 2017, SLIDO-3.4, Statewide Landslide Information Database for Oregon, Release 3.4; Oregon Department of Geology and Mineral Industries, available: https://gis.dogami.oregon.gov/slido/, accessed 01/08/2018 06:13 PM.

Burns, W.J., Mickelson, K.A., Saint-Pierre, E.C., 2011, SLIDO-2, Statewide Landslide Information Database for Oregon, Release 2; Oregon Department of Geology and Mineral Industries.

Busskohl, C., 2006, Land type associations of the Malheur, Umatilla, and Wallowa-Whitman National Forests: US. Department of Agriculture Forest Service, Pacific NW Region, scale 1:100,000.

Campbell, K.W., and Bozorgnia, Y., 2008, NGA Ground Motion Model for the Geometric Mean Horizontal Component of PGA, PGV, PGD and 5% Damped Linear Elastic Response Spectra for Periods Ranging from 0.01 s to 10 s: Earthquake Spectra, v. 24, p. 139-171.

Chiou, B.S-J., and Youngs, R.R., 2008, An NGA Model for the Average Horizontal Component of Peak Ground Motion and Response Spectra: Earthquake Spectra, v. 24, p. 173–215.

Ferns, M.L., McConnell, V.S., Madin, I.P., and Johnson, J.A., 2010, Geology of the Upper Grande Ronde Basin, Union County, Oregon; Oregon Department of Geology and Mineral Industries Bulletin 107, vector digital data, scale 1:100,000.

Ferns, M.L., McConnell, V.S., Madin, I.P., and Johnson, J.A., 2003, Geologic Map of the Upper Grande Ronde River Basin, Union County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-2003-11, 85 p., scale 1:125,000.

Ferns, M.L., Madin, I.P., and Taubeneck, W.H., 2001a, Reconnaissance geologic map of the La Grande 30' x 60' quadrangle, Baker, Grant, Umatilla, and Union Counties, Oregon: Oregon Department of Geology and Mineral Industries Recon. Map Series RMS-1, scale 1:100,000.

Ferns, M.L., Madin, I.P., McConnell, V.S., and Johnson, J.J., 2001b, Geology of the surface and subsurface of the southern Grande Ronde Valley and lower Catherine Creek drainage, Union County, Oregon: Oregon Department of Geology and Mineral Industries Open File Report O-2002-02, 54 p., 3 plates, vector digital data, scale 1:24000.

Ferns, M.L., Brooks, H.C., Evans, J.G., and Cummings, M.L., 1993a, Geologic map of the Vale 30' x 60' quadrangle, Malheur County, Oregon and Owyhee County, Idaho: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-77, scale 1:100,000.

Ferns, M.L., Evans, J.G., and Cummings, M.L., 1993b, Geologic map of the Mahogany Mountain 30' x 60' quadrangle, Malheur County, Oregon and Owyhee County, Idaho: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-78, scale 1:100,000.

Ferns, M.L., 1989, Geology and Mineral Resources Map of the Owyhee Dam Quadrangle, Malheur County, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-55, scale 1:24,000.

Idriss, I.M. and Boulanger, R.W., 2006, Semi-empirical procedures for evaluating liquefaction potential during earthquakes. Soil Dynamics and Earthquake Engineering, 26(2), pp.115-130.

IEEE Power Engineering Society and American Society of Civil Engineers, 2001, IEEE Guide for Transmission Structure Foundation Design and Testing: IEEE Standard 691, Published by the Institute of Electrical and Electronics Engineers.

IEEE Power Engineering Society, 2000, IEEE Guide for Safety in AC Substation Grounding: IEEE Standard 80, Published by the Institute of Electrical and Electronics Engineers.

IEEE Power Engineering Society and American Society of Civil Engineers, 1983, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System: IEEE Standard 81, Published by the Institute of Electrical and Electronics Engineers.

International Building Code, 2015, Published by the International Code Council.

International Building Code, 2009, Published by the International Code Council.

Idaho Power Corporation, 2016, Exhibit H of the Amended Preliminary Application for Site Certificate for the Boardman to Hemingway Transmission Line Project: Report Prepared by Idaho Power Corporation, Boise, Idaho.

Johnson, A.G., Scofield., D.H., and Madin, I.P., 1994, Earthquake Database for Oregon, 1833 through October 25, 1993: Oregon Department of Geology and Mineral Industries Open-File Report O-1994-04.

Kramer, Steven L., 1996, Geotechnical Earthquake Engineering: Pearson, 653 p.

Luco, Nicolas, 2007, Risk-Targeted versus Current Seismic Design Maps for the Conterminous United States, *in* SEAOC 2007 Convention Proceedings.

Madin, I.P., and Geitgey, R.P., 2007, Preliminary geologic map of the Umatilla Basin, Morrow and Umatilla Counties, Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-2007-15, 19 p., scale 1:100,000.

Madin, I.P., and Mabey, M.A., 1996, Earthquake Hazard Map for Oregon, State of Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-100.

Madin, I.P., and Ferns, M.L., 1977, Geology of the Malheur Butte quadrangle, Malheur County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-1997-02, scale 1:24,000.

National Academies of Sciences, Engineering, and Medicine, 2016, State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences, Washington, DC: The National Academies Press, https://doi.org/10.17226/23474.

National Geophysical Data Center (NGDC), 1985, Earthquake Intensity Database Search, 1683 – 1985, NOAA Satellite and Information Service: accessed September, 2015: Available: http://www.ngdc.noaa.gov/hazard/earthqk.shtml.

Oregon Geologic Data Compilation (OGDC), 2015, Oregon Geologic Data Compilation DVD, Release 6, compiled by Smith, R.L., and Roe, Warren P., Oregon Department of Geology and Mineral Industries.

Oregon State Board of Geologist Examiners, 2014, Guideline for Preparing Engineering Geologic Reports, Second Edition, May 30, 2014, Salem, Oregon.

Oregon Structural Specialty Code (OSSC), 2010, Published by the International Code Council.

Orr, E.L. and Orr, W.N., 2000, Geology of Oregon, Fifth Ed., Kendall/Hunt Publishing Co., Dubuque, Iowa, 254 p.

Pacific Northwest Seismic Network (PNSN), 2008, Earthquake Catalogs and Data: accessed November, 2016: Available: http://www.pnsn.org/HIST_CAT/catalog.html.

Personius, S.F., and Lewis, R.S., compilers, 2003, Fault number 636, Owyhee Mountains fault system, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:19 PM.

Personius, S.F., compiler, 2002a, Fault number 709, South Grande Ronde Valley faults, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:22 PM.

Personius, S.F., compiler, 2002b, Fault number 712, Unnamed eastern Baker Valley faults, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:21 PM.

Personius, S.F., compiler, 2002c, Fault number 802a, West Grande Ronde Valley fault zone, Mount Emily section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:23 PM.

Personius, S.F., compiler, 2002d, Fault number 802b, West Grande Ronde Valley fault zone, La Grande section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:23 PM.

Personius, S.F., compiler, 2002e, Fault number 802c, West Grande Ronde Valley fault zone, Craig Mountain section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:22 PM.

Personius, S.F., compiler, 2002f, Fault number 804, West Baker Valley fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:21 PM.

Personius, S.F., compiler, 2002g, Fault number 806, Cottonwood Mountain fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:20 PM.

Personius, S.F., compiler, 2002h, Fault number 808, Faults near Owyhee Dam, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:19 PM.

Personius, S.F., and Lidke, D.J., compilers, 2003a, Fault number 845c, Hite fault system, Thorn Hollow section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:24 PM.

Personius, S.F., and Lidke, D.J., compilers, 2003b, Fault number 845d, Hite fault system, Agency section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 11/16/2016 06:23 PM.

Pierce, K. L., and Morgan, L. A., 1992, The track of the Yellowstone hot spot: Volcanism, faulting, and uplift, *in* Link, P. K., Kuntz, M. A., and Platt, L. B., eds., Regional Geology of Eastern Idaho and Western Wyoming: Geological Society of America Memoir 179, p. 1-53.

PNNL, 2014, Hanford Sitewide Probabilistic Seismic Hazard Analysis: Report prepared by the Pacific Northwest National Laboratory (PNNL), Richland, WA, PNNL-23361, for the U.S. Department of Energy and Energy Northwest, November, 37 p.

Prostka, H.J., 1967, Preliminary geologic map of the Durkee quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS- 003, 8 p., scale 1:62,500.

Prostka, H.J., 1962, Geology of the Sparta quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-001, 8 p., scale 1:62,500.

Schlicker, H.G., and Deacon, R.J., 1971, Engineering Geology of the La Grande Area, Union County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-1971-03, 16 p., 1 plate, scale 1:24,000.

Shaw Environmental & Infrastructure, Inc., 2012, Desktop Geotechnical Report, Proposed 500kV Transmission Line, Boardman, Oregon to Hemingway, Idaho: Report Prepared by Shaw Environmental & Infrastructure Inc., Portland, Oregon, for Pike Energy Solutions, Portland, Oregon, 48 p.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database Baker County, Oregon: Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database Malheur County, Oregon: Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database Morrow County, Oregon: Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database Owyhee County, Idaho: Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=ID

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database Umatilla County, Oregon: Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database Union County, Oregon: Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR.

Seed, R.B., Cetin, K.O., Moss, R.E.S., Dammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Dayen, R.E., and Faris, A., 2003, Recent Advances in Soil Liquefaction Engineering – A Unified and Consistent Framework, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Long Beack, California, April 30, 2003.

Shervais, J.W, Kauffman, J.D., Gillerman, V.S., Othberg, K.L., Vetter, S.K., Hobson, V.R., Zarnetske, M., Cooke, M.F., Mathews, S.H., and Hanan, B.B., 2005, Basaltic Volcanism of the Central and Western Snake River Plain: A Guide to Field Relations Between Twin Falls and Mountain Home, Idaho, *in* Pederson, J., and Dehler, C.M., eds., Interior Western United States: Geological Society of America Field Guide 6, 26 p.

Swanson, D.A., Anderson, J.L., Camp, V.E., Hooper, P.R., Taubeneck, W.H., and Wright, T.L., 1981, Reconnaissance geologic map of the Columbia River Basalt Group, northern Oregon and western Idaho: U.S. Geological Survey Open-File Report 81-797, scale 1:250,000.

URS Corporation, Jack Benjamin & Associates, Geomatrix Consultants, Inc., and Shannon & Wilson, Inc., 2012, Probabilistic Seismic Hazard Analyses Project for the Mid-Columbia Dams: Report prepared by URS, Oakland, CA, and others, for the Public Utility Districts of Chelan, Douglas, and Grant Counties, WA, February, 344p.

U.S. Geological Survey (USGS), 2002, Earthquake Hazards Program, 2002 interactive disaggregation tool: Available: https://geohazards.usgs.gov/deaggint/2002/.

U.S. Geological Survey (USGS), 2016a, Search Earthquake Catalog: accessed 11/16/16: Available: http://earthquake.usgs.gov/earthquakes/search/.

U.S. Geological Survey (USGS), 2016b, Earthquake Hazards Program, The Modified Mercalli Intensity Scale: accessed September, 2015: Available: http://earthquake.usgs.gov/learn/topics/mercalli.php.

U.S. Geological Survey (USGS), 2016c, Earthquake Hazards Program, 2014 uniform hazard curve data: Available: ftp://hazards.cr.usgs.gov/web/nshm/conterminous/2014/data/.

U.S. Geological Survey (USGS), 2006, Quaternary fault and fold database for the United States, accessed November, 2016: Available: http//earthquakes.usgs.gov/hazards/qfaults/.

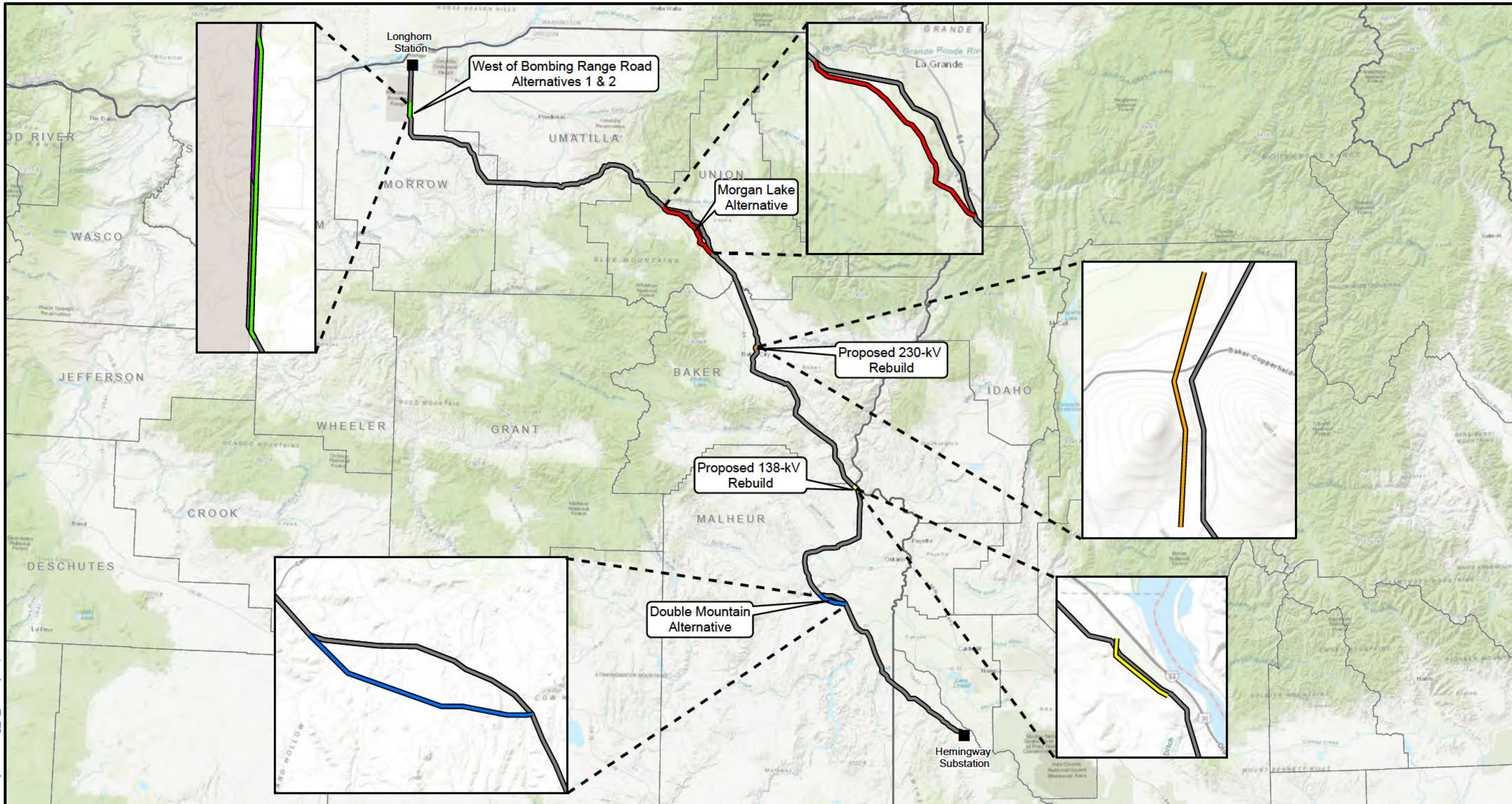
Wald, D.J., Quitoriano, V., Heaton, T.H., and Kanamori, H., 1999, Relationship between Peak Ground Acceleration, Peak Ground Velocity, and Modified Mercalli Intensity in California: Earthquake Spectra, vol. 15, no. 3, p. 557-564.

Walker, G.W., Raines, G.L., and Connors, Katherine A., 2002, Spatial Digital Database for the Geologic Map of Oregon; U.S. Geological Survey Open File Report 03-67, scale 1:500,000.

Walker, G.W., 1979, Reconnaissance geologic map of the Oregon part of the Grangeville quadrangle, Baker, Union, Umatilla, and Wallowa Counties, Oregon: U.S. Geological Survey Miscellaneous Investigations Map I-1116, scale 1:250,000.

Walker, G.W., 1973, Reconnaissance Geologic map of the Pendleton Quadrangle, Oregon and Washington: U.S. Geological Survey Miscellaneous Investigations Map I-727, scale 1:250,000.

Youd, T. L., et al., 2001, Liquefaction resistance of soils: summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils. Journal of geotechnical and geoenvironmental engineering 127.10: 817-833.



LEGEND

IPC Proposed Route	Proposed 230-kV Rebuild
West of Bombing Range Road - Alternative 1	Proposed 138-kV Rebuild
West of Bombing Range Road - Alternative 2	Double Mountain Alternative
Morgan Lake Alternative	Stations

NOTE
Alignments provided by Idaho Power, dated 9/9/2016.

0 25 50 Miles

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

VICINITY MAP

January 2018 24-1-03820-006

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FIG. 1

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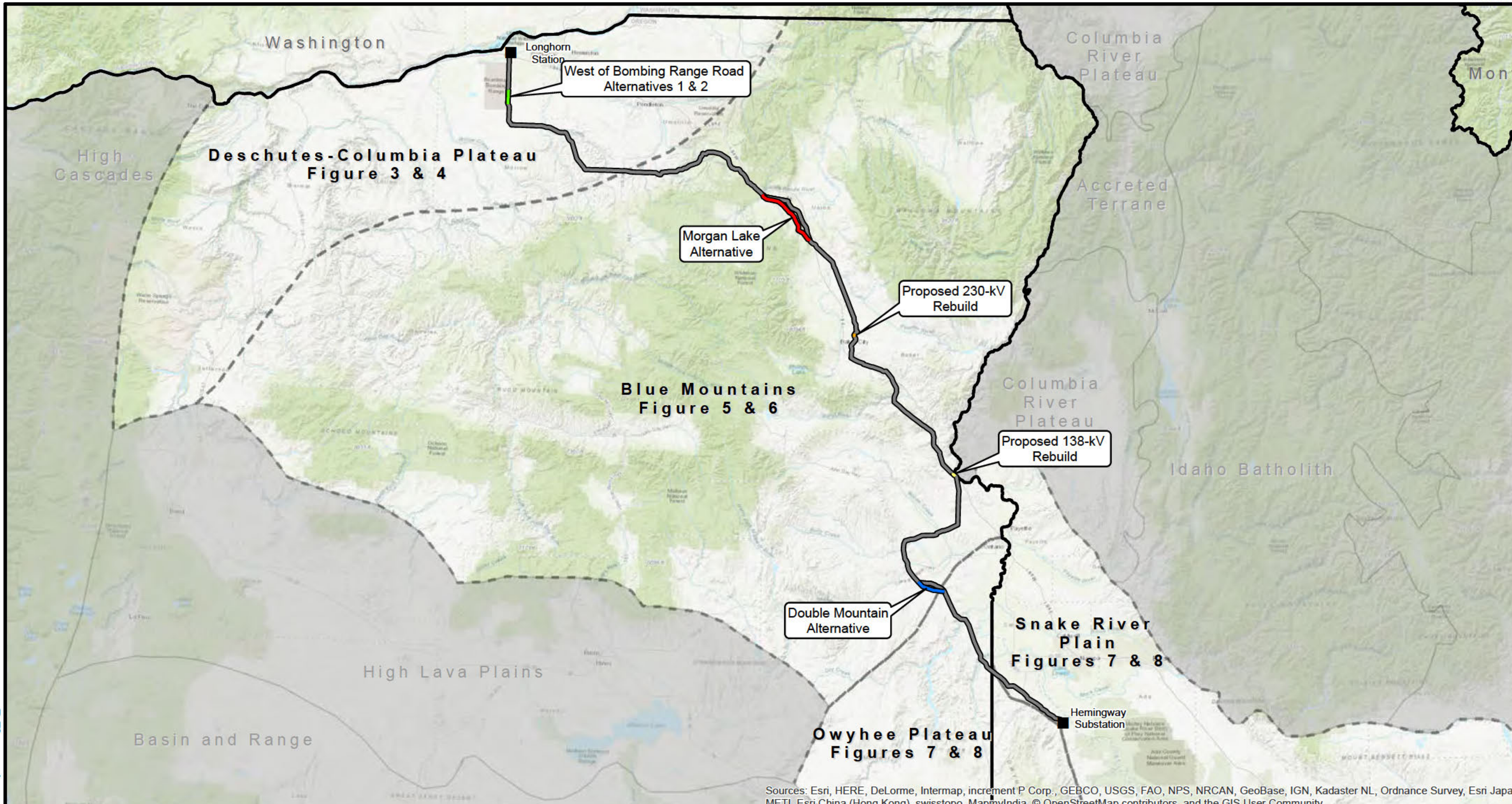

LEGEND

- IPC Proposed Route
- West of Bombing Range Road - Alternative 1
- West of Bombing Range Road - Alternative 2
- Morgan Lake Alternative
- Proposed 230-kV Rebuild
- Proposed 138-kV Rebuild
- Double Mountain Alternative
- Stations
- Physiographic Province Boundaries (approximate)
- State Boundaries

NOTE
1. Alignments provided by Idaho Power, dated 9/9/2016.
2. Physiographic province boundaries are approximate.

0 25 50 Miles

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

PHYSIOGRAPHIC PROVINCE PAGE INDEX

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FIG. 2

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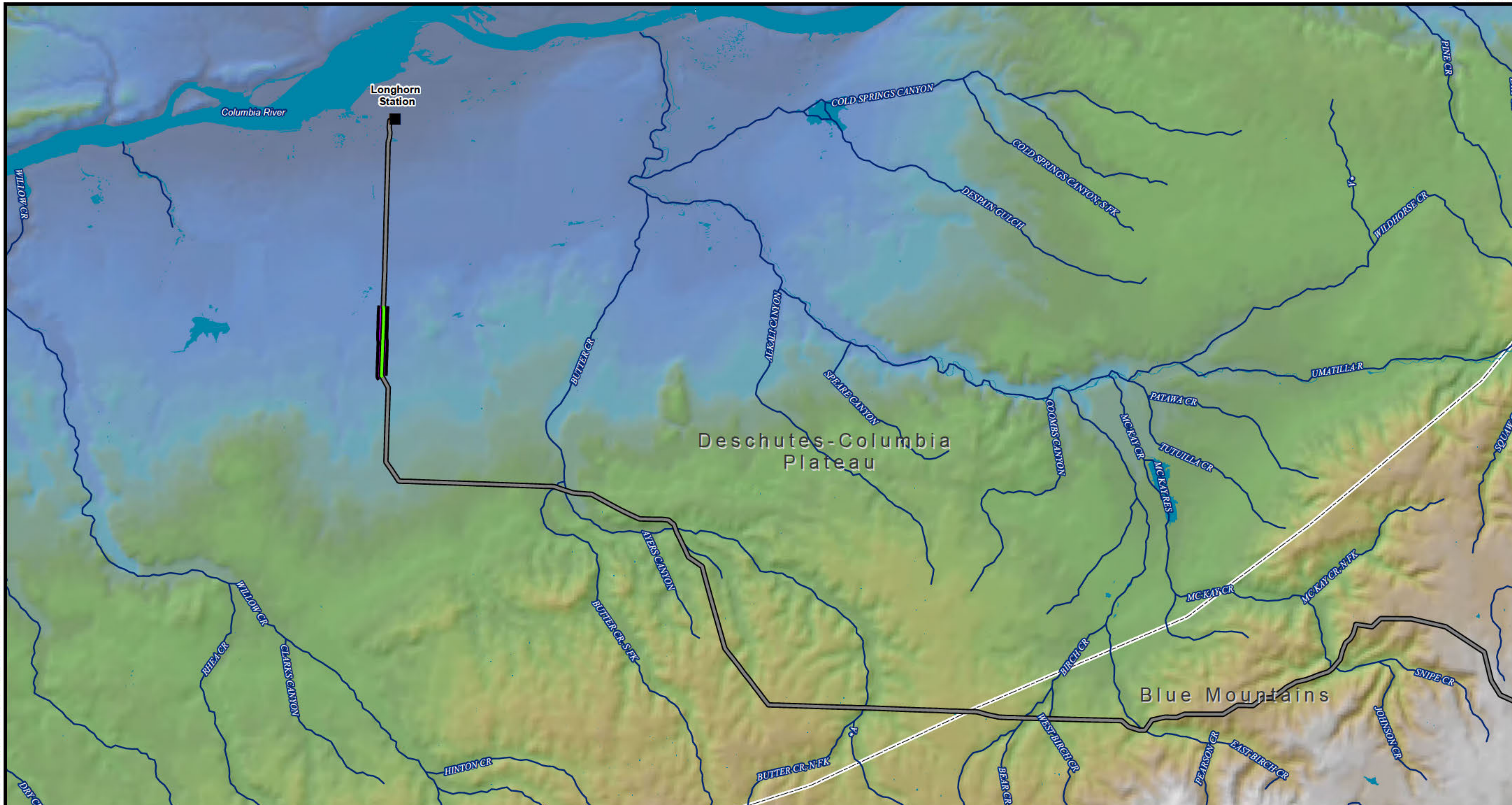

T:\Projects\24-1-3820_B2HAV_mxd\January 2018\Deschutes-ColumbiaTopo_Drainage.mxd 11/23/2016 ath

LEGEND

- IPC Proposed Route
- West of Bombing Range Road - Alternative 1
- West of Bombing Range Road - Alternative 2
- Physiographic Province Boundary
- Proposed Station
- Major Creeks and Rivers

ELEVATION (feet)
~5000 (ft)
0 (ft)

N W E S

0 5 10 Miles

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

DESCHUTES-COLUMBIA PLATEAU TOPOGRAPHY AND DRAINAGE

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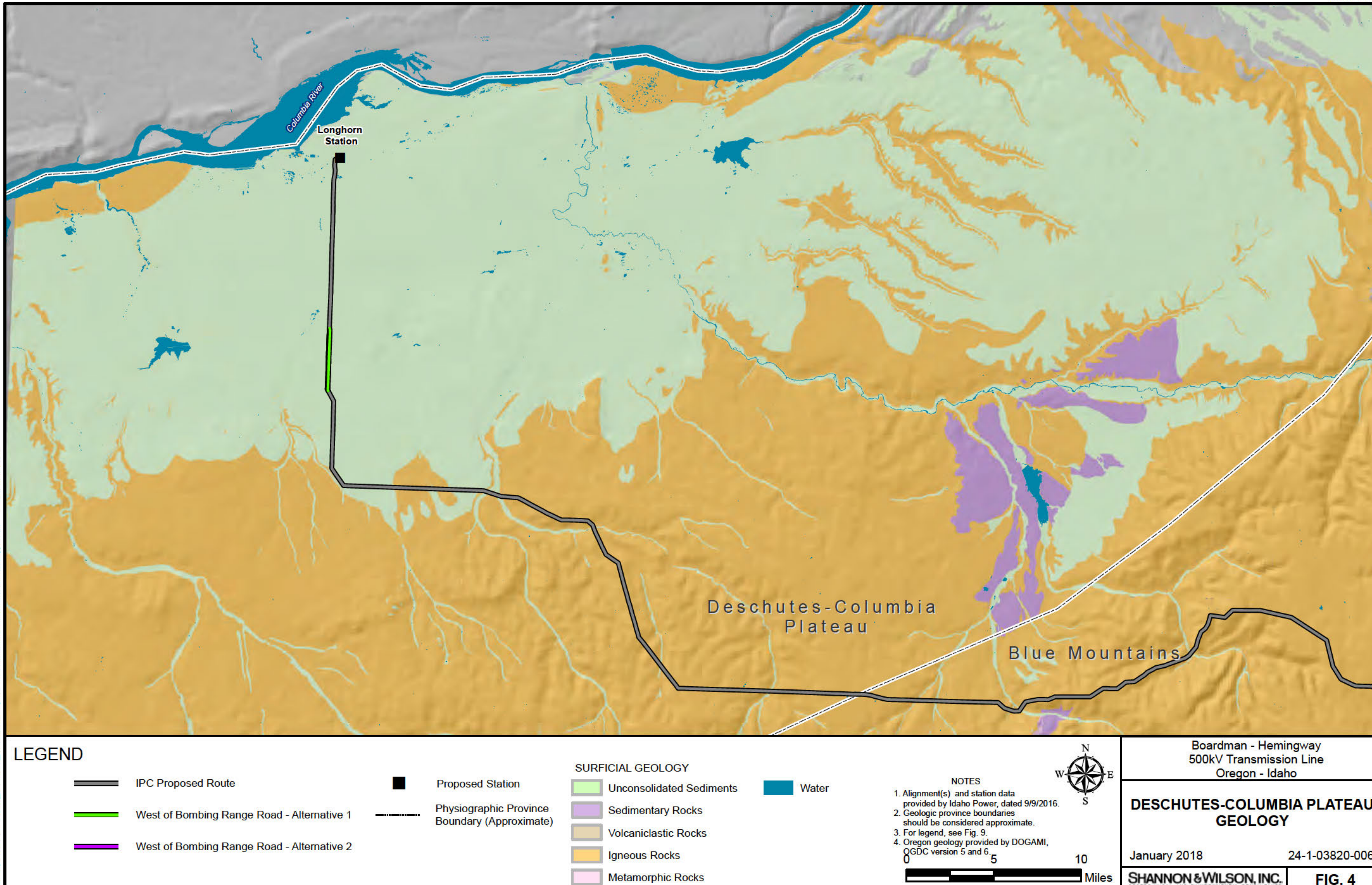
FIG. 3



Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

DESCHUTES-COLUMBIA PLATEAU GEOLOGY

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FIG. 4

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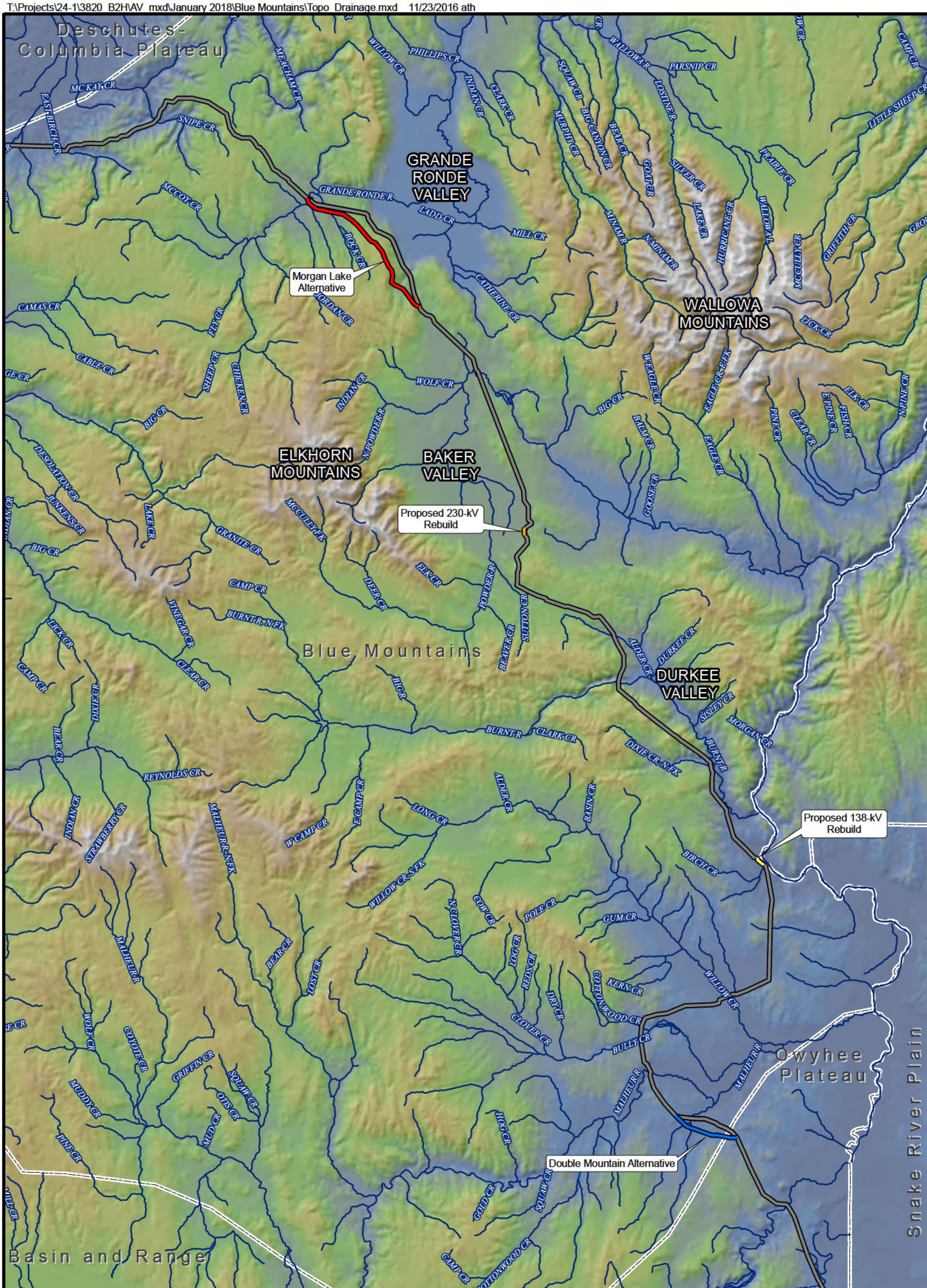

LEGEND

- IPC Proposed Route
- Morgan Lake Alternative
- Proposed 230-kV Rebuild
- Proposed 138-kV Rebuild
- Double Mountain Alternative
- Physiographic Province Boundary (Approximate)
- Major Creeks and Rivers

ELEVATION (feet)
~9000 ft
0 ft

0 10 Miles

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

BLUE MOUNTAINS
TOPOGRAPHY AND DRAINAGE

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FIG. 5

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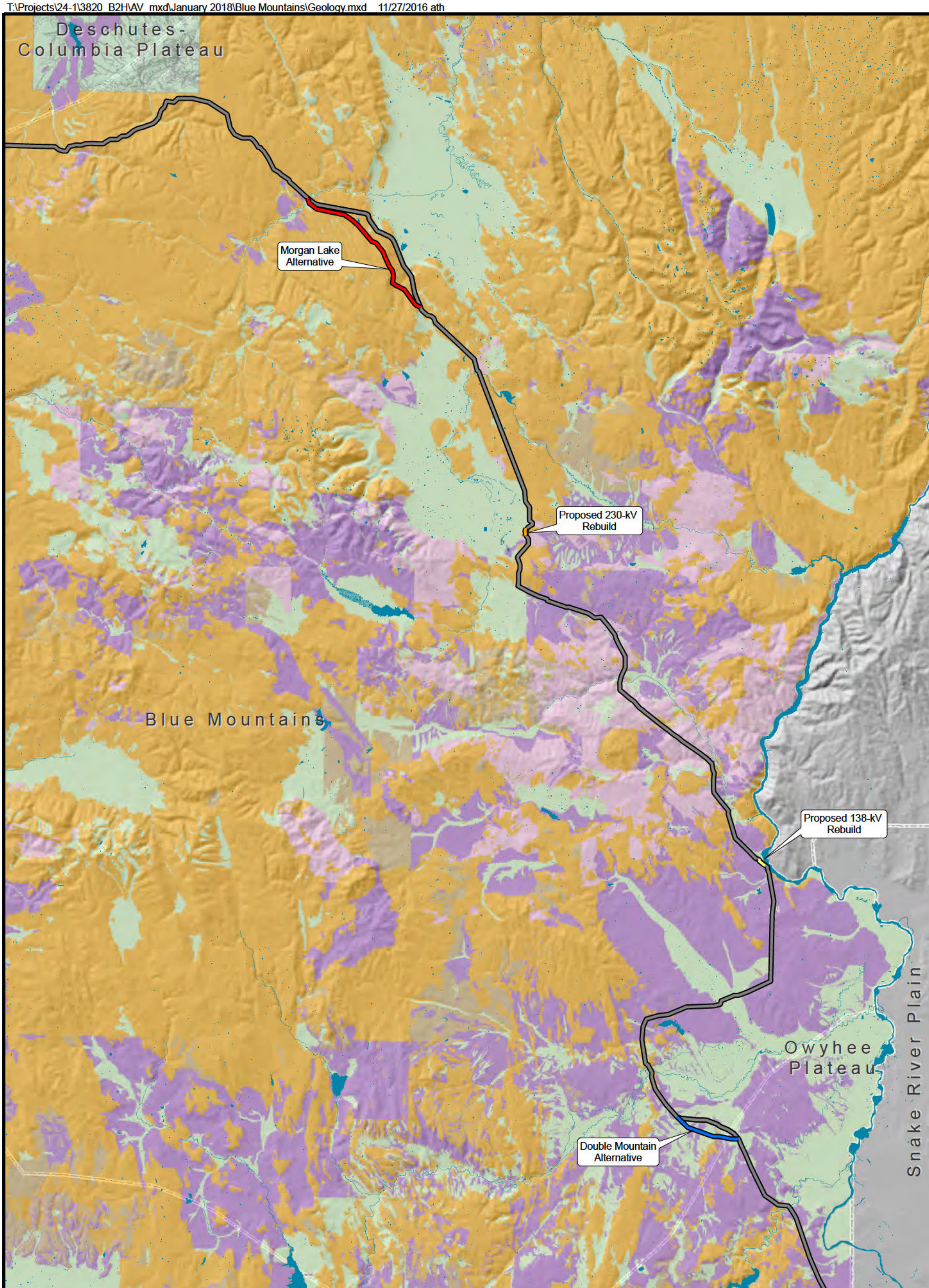

LEGEND

- IPC Proposed Route
- Morgan Lake Alternative
- Proposed 230-kV Rebuild
- Proposed 138-kV Rebuild
- Double Mountain Alternative

SURFICIAL GEOLOGY

- Unconsolidated Sediments
- Sedimentary Rocks
- Volcaniclastic Rocks
- Igneous Rocks
- Metamorphic Rocks
- Water

NOTES
1. Alignment(s) provided by Idaho Power, dated 9/9/2016.
2. Geologic province boundaries should be considered approximate.
3. For legend, see Fig. 9.
4. Oregon geology provided by DOGAMI.

0 10 20 Miles

N W E S

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

BLUE MOUNTAINS GEOLOGY

January 2018 34-1-03820-006

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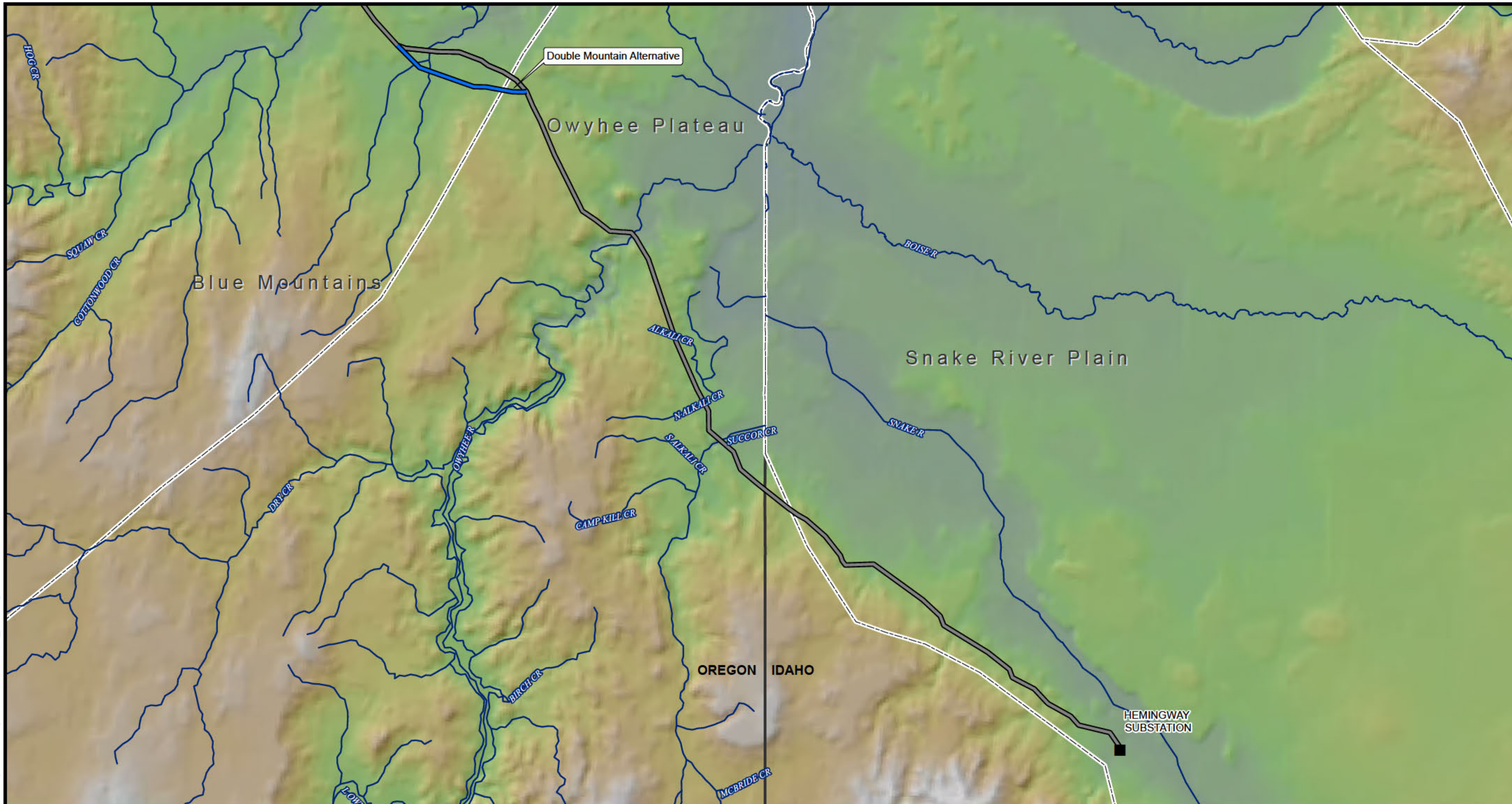
FIG. 6



LEGEND

IPC Proposed Route

Proposed Substation

Double Mountain Alternative

Physiographic Province Boundary

Major Creeks and Rivers

ELEVATION (feet)

~6000 ft

0 ft

N
W E
S

0 5 10
Miles

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

**OWYHEE PLATEAU
TOPOGRAPHY AND DRAINAGE**

January 2018 24-1-03820-006

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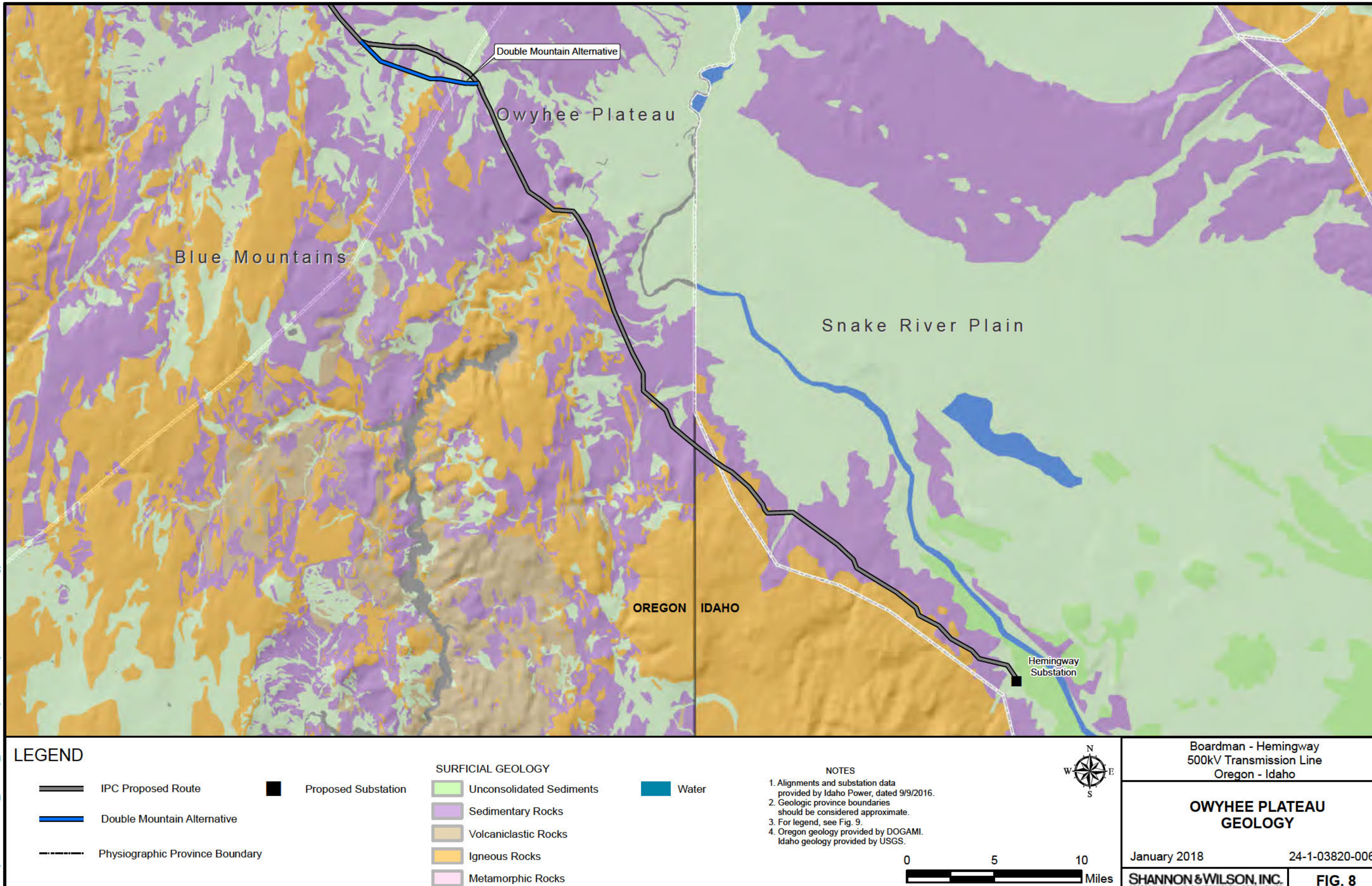
FIG. 7

T:\Projects\24-13820_B2HVAV_mxd\January 2018\Owyhee Plateau\Topo_Drainage.mxd 1/10/2018 ath



Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

OWYHEE PLATEAU GEOLOGY

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FIG. 8

APPENDIX A

GEOLOGIC MAPS AND UNIT DESCRIPTIONS

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TABLES

FIGURES

APPENDIX A

GEOLOGIC MAPS AND UNIT DESCRIPTIONS

A.1 INTRODUCTION

This appendix presents geologic maps that cover the IPC Proposed Route; Proposed 230 kV Rebuild; Proposed 138 kV Rebuild; West of Bombing Range Road Alternative 1; West of Bombing Range Road Alternative 2; Morgan Lake Alternative; and Double Mountain Alternative project alignments, as well as associated multi-use areas. Geologic maps along the majority of the alignment were originally created by Shaw Environmental & Infrastructure, Inc., and were first presented in their Desktop Geotechnical Report, dated January 19, 2012.

Subsequent new alignments, as well as changes to the previous alignments, were evaluated by Shannon & Wilson, Inc. Maps from the Proposed 230 kV Rebuild; Proposed 138 kV Rebuild; West of Bombing Range Road Alternative 1; West of Bombing Range Road Alternative 2; Morgan Lake Alternative; and Double Mountain Alternative alignments, and associated multi-use areas, are integrated with the IPC Proposed Route in this appendix. The following sections describe how the maps were generated and the general characteristics of geologic units.

Table A1 presents a Geologic Time Scale, for reference. Table A2 summarizes all surficial geologic units encountered within a 0.5-mile radius of the proposed alignments. Table A3 presents geologic unit data for multi-use areas located away from the alignment such that they fall outside the boundaries of the map sheets presented. Map Sheet 1 presents an index map for the geologic maps, and Sheets 2 through 114 present the geologic maps themselves.

A.2 SURFICIAL GEOLOGIC MAPPING

GIS base files obtained for this study were compiled in the Oregon Geologic Data Compilation (OGDC) by the Oregon Department of Geology and Mineral Industries (DOGAMI) and the Idaho Department of Water Resources (IDWR). The GIS data were then compared with geologic maps for those areas of Oregon and Idaho where the IPC Proposed Route; Proposed 230 kV Rebuild; Proposed 138 kV Rebuild; West of Bombing Range Road Alternative 1; West of Bombing Range Road Alternative 2; Morgan Lake Alternative; and Double Mountain Alternative alignments are proposed.

The mapped geologic units and formations along these routes were generalized by this study into five lithologic categories and landslides (which frequently include many different lithologies). The lithologic categories are divided based on generalized geotechnical engineering properties.

The lithologic categories include the following:

- Unconsolidated sediments
- Landslide deposits
- Sedimentary rocks
- Volcaniclastic rocks
- Igneous rocks
- Metamorphic rocks

The categories allow for a better understanding of the general site geology and subsurface conditions, while allowing for variations in formation names and descriptions between different maps of the same area or maps of adjoining areas created by different authors. Prior to final design, site-specific geologic reconnaissance and geotechnical drilling will be performed to confirm the geology and engineering properties of subsurface materials at specific locations along the alignments. Proposed locations for geotechnical drilling are shown on the geologic map sheets in this Appendix. Additional information regarding the proposed explorations is presented in Appendix C, Summary of Proposed Boring Locations. The generalized lithologic categories and the major geologic units included in each category are described below. All surficial geologic formations and mapped subunits encountered within a 0.5-mile radius of the proposed alignments are summarized in Table A2, and geologic data for all multi-use areas located away from the alignment are summarized in Table A3.

A.2.1 Unconsolidated Sediments

Unconsolidated sediments are found at various locations throughout the alignments and consist primarily of water-, wind-, and gravity-transported sediments including clay, silt, sand, gravel, cobbles and boulders, and minor ash. Included in this category are alluvium, fan deposits, terrace deposits, flood deposits, eolian deposits, and colluvium.

A.2.1.1 Alluvim

Alluvium (Qa, Qal, Qu) generally consists of Quaternary-age unconsolidated sediments deposited on active stream channels and floodplains. Deposits include clay, silt, sand, gravel, cobbles, boulders, and, in some areas, abundant organic material with thin peat beds. Fine-grained deposits are generally located along low terraces along river banks. Playa-lake deposits exist near the southern portion of the alignment, near Vale. Overbank silt deposits exist within the floodplains of the Owyhee, Malheur, and Snake Rivers (Ferns et al., 1993a). Overall, thicknesses of Alluvium deposits vary from approximately 10 feet to over 30 feet.

A.2.1.2 Fan and Terrace Deposits

Fan and terrace deposits are types of alluvium and, in many cases, are mapped together in the same units (Qas, Qas1, Qf, Qfd, Qtg). Alluvial fans consist of poorly sorted, unconsolidated to poorly consolidated boulder- to clay-size sediments deposited by streams, typically at the mouth of a drainage or canyon. Terrace deposits are typically composed of poorly sorted gravel and bouldery soils above modern stream channels. The terraces are formed when rivers and streams cut down through the sediments they previously deposited.

A.2.1.3 Missoula Flood Deposits

Missoula Flood deposits (Qmf) are the result of repeated glacial outburst floods, which occurred around 15,500 to 13,000 years ago due to rupture of ice dams that formed glacial Lake Missoula in modern-day Montana. The floods drained across the Idaho panhandle, through the Washington Scablands, and into the Columbia River. The deposits are generally mapped within the first 16 miles of the IPC Proposed Route, near the Columbia River. In the project area, this unit primarily includes unconsolidated silt, sand, gravel, and boulders. Thickness generally ranges from 15 to 50 feet with a maximum thickness of 150 feet (Madin and Geitgey, 2007).

A.2.1.4 Bonneville Flood Deposits

The Bonneville Flood deposits (Qpug, Qsbf, Qpa) are the result of a single catastrophic outburst flood that occurred around 14,500 years ago, due to rupture of a natural rock formation which had contained Lake Bonneville, which occupied the present-day basin of the Great Salt Lake. The flood waters washed across the Snake River Plain, through Hells Canyon, and ultimately out through the Columbia River. Deposits include unconsolidated silt, sand, and gravel and are found along IPC Proposed Route between milepost 255 (MP255) and MP256, and near the end, past MP294.

A.2.1.5 Eolian Sand and Ash

Aeolian Sand and Ash (Qe) is a windblown deposit of Quaternary age that is generally mapped within the first 16 miles of the IPC Proposed Route, near the Columbia River. This unit consists primarily of unconsolidated sands and silt from older Missoula Flood deposits and airfall volcanic ash deposits. Thickness ranges from a thin veneer just outside of the

Missoula Flood deposits to approximately 3 feet thick in the highlands (Madin and Geitgey, 2007).

A.2.1.6 Colluvium

Colluvium (Qcf) includes mixed sedimentary deposits at the foot of a slope of a cliff, transported principally by gravity. Depending on the geology of the surrounding highlands, deposits of colluvium can range from mixtures of silt, sand, gravel, and cobbles, to clean accumulations of gravel- to boulder-sized rock fragments (talus). As many slopes contain at least a thin veneer of colluvium, it is likely that more colluvium exists along the alignment than is shown on the geologic maps, which tend to emphasize the underlying rock units.

A.2.2 Landslide Deposits

Landslide Deposits (Qls, Qdf) are mapped at various locations throughout the alignments and result from the downslope movement of soil and/or rock masses. Landslides are generally differentiated from colluvium by the scale and rate of movement. Deposition of colluvium is typically a gradual process; whereas landslides occur as masses of soil or rock fail downslope, often along preexisting planes of weakness. Deposits may include large-scale rock-fall, mudflow, debris flow, scree, and talus deposits. The deposits may consist of unconsolidated, unsorted, chaotically mixed soil and/or rock debris. Landslide deposits can often be identified by hummocky topography, scarps, ponds, seeps, and tension cracks. If a landslide is active, or recently active, it may be identified by tilted trees and relatively fresh scarps. In the vicinity of the project alignment, failures often occur where basalt and/or other coherent rock units slide on top of weathered tuffaceous sedimentary rocks. Landslide deposits are discussed in further detail in Appendix E.

A.2.3 Sedimentary Rocks

Sedimentary rocks form through consolidation and cementation of loose sediments, and are generally found in layers. The layers are formed by the sequential deposition of soil particles by features such as streams and lakes. The following sections describe sedimentary rock formations within the major terrane groups that may be encountered along the proposed alignments.

A.2.3.1 Sedimentary Rocks of the Baker Terrane Group

Formations of the Baker Terrane Group that fall within the category of sedimentary rocks include the Paleozoic to Mesozoic Elkhorn Ridge Argillite (Pe, TRPbe).

These sedimentary rocks are generally located southeast of Baker City, between MP159 and MP188 of the IPC Proposed Route, and consist mainly of highly contorted fine-grained argillite, chert, and tuffaceous sediments that are believed to have been deposited in deep-water ocean-floor environments (OGDC, 2015). The argillite, chert, and tuff are interlayered with thin lenses of island arc volcanics, such as andesitic and basaltic lavas, as well as conglomerate beds, and pod-like limestone lenses, which range from a few inches to many hundreds of feet thick (Prostka, 1967).

A.2.3.2 The Dalles Group

Sedimentary rocks of the Dalles Group that are mapped along the alignments consist primarily of the late Miocene and Pliocene Alkali Canyon Formation (Tac). These rocks are generally located between MP18 and MP89 along the IPC Proposed Route, and typically include interbedded fluvial and lacustrine (lake-deposited) sediments. The lower portion of the Tac generally consists of interbedded clay, silt, and conglomerate. The upper portion of the Tac generally consists of fine-grained deposits over conglomerate. Maximum thickness of the Tac is approximately 360 feet (Madin and Geitgey, 2007).

A.2.3.3 Sedimentary Rocks of the Idaho Group

The Idaho Group (Tic, Tig, Tpd) is from the late Miocene and Pliocene and includes mostly lacustrine sedimentary rocks associated with the large, ancient lake systems of western Idaho. These units are generally mapped along the IPC Proposed Route between MP234 and MP266 in Oregon, and between MP271 to MP293 in Idaho. They are also mapped along the Double Mountain Alternative. Sedimentary rocks in the Idaho Group consist mainly of well to poorly consolidated siltstone; fine-grained sandstone; mudstone; tuffaceous siltstone; limestone with thin beds of siltstone; pebble conglomerate; tuff; and tuffaceous sandstone. Encountered thicknesses of the Idaho Group are on the order of 350 feet to over 400 feet (Ferns et al., 1993a).

A.2.3.4 Neogene Sedimentary Rocks

A broadly named group of “Neogene Sedimentary Rocks” (Tms, Tst) are mapped along IPC Proposed Route around MP97 to MP99, and between MP153 to MP228. The rocks are generally from the Neogene period, specifically from the Miocene to late Miocene and Pliocene epochs. The units consist mainly of tuffaceous lacustrine and stream deposits, including poorly to moderately well-consolidated, bedded deposits of clay, siltstone, and sandstone, with intermixed ash and pumice, minor rhyolite flows, basalt flows, and mudflow deposits. The sedimentary rocks mainly overly basalt flows, but inter-finger with basalt in some locations. The units are up to 500 feet thick in the Durkee area (Prostka, 1967; Brooks et al., 1976; Brooks, 2006).

A.2.3.5 Sedimentary Rocks of the Olds Ferry Terrane

The Olds Ferry Terrane (composed of island arc volcanic and fore-arc marine deposits, associated with the southernmost-northeast Oregon terranes) is mainly from the Jurassic period. Sedimentary rocks of the Olds Ferry Terrane include the Weatherby Formation's Jet Creek Member (Jwj), which is mapped along the IPC Proposed Route between MP188 and MP191. The Jet Creek Member consists mainly of cobble conglomerate, wacke, siltstone, massive and thinly bedded limestone, sandstone, and minor gypsum and anhydrite. Thickness of the overall unit may be over 1,000 feet near Lime (Brooks, 1979).

A.2.3.6 Sedimentary Rocks of the Oregon-Idaho Graben

Rocks of the Oregon-Idaho Graben are of Miocene age and generally contain interbedded basalt, andesite, and dacite lava flows with small ash-flow tuffs, mafic hydrovolcanic deposits, tuffaceous sedimentary rocks, sandstone, and conglomerate. Sedimentary rock portions of this group (Tstl, Tstu) are mapped along the IPC Proposed Route between MP266 and MP271. These units consist primarily of tuffaceous siltstone and claystone, massive, well-indurated, moderately- to well-sorted, fine- to medium-grained sandstone, and medium- to coarse-grained conglomerate. Overall thicknesses range from 300 to greater than 650 feet (Ferns et al., 1993a).

A.2.4 Igneous (Intrusive and Volcanic) and Volcaniclastic Rocks

Igneous rocks result from solidification of magma or lava upon cooling. Igneous rocks can either be intrusive (plutonic), formed as a result of the magma cooling very slowly below the surface, or extrusive (volcanic), formed above the ground surface as a result of a volcanic eruption. Volcaniclastic rocks are rocks that include volcanic rock fragments. They may include any portion of non-volcanic rock fragments and may be classified as either igneous or sedimentary, depending on the geologic processes and depositional environment in which the rocks were formed.

A.2.4.1 Columbia River Basalt Group

The Columbia River Basalt Group (CRBG) is a series of voluminous basaltic lava flows that erupted from vents near the Oregon-Idaho-Washington borders during the Miocene epoch, between about 17 million and 6 million years ago. Units of the CRBG are mapped along several portions of the alignments, including MP18 to MP118; MP124 to MP126; MP151 to MP154; MP185 to MP194; and MP270 to MP271 of the IPC Proposed route; and along the Morgan Lake Alternative. Major CRBG formations exposed along or near the alignment include Grande Ronde Basalt (Tcg, Tcgf, Tcgn1, Tcgn2, Tcgr2, Tg, Tgn2, Tgr2) and Wanapum Basalt (Tbf, Tcwf, Tf). These and other individual units have been defined on the basis of stratigraphic position, geochemistry, magnetic polarity, and petrography (Madin and Geitgey, 2007). CRBG flows generally occur sequentially on top of one another, often with thin interbeds of sediment between them. Undifferentiated CRBG units on the geologic maps include Tb, Tbtv, Tcr, and Tm?b.

The Grande Ronde Basalt consists of fine-grained flow-on-flow sequences that comprise the thickest and most voluminous portion of the CRBG. This unit is described by Madin and Geitgey (2007) as “bluish-black aphyric to sparsely plagioclase phyric lava flows.” The Frenchman Springs member of the Wanapum Basalt is a thick and widely distributed unit. Individual flows typically range from 3 to 100 feet, and the total thickness of rock encountered in wells ranges from 150 to 620 feet. Flows typically have rubbly flow tops; solid, jointed interiors; and are typically flow-on-flow basalts with little or no intervening sediments (Madin and Geitgey, 2007).

A.2.4.2 Idaho Batholith

The Idaho Batholith is a large igneous intrusion of Cretaceous to Eocene age that covers about 15,400 square miles in central Idaho. While most of the unit is located in central Idaho, smaller areas of the intrusion are also mapped south of the Snake River Plain, on the western side of the state. Mapped portions of the Idaho Batholith (Kii) intersect the IPC Proposed Route between MP290 and MP291. Rock types within the unit include granite and granodiorite.

A.2.4.3 Igneous Rocks of the Idaho Group

Igneous rocks of the Idaho Group include some olivine basalt flows of late Miocene age (Tbou). These flows are mainly black to greenish- and grayish-black basalt flows and flow breccias, interbedded with tuffaceous siltstones and claystones. Tbou is mapped along the IPC Proposed Route between MP250 and MP256. Thickness of the unit varies from 50 feet to more than 400 feet (Ferns et al., 1993a).

A.2.4.4 Idavada Volcanics

The Idavada Volcanics are a collection of Miocene- to Pliocene-age silicic volcanic rocks that include rhyolite and pyroclastic flows of welded ash and vitric tuff. Mapped portions of the Idavada Volcanics (Tmf) intersect the IPC Proposed Route between MP272 and MP289.

A.2.4.5 Lake Owyhee Volcanic Field

Lake Owyhee Volcanic Field volcaniclastic rocks along the alignment are of Miocene age and include silicic welded and non-welded tuff (Twt), mapped intermittently between MP153 and MP180 of the IPC Proposed Route. Non-welded varieties of the tuff include ash-flow and air-fall tuff, some of which was water-lain. The unit also contains small patches of vitric welded tuff that are gradationally overlain by lake and stream sediments of the lower Pliocene (Brooks et al., 1976). Lesser amounts of rhyolite and andesite are mapped along the IPC Proposed Route between MP228 and MP229.

A.2.4.6 Nevadan Intrusives

The Nevadan Intrusives are Jurassic/Cretaceous plutons consisting primarily of quartz diorite and granodiorite (Brooks, et al., 1976; Prostka, 1967). Limited amounts of Nevadan Intrusives (KJi, kgd) are mapped along the IPC Proposed Route near MP147 and MP178.

A.2.4.7 Igneous Rocks of the Oregon-Idaho Graben

The Oregon-Idaho Graben is comprised of a series of interbedded olivine basalt, andesite, and dacite lava flows of Miocene age. Units of the Oregon-Idaho Graben are mapped along the IPC proposed Route between MP228 and MP266, and along the Double Mountain Alternative. Lower alkaline lava flows (Tbcl) are comprised mainly of dark gray to black, fine-grained platy lava flows and breccias that typically weather to brown. Upper alkaline lava flows (Tbcu) are comprised mainly of grayish black olivine basalt, basaltic andesite, and andesite flows. Middle lava flows (Tbcm) consist of gray, vesicular, mainly basalt and basaltic andesite. Lower olivine-rich basalt flows (Tbol) are mainly black to dark-gray and vesicular. Upper calc-alkaline rhyolite and dacite flows and domes (Trcu) are dark gray and gray rhyolite, rhyodacite, and dacite, which weather to various shades of red. Unit thickness is estimated to be over 300 feet thick in some locations (Ferns et al., 1993a).

A.2.4.8 Powder River Volcanic Field

The Powder River Volcanic Field is comprised of a series of Miocene andesite, dacite, olivine-rich basalt, and basaltic lava flows resulting from multiple small volcanoes located between La Grande and Baker City. Units of the Powder River Volcanic Field are mapped along the IPC Proposed Route between MP100 and MP154, between MP185 and MP187, and along the Morgan Lake Alternative. Olivine basalt flows overlying ash-flows are from the earliest of eruptions. Major formations of the Powder River Volcanic Field include Andesite of Sawtooth Crater (Ta, Tan, Tpa), Basalt of Little Catherine Creek (Tb, Tb1, Tgo, Tob, Tpb, Tpgb, Tyb), and Dacite of Mt. Emily (Td, Tpd, Tpgd). The Andesite of Sawtooth Crater is typically fine-grained, plated andesite erupted from locations such as Sawtooth Ridge, located northeast of Baker City (Swanson, 1981). Basalt of Little Catherine Creek is commonly olivine basalt; and flows in the Baker Valley to Lower Powder Valley area are often severely faulted. The Dacite of Mt. Emily consists of a single lava flow with matrix-supported basal breccias and an upper massive, locally vesicular flow top. Cumulative dacite flows near Mt. Emily (Tpgd) are estimated to be more than 400 feet thick (Ferns et al., 2001b).

A.2.4.9 Igneous Rocks of the Wallowa Terrane

The Wallowa Terrane consists of Permian/Triassic island arc volcanic and shallow marine deposits associated with the northernmost of the northeast Oregon accreted terranes. Igneous rocks of the Wallowa Terrane (TRPv, TRqd) are mapped along the IPC Proposed Route between MP132 and MP137. TRPv rock types may include basaltic lava flows, flow breccias, and volcaniclastic rocks. TRqd rock types may include quartz diorite, diorite, and granite (Brooks et al., 1976).

A.2.5 Metamorphic Rocks

Metamorphic rocks are igneous, sedimentary, or preexisting metamorphic rocks that have been physically and/or chemically altered over time by temperature, pressure, and/or circulation of hydrothermal fluids. Metamorphic rocks are included in the Baker Terrane, the Olds Ferry Terrane, and the Wallowa Terrane.

A.2.5.1 Metamorphic Rocks of the Baker Terrane

Metamorphic rocks of the Baker Terrane are Paleozoic to Mesozoic in age and include the Burnt River Schist (g, gb, m, mg/md, mqbd, p, q, TRgb, TRn, TRPbi) and the Elkhorn Ridge Argillite (MZPZa). Common rock types among the subunits include greenshchist, phyllite, quartzite, marble, and argillite (OGDC, 2015). Metamorphic Rocks of the Baker Terrane are generally mapped along the IPC Proposed Route between MP151 and MP152, and between miles MP161 and MP180.

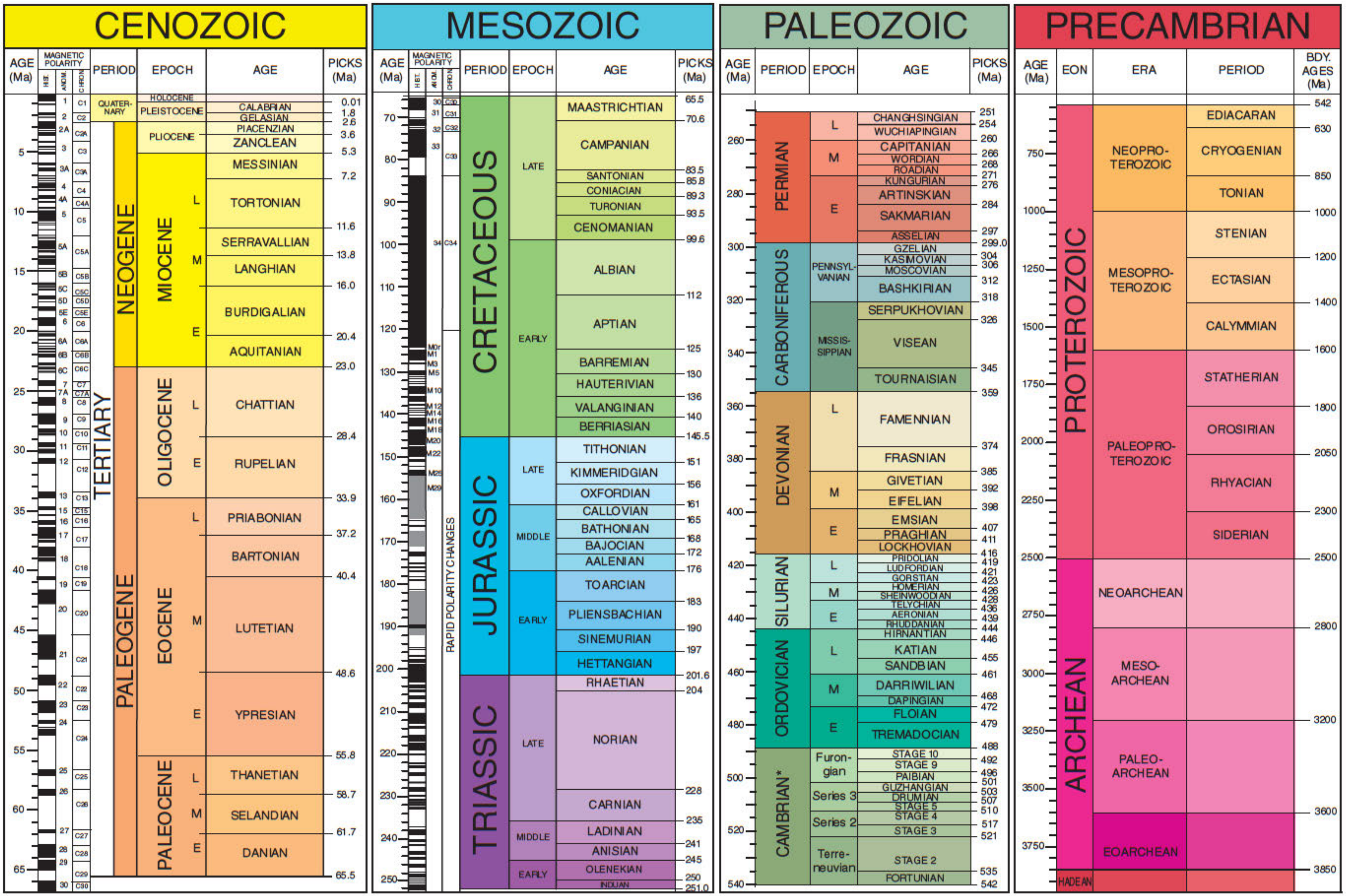
A.2.5.2 Metamorphic Rocks of the Olds Ferry Terrane

The Olds Ferry Terrane is composed of island arc volcanic and fore-arc marine deposits associated with the southernmost of the northeast Oregon terranes. Metamorphic rocks of the Olds Ferry Terrane include those in the Jurassic Weatherby Formation (Jw, TRg), which are generally mapped along the IPC Proposed Route between MP180 and MP190. Metamorphic rocks within the Weatherby Formation include gray phyllite, argillite, and slate. Overall unit thickness may be more than 1,000 feet (Brooks, 1979).

A.2.5.3 Metamorphic Rocks of the Wallowa Terrane

The Wallowa Terrane consists of Permian/Triassic island arc volcanic and shallow marine deposits associated with the northernmost of the northeast Oregon accreted terranes. Metamorphic rocks within the terrane group include the Clover Creek Greenstone (TRPwc, TRc) and other mafic metamorphic rocks (Tri), such as greenshcist (OGDC, 2015). Mapped portions of the unit intersect the IPC Proposed Route between MP126 to MP148.

GEOLOGIC TIME SCALE



*International ages have not been fully established. These are current names as reported by the International Commission on Stratigraphy.

Walker, J.D., and Geissman, J.W., compilers, 2009, Geologic Time Scale: Geological Society of America, doi: 10.1130/2009.CTS004R2C. ©2009 The Geological Society of America.

Sources for nomenclature and ages are primarily from Gradstein, F., Ogg, J., Smith, A., et al., 2004, A Geologic Time Scale 2004: Cambridge University Press, 589 p. Modifications to the Triassic after: Furin, S., Preto, N., Rigo, M., Roghi, G., Gianolla, P., Crowley, J.L., and Bowring, S.A., 2006, High-precision U-Pb zircon age from the Triassic of Italy: Implications for the Triassic time scale and the Carnian origin of calcareous nannoplankton and dinosaurs: Geology, v. 34, p. 1009–1012, doi: 10.1130/G22967A.1; and Kent, D.V., and Olsen, P.E., 2008, Early Jurassic magnetostratigraphy and paleolatitudes from the Hartford continental rift basin (eastern North America): Testing for polarity bias and abrupt polar wander in association with the central Atlantic magmatic province: Journal of Geophysical Research, v. 113, B06105, doi: 10.1029/2007JB005407.

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TABLE A2: SUMMARY OF SURFICIAL GEOLOGIC MAP UNITS

Map Unit Label	State	Lithologic Category	Map Unit Name	Age	Terrane / Group	Formation	Member	Geologic Material Type
g	OR	Metamorphic Rocks	Greenstones and greenschists	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
gb	OR	Metamorphic Rocks	Gabbro and meta-gabbro	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
JKi	OR	Igneous Rocks	Quartz diorite	Jurassic/Cretaceous	Nevadan Intrusives	No data	No data	intermediate composition lithologies
JKqd	OR	Metamorphic Rocks	Quartz diorite	Jurassic/Cretaceous	Nevadan Intrusives	Pedro Mountain Stock	No data	intermediate composition lithologies
Jw	OR	Metamorphic Rocks	Weatherby Formation	Jurassic	Olds Ferry Terrane	Weatherby Formation	Jet Creek	mixed grained sediments
Jwj	OR	Sedimentary Rocks	Jet Creek member	Jurassic	Olds Ferry Terrane	Weatherby Formation	Jet Creek	mixed grained sediments
Jwjl	OR	Sedimentary Rocks	Jet Creek member limestone	Jurassic	Olds Ferry Terrane	Weatherby Formation	Jet Creek	limestone
kgd	OR	Igneous Rocks	Quartz diorite and granodiorite	Jurassic/Cretaceous	Nevadan Intrusives	No data	No data	intermediate composition lithologies
Kii	ID	Igneous Rocks	No data	Cretaceous to Eocene	Idaho Batholith	No data	No data	monzogranite
KJi	OR	Igneous Rocks	Upper Jurassic-lower Cretaceous plutons	Jurassic/Cretaceous	Nevadan Intrusives	No data	No data	intermediate composition lithologies
m	OR	Metamorphic Rocks	Marble	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	marble
mg/md	OR	Metamorphic Rocks	Metamorphosed intrusions	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
mqbd	OR	Metamorphic Rocks	Metamorphosed intrusions	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
mqd	OR	Metamorphic Rocks	Metamorphosed intrusions	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
mvc	OR	Metamorphic Rocks	Metavolcaniclastic rocks and greenstones	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	volcaniclastic rocks
MZPZa	OR	Metamorphic Rocks	Sedimentary and volcanic rocks	Paleozoic/Mesozoic	Baker Terrane	Elkhorn Ridge Argillite	No data	fine grained sediments
MZPZsv	OR	Metamorphic Rocks	Foliated sedimentary and volcanic rocks	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	mixed lithologies
p	OR	Metamorphic Rocks	Phyllitic rocks	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	sedimentary rocks
Pe	OR	Sedimentary Rocks	Elkhorn Ridge Argillite	Paleozoic/Mesozoic	Baker Terrane	Elkhorn Ridge Argillite	No data	fine grained sediments
q	OR	Metamorphic Rocks	Quartzite	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	chert
Qa	ID	Unconsolidated Sediments	No data	Quaternary	No data	No data	No data	gravel; floodplain, alluvial fan, colluvium
Qa	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
Qal	OR	Unconsolidated Sediments	Stream alluvium and alluvial fans	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
Qal	OR	Unconsolidated Sediments	Lacustrine and alluvial plain deposits	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	fine grained sediments
Qal	OR	Unconsolidated Sediments	Alluvium and colluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
Qas	OR	Unconsolidated Sediments	Terrace gravels and alluvial fan deposits	Quaternary	Quaternary surficial deposits	Alluvial fan deposits	No data	mixed grained sediments
Qas1	OR	Unconsolidated Sediments	Terrace gravels and alluvial fan deposits	Quaternary	Quaternary surficial deposits	Terrace deposits	No data	mixed grained sediments
Qcf	OR	Unconsolidated Sediments	Colluvium and talus deposits	Quaternary	Quaternary surficial deposits	Colluvial deposits	No data	mixed grained sediments
Qdf	OR	Landslide Deposits	Debris-avalanche and debris-flow deposits	Quaternary	Quaternary surficial deposits	Landslide deposits	No data	mixed grained sediments
Qe	OR	Unconsolidated Sediments	Eolian sand and ash	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
Qf	OR	Unconsolidated Sediments	Alluvial fill	Quaternary	Quaternary surficial deposits	Terrace deposits	No data	mixed grained sediments
Qf	OR	Unconsolidated Sediments	Alluvial fan deposits	Quaternary	Quaternary surficial deposits	Alluvial fan deposits	No data	mixed grained sediments
Qfd	OR	Unconsolidated Sediments	Fluvial fan delta deposits	Quaternary	Quaternary surficial deposits	Fan delta deposits	No data	coarse grained sediments
Qls	OR	Landslide Deposits	Landslide debris	Quaternary	Quaternary surficial deposits	Landslide deposits	No data	mixed grained sediments
Qls	OR	Landslide Deposits	Landslides	Quaternary	Quaternary surficial deposits	Landslide deposits	No data	mixed grained sediments
Qls	OR	Landslide Deposits	Landslide deposits	Quaternary	Quaternary surficial deposits	Landslide deposits	No data	mixed grained sediments
Qmf	OR	Unconsolidated Sediments	Missoula Flood deposits	Quaternary	Quaternary surficial deposits	Missoula Flood deposits	No data	mixed grained sediments
Qpa	ID	Unconsolidated Sediments	No data	Late Pleistocene	No data	Caldwell Beds	No data	stratified glacial sediment
Qpug	ID	Unconsolidated Sediments	No data	Late Pleistocene	Lake Bonneville Flood Deposits and Snake River Group	Multiple	No data	sand and gravel
Qsbf	OR	Unconsolidated Sediments	Fluviatile sand, gravel, and silt	Quaternary	Quaternary surficial deposits	Bonneville Flood deposits	No data	fine grained sediments
Qtg	OR	Unconsolidated Sediments	Terrace and fan deposits	Quaternary	Quaternary surficial deposits	Terrace deposits	No data	mixed grained sediments
QTt	OR	Sedimentary Rocks	Terrace deposits	Tertiary/Quaternary	Neogene sedimentary rocks	Terrace deposits	No data	mixed grained sediments

TABLE A2: SUMMARY OF SURFICIAL GEOLOGIC MAP UNITS

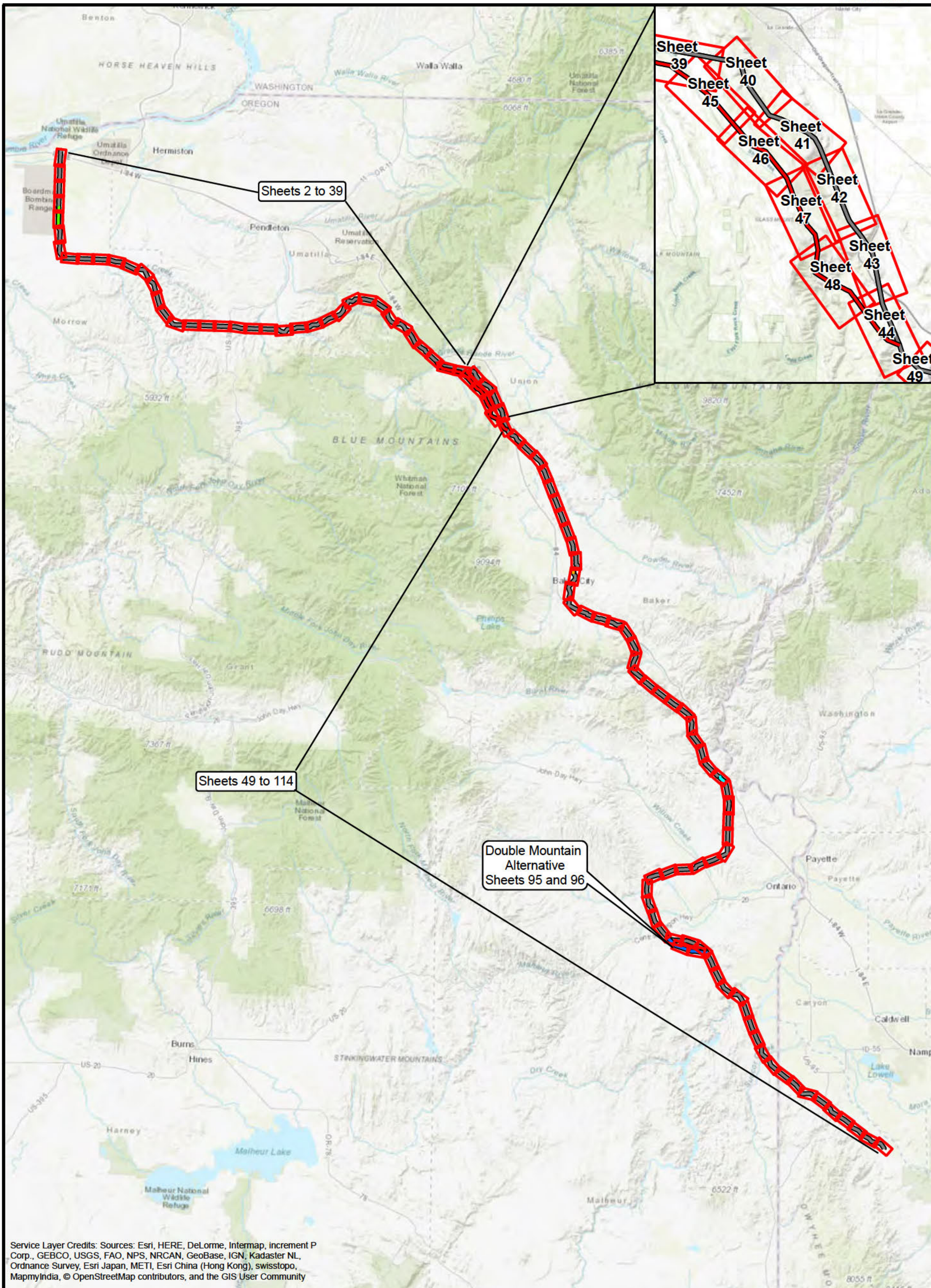
Map Unit Label	State	Lithologic Category	Map Unit Name	Age	Terrane / Group	Formation	Member	Geologic Material Type
Qu	OR	Unconsolidated Sediments	Undifferentiated surficial deposits	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
Ta	OR	Igneous Rocks	Andesite flows and domes	Miocene	Powder River Volcanic Field	Andesite of Sawtooth Crater	No data	andesite
Tac	OR	Sedimentary Rocks	Alkali Canyon Formation	Miocene/Pliocene	Dalles Group	Alkali Canyon Formation	No data	mixed grained sediments
Tan	OR	Igneous Rocks	Andesite	Miocene	Powder River Volcanic Field	Andesite of Sawtooth Crater	No data	andesite
Tb	OR	Igneous Rocks	Basalt	Miocene	Columbia River Basalt Group	No data	No data	basalt
Tb	OR	Igneous Rocks	Porphyritic olivine basalt	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tb	OR	Igneous Rocks	Basalt	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tb	OR	Igneous Rocks	Basalt	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tb1	OR	Igneous Rocks	Basalt and andesite	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tbcl	OR	Igneous Rocks	Lower calc-alkaline lava flows	Miocene	Oregon-Idaho Graben	No data	No data	basalt
Tbcm	OR	Igneous Rocks	Middle calc-alkaline lava flows	Miocene	Oregon-Idaho Graben	No data	No data	basalt
Tbcu	OR	Igneous Rocks	Upper calc-alkaline lava flows	Miocene	Oregon-Idaho Graben	No data	No data	basalt
Tbf	OR	Igneous Rocks	Basalt	Miocene	Columbia River Basalt Group	Wanapum Basalt	No data	basalt
Tbf1	OR	Igneous Rocks	Basalt	Miocene	Powder River Volcanic Field	Dacite of Mt. Emily	No data	dacite
Tbol	OR	Igneous Rocks	Lower olivine basalt flows	Miocene	Oregon-Idaho Graben	No data	No data	basalt
Tbou	OR	Igneous Rocks	Upper olivine basalt flows	Miocene	Idaho Group	No data	No data	basalt
Tbtv	OR	Igneous Rocks	Eastern tholeiitic lavas	Miocene	Columbia River Basalt Group	No data	No data	mixed lithologies
Tcg	OR	Igneous Rocks	Grande Ronde Basalt	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	No data	basalt
Tcgf	OR	Igneous Rocks	Ferroandesite of Fiddlers Hell	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Andesite of Fiddlers Hell	andesite
Tcgn1	OR	Igneous Rocks	N1 Grande Ronde Basalt	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 1	basalt
Tcgn2	OR	Igneous Rocks	N2 Grande Ronde Basalt	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 2	basalt
Tcgn2	OR	Igneous Rocks	N2 magnetostratigraphic unit	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 2	basalt
Tcgr2	OR	Igneous Rocks	R2 Grande Ronde Basalt	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Reversed mag. unit 2	basalt
Tcr	OR	Igneous Rocks	Columbia River Basalt	Miocene	Columbia River Basalt Group	No data	No data	basalt
Tcwf	OR	Igneous Rocks	Frenchman Springs basalt	Miocene	Columbia River Basalt Group	Wanapum Basalt	Frenchman Springs Member	basalt
Td	OR	Igneous Rocks	Dacite flows and domes	Miocene	Powder River Volcanic Field	Dacite of Mt. Emily	No data	dacite
Tdr	OR	Volcaniclastic Rocks	Dooley rhyolite breccia	Miocene	Lake Owyhee Volcanic Field	Dooley Mountain Complex	No data	felsic composition lithologies
Tf	OR	Igneous Rocks	Undifferentiated Frenchman Springs flows	Miocene	Columbia River Basalt Group	Wanapum Basalt	Frenchman Springs Member	basalt
Tfls	OR	Sedimentary Rocks	Fluvial and lacustrine basinal sediments	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tfs	OR	Sedimentary Rocks	Fluvial and colluvial sediments	Paleocene/Eocene	Paleogene sedimentary rocks	No data	No data	mixed grained sediments
Tg	OR	Igneous Rocks	Grande Ronde Basalt, undivided	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	No data	basalt
Tgn2	OR	Igneous Rocks	N2 magnetostratigraphic unit	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 2	basalt
Tgo	OR	Igneous Rocks	Basalt of Powder River	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tgr2	OR	Igneous Rocks	R2 magnetostratigraphic unit	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Reversed mag. unit 2	basalt
Th	OR	Sedimentary Rocks	Herren Formation	Paleocene/Eocene	Paleogene sedimentary rocks	Herren Formation	No data	mixed grained sediments
Tic	OR	Sedimentary Rocks	Lacustrine sediments	Miocene/Pliocene	Idaho Group	No data	No data	fine grained sediments
Tig	OR	Sedimentary Rocks	Lacustrine sediments	Miocene/Pliocene	Idaho Group	No data	No data	fine grained sediments
Tm?b	ID	Igneous Rocks	No data	Miocene	Columbia River Basalt Group	Multiple	No data	basalt
Tmd	ID	Volcaniclastic Rocks	No data	Miocene	No data	Payette Fm, Sucker Creek Fm, Latah Fm	No data	volcanic, pyroclastic, tuff
Tmf	ID	Igneous Rocks	No data	Miocene	Idavada Volcanics	Cougar Pt. Welded Tuff, Jenny Creek Tuff	No data	rhyolite, pyroclastic, ash-flow
Tms	OR	Sedimentary Rocks	Sedimentary rocks	Miocene/Pliocene	Neogene sedimentary rocks	No data	No data	mixed grained sediments
Tms	OR	Sedimentary Rocks	Sedimentary rocks	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tob	OR	Igneous Rocks	Olivine basalt sheet flows	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tob	OR	Igneous Rocks	Olivine basalt	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt

TABLE A2: SUMMARY OF SURFICIAL GEOLOGIC MAP UNITS

Map Unit Label	State	Lithologic Category	Map Unit Name	Age	Terrane / Group	Formation	Member	Geologic Material Type
Tpa	OR	Igneous Rocks	Andesite and basaltic andesite	Miocene	Powder River Volcanic Field	Andesite of Sawtooth Crater	No data	andesite
Tpb	OR	Igneous Rocks	Basalt of Little Catherine Creek	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tpb1	OR	Igneous Rocks	Basalt	Miocene	Kivett Volcanics	No data	No data	andesite
Tpbo	OR	Igneous Rocks	Basanite and trachybasalt	Miocene	Powder River Volcanic Field	Basanite of Horseshoe Basin	No data	basanite
Tpd	OR	Igneous Rocks	Dacite	Miocene	Powder River Volcanic Field	Dacite of Mt. Emily	No data	dacite
Tpd	ID	Sedimentary Rocks	No data	Pliocene	Idaho Group	Multiple	No data	sandstone
Tpgb	OR	Igneous Rocks	Olivine basalt	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt
Tpgd	OR	Igneous Rocks	Undifferentiated andesite and dacite	Miocene	Powder River Volcanic Field	Dacite of Mt. Emily	No data	dacite
Tr3	OR	Igneous Rocks	Rhyolite and andesite	Miocene	Lake Owyhee Volcanic Field	Littlefield Rhyolite	No data	rhyolite
Trcu	OR	Igneous Rocks	Upper calc-alkaline rhyolite and dacite flows and domes	Miocene	Oregon-Idaho Graben	No data	No data	rhyolite
TRg	OR	Metamorphic Rocks	Gray phyllite	Jurassic	Olds Ferry Terrane	Weatherby Formation	Jet Creek	mixed grained sediments
TRg1	OR	Metamorphic Rocks	Gray phyllite	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	sedimentary rocks
TRgb	OR	Metamorphic Rocks	Pre-upper Triassic intrusive complex	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
TRgb	OR	Metamorphic Rocks	Mafic and ultramafic rocks	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
TRgb2	OR	Metamorphic Rocks	Pre-upper Triassic intrusive complex	Permian	Wallowa Terrane	No data	No data	mafic composition lithologies
TRh	OR	Volcaniclastic Rocks	Huntington Formation	Permian/Triassic	Olds Ferry Terrane	Huntington Volcanics	No data	mixed lithologies
TRi	OR	Metamorphic Rocks	Mafic intrusive rocks	Permian	Wallowa Terrane	No data	No data	mafic composition lithologies
TRn	OR	Metamorphic Rocks	Nelson marble	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	marble
TRPbe	OR	Sedimentary Rocks	Elkhorn Ridge Argillite	Paleozoic/Mesozoic	Baker Terrane	Elkhorn Ridge Argillite	No data	fine grained sediments
TRPbi	OR	Metamorphic Rocks	Pre-Tertiary rocks, undivided	Paleozoic/Mesozoic	Baker Terrane	Burnt River Schist	No data	greenstone
TRPms	OR	Metamorphic Rocks	Chlorite-mica schists of Pearson Creek	Paleozoic/Mesozoic	Mountain Home Complex	No data	No data	schist
TRPv	OR	Volcaniclastic Rocks	Volcanic and sedimentary rocks	Permian/Triassic	Wallowa Terrane	Clover Creek Greenstone	No data	greenstone
TRPwc	OR	Metamorphic Rocks	Clover Creek Greenstone	Permian/Triassic	Wallowa Terrane	Clover Creek Greenstone	No data	greenstone
TRqd	OR	Igneous Rocks	Pre-upper Triassic intrusive complex	Triassic	Wallowa Terrane	No data	No data	felsic composition lithologies
TRqd	OR	Igneous Rocks	Quartz diorite, diorite, and gabbro	Triassic	Wallowa Terrane	No data	No data	felsic composition lithologies
TRv	OR	Metamorphic Rocks	Volcanic and metavolcanic rocks	Permian/Triassic	Wallowa Terrane	Clover Creek Greenstone	No data	greenstone
Ts	OR	Sedimentary Rocks	Sedimentary rocks	Miocene/Pliocene	Neogene sedimentary rocks	No data	No data	mixed grained sediments
Tsal	OR	Sedimentary Rocks	Lower arkosic sandstone and conglomerate	Miocene	Oregon-Idaho Graben	No data	Lower member	coarse grained sediments
Tsau	OR	Sedimentary Rocks	Upper arkosic sandstone, conglomerate and tuffaceous siltstone	Miocene	Oregon-Idaho Graben	No data	Upper member	coarse grained sediments
Tst	OR	Sedimentary Rocks	Tuffaceous sedimentary rocks	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tst	OR	Sedimentary Rocks	Tuffaceous sedimentary rocks	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tst	OR	Sedimentary Rocks	Tuffaceous lacustrine and fluviatile sediments	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tst	OR	Sedimentary Rocks	Lacustrine and fluviatile deposits	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tst	OR	Sedimentary Rocks	Tuffaceous lake and stream deposits	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
Tstl	OR	Sedimentary Rocks	Lower tuffaceous sedimentary rocks	Miocene	Oregon-Idaho Graben	No data	Lower member	tuffaceous sedimentary rocks
Tstu	OR	Sedimentary Rocks	Tuffaceous siltstones, tuffs, and nonwelded ash-flow tuff	Miocene	Oregon-Idaho Graben	No data	Upper member	tuffaceous sedimentary rocks
Tt	OR	Volcaniclastic Rocks	Welded tuff	Miocene	Lake Owyhee Volcanic Field	No data	No data	welded tuff
Ttat	OR	Volcaniclastic Rocks	Welded ash-flow tuffs	Miocene	Lake Owyhee Volcanic Field	No data	No data	ash flow tuff
Twt	OR	Volcaniclastic Rocks	Silicic welded and non-welded tuff	Miocene	Lake Owyhee Volcanic Field	No data	No data	welded tuff
Tx	OR	Volcaniclastic Rocks	No name in explanation	Miocene	Neogene volcanic rocks	No data	No data	mixed lithologies
Tyb	OR	Igneous Rocks	Basalt	Miocene	Powder River Volcanic Field	No data	Little Catherine Creek	basalt

TABLE A3: SUMMARY OF GEOLOGIC INFORMATION FOR MULTI-USE AREAS AWAY FROM PROPOSED ALIGNMENT

Multi-Use Area	Northing (meters)	Easting (meters)	Map Unit Label	State	Lithologic Category	Map Unit Name	Age	Terrane / Group	Formation	Member	Geologic Material Type
MU BA-02	4958846	436511	Tst	OR	Sedimentary Rocks	Tuffaceous lacustrine and fluviatile sediments	Miocene	Neogene sedimentary rocks	No data	No data	fine grained sediments
MU BA-04	4936252	461150	Qtg	OR	Unconsolidated Sediments	Terrace deposits	Quaternary	Quaternary surficial deposits	Terrace deposits	No data	mixed grained sediments
MU BA-06	4911097	478177	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU MA-03	4866475	469461	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU MA-07	4839634	492740	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU MA-07	4839634	492740	Qsbf	OR	Unconsolidated Sediments	Fluviatile sand, gravel, and silt	Quaternary	Quaternary surficial deposits	Bonneville Flood deposits	No data	fine grained sediments
MU MA-08	4835510	492443	Tic	OR	Sedimentary Rocks	Lacustrine sediments	Miocene/Pliocene	Idaho Group	No data	No data	fine grained sediments
MU MO-02	5051813	301969	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU MO-02	5051813	301969	Tac	OR	Sedimentary Rocks	Alkali Canyon Formation	Miocene/Pliocene	Dalles Group	Alkali Canyon Formation	No data	mixed grained sediments
MU MO-05	5028732	329294	Tgn2	OR	Igneous Rocks	N2 magnetostratigraphic unit	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 2	basalt
MU OW-1	4822912	498766	Tpb	ID	Igneous Rocks	Basalt	Pliocene	No data	No data	No data	Basalt
MU OW-1	4822912	498766	Tpd	ID	Sedimentary Rocks	Sandstone	Pliocene	No data	No data	No data	Sandstone Conglomerate
MU UM-01	5075048	315092	Qmf	OR	Unconsolidated Sediments	Missoula Flood deposits	Quaternary	Quaternary surficial deposits	Missoula Flood deposits	No data	mixed grained sediments
MU UM-02	5043374	327250	Tgn2	OR	Igneous Rocks	N2 magnetostratigraphic unit	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 2	basalt
MU UM-04	5033588	356470	Tgn2	OR	Igneous Rocks	N2 magnetostratigraphic unit	Miocene	Columbia River Basalt Group	Grande Ronde Basalt	Normal mag. unit 2	basalt
MU UM-05	5028834	363663	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU UM-05	5028834	363663	Th	OR	Sedimentary Rocks	Herren Formation	Paleocene/Eocene	Paleogene sedimentary rocks	Herren Formation	No data	mixed grained sediments
MU UN-01	5015809	420060	Qal	OR	Unconsolidated Sediments	Lacustrine and alluvial plain deposits	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	fine grained sediments
MU UN-01	5015809	420060	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU UN-03	4993637	426871	Qal	OR	Unconsolidated Sediments	Alluvium	Quaternary	Quaternary surficial deposits	Alluvial deposits	No data	mixed grained sediments
MU UN-03	4993637	426871	Ts	OR	Sedimentary Rocks	Sedimentary rocks	Miocene/Pliocene	Neogene sedimentary rocks	No data	No data	mixed grained sediments
MU UN-04	4986206	426744	Ts	OR	Sedimentary Rocks	Sedimentary rocks	Miocene/Pliocene	Neogene sedimentary rocks	No data	No data	mixed grained sediments



LEGEND

- IPC Proposed Route
- West Bombing Range Road Alternative 1
- West Bombing Range Road Alternative 2
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- Proposed 138-kV Rebuild
- Double Mountain Alternative
- Map Sheets

0 16 32 Miles

Boardman - Hemingway
500kV Transmission Line
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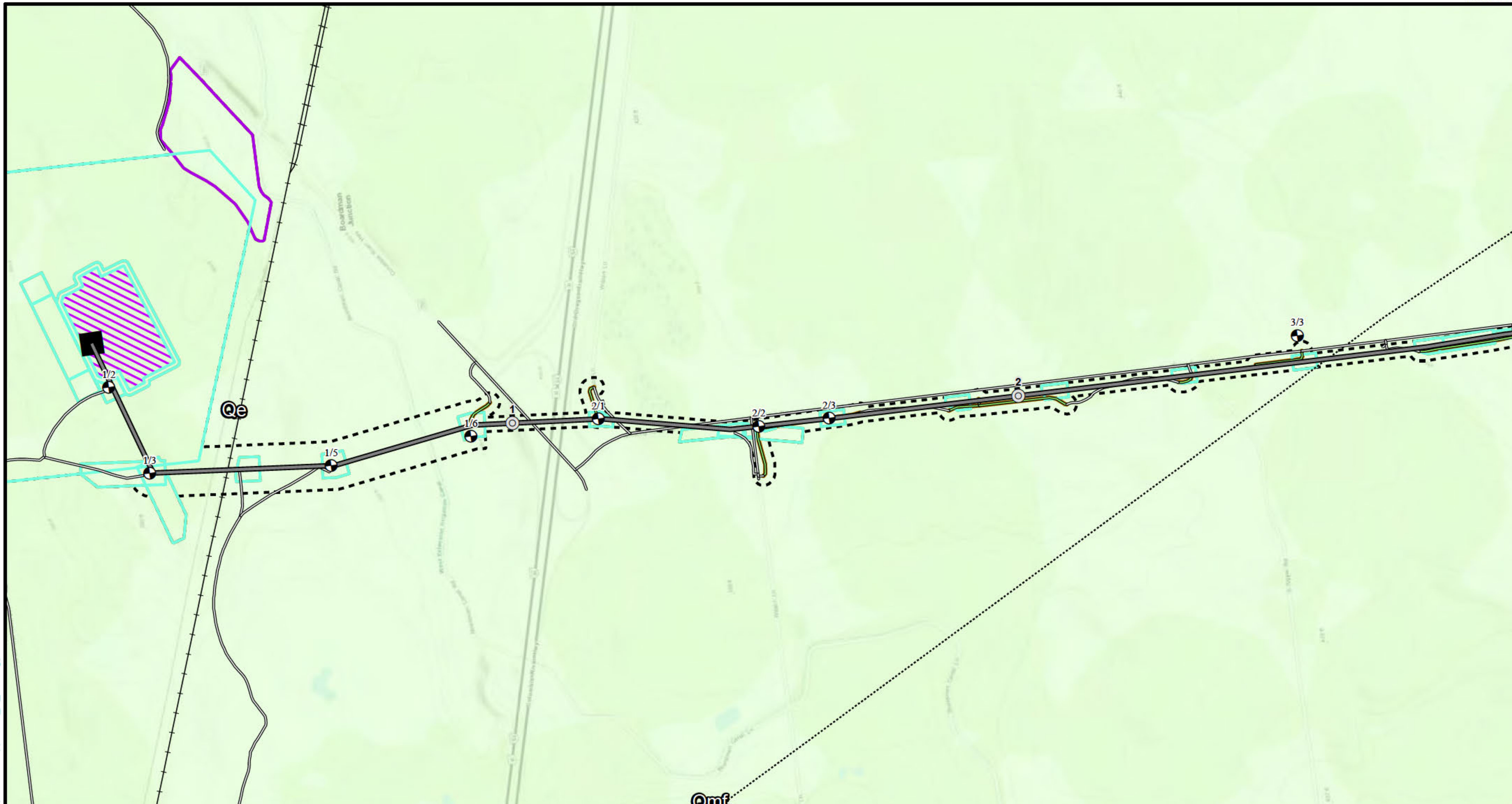

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ROADS
- New, Bladed
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- Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000
Feet

Boardman - Hemingway
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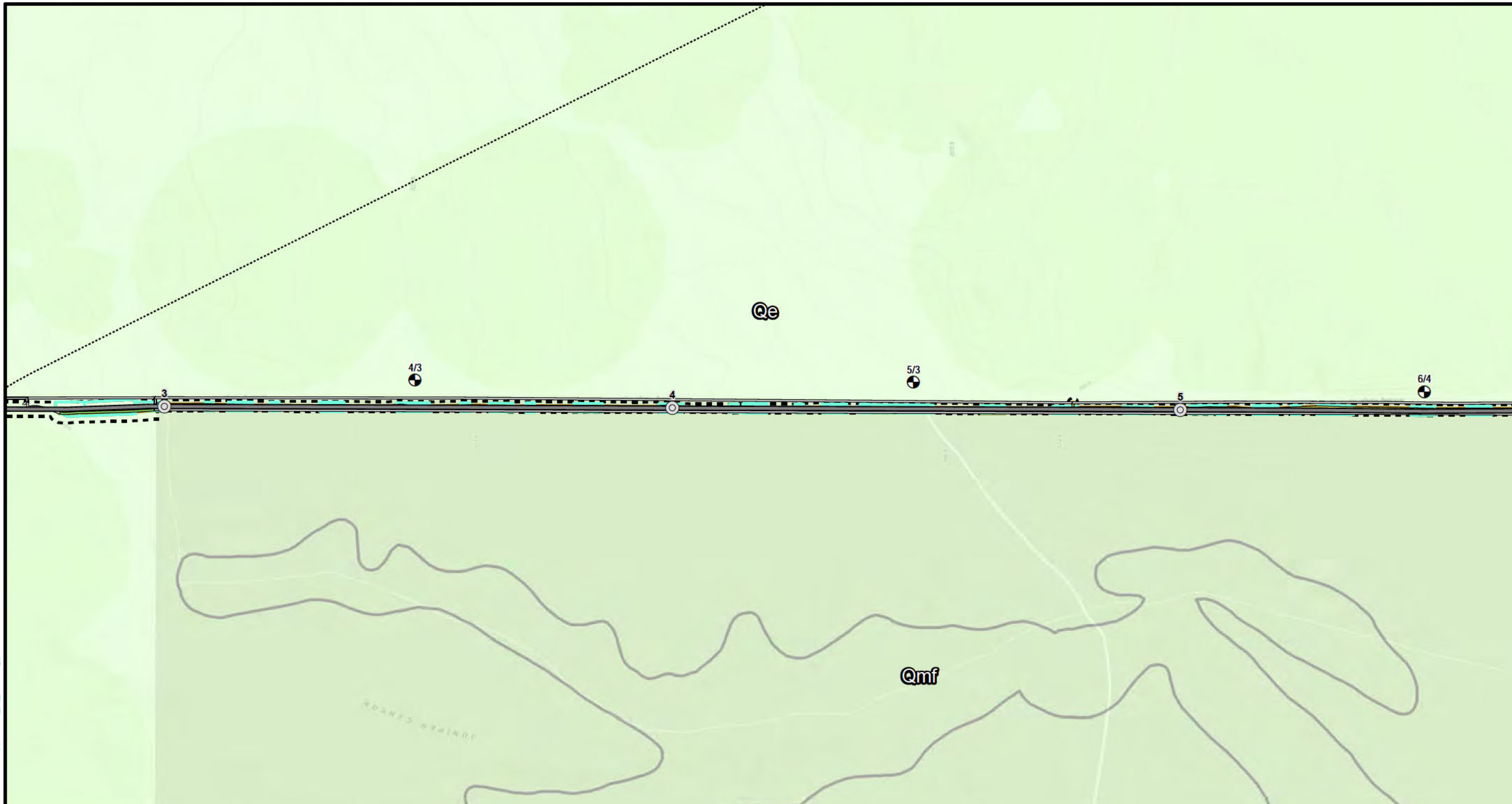

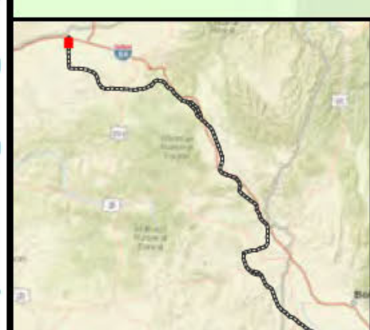

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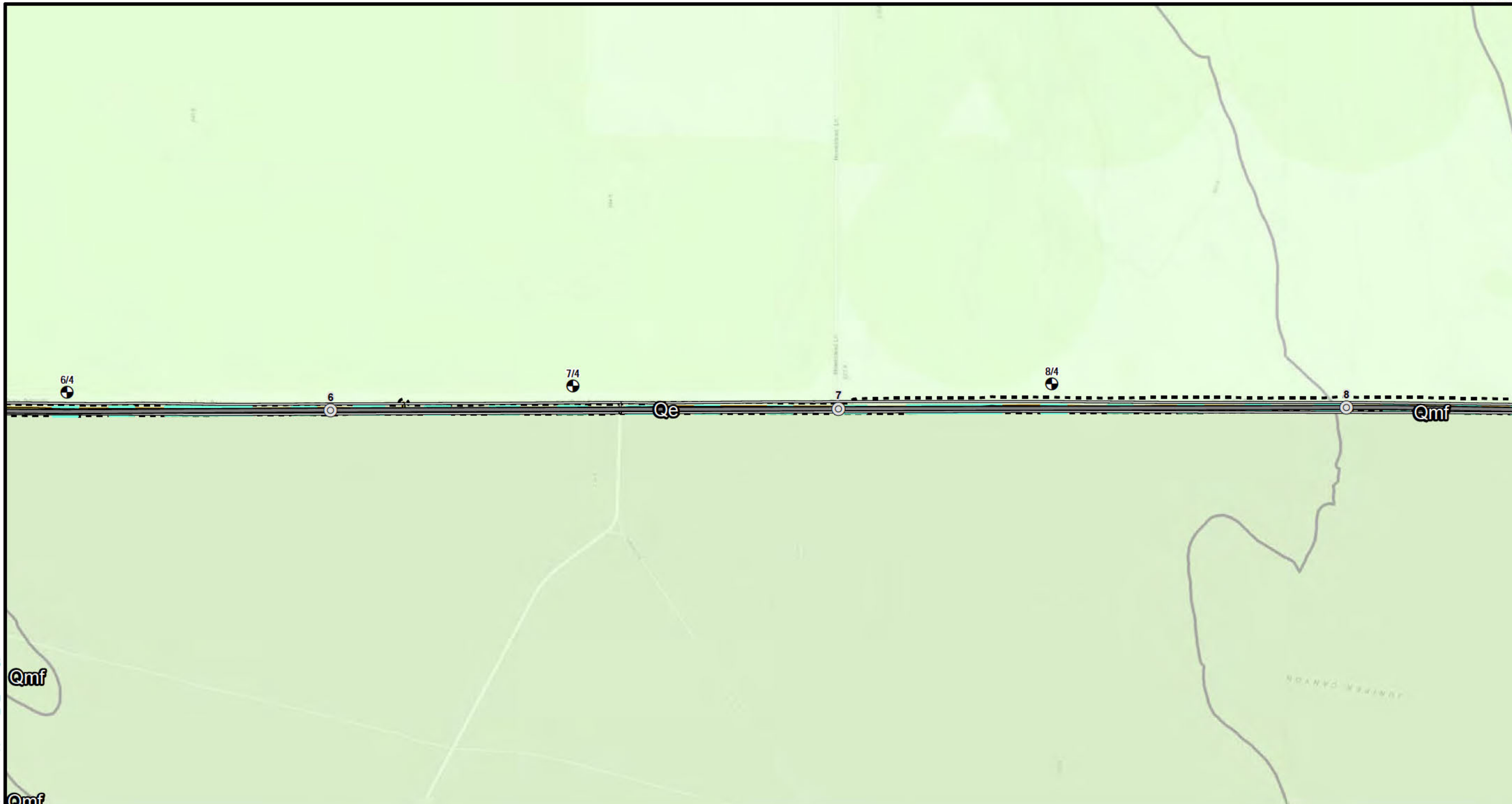

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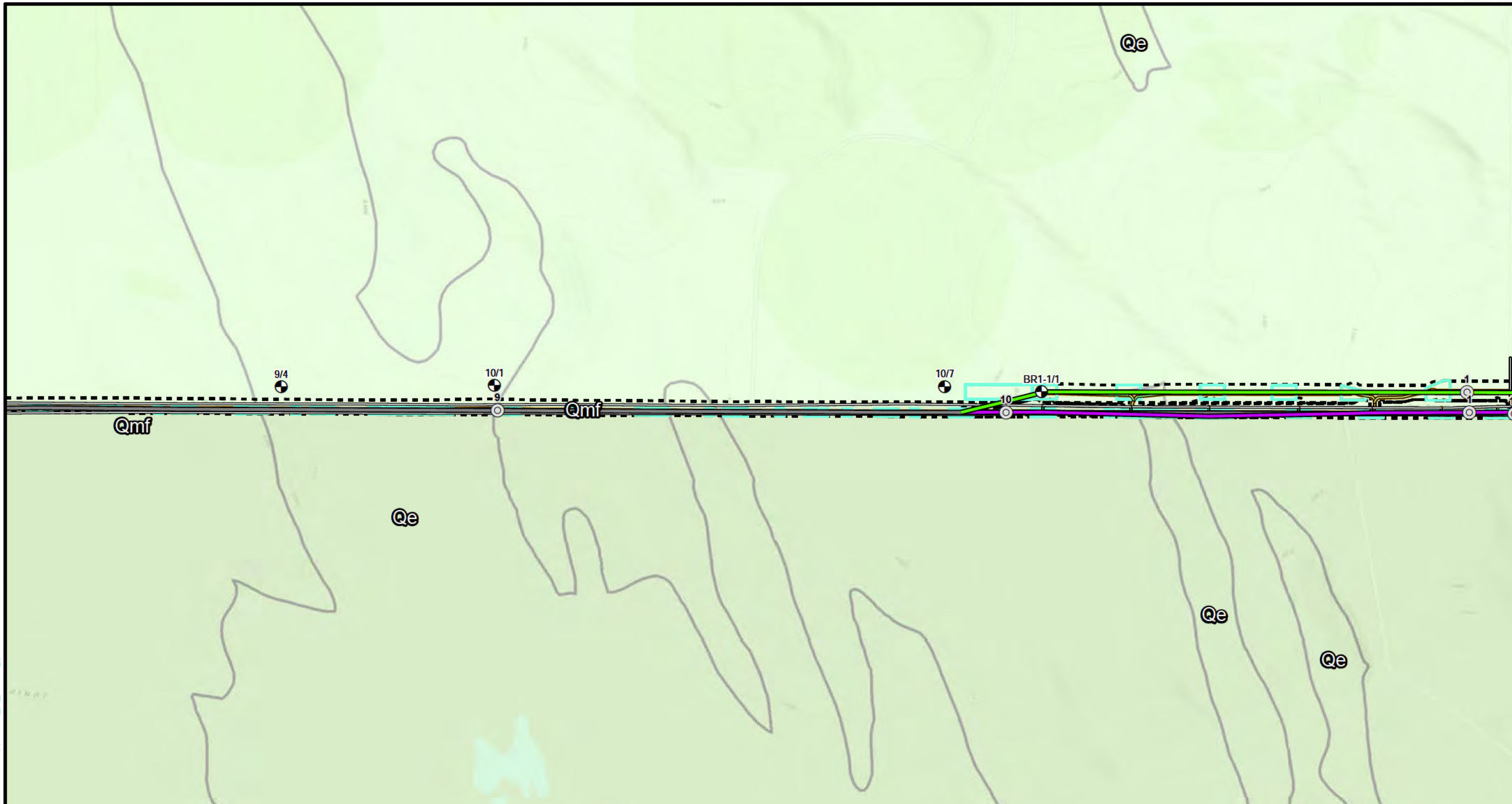

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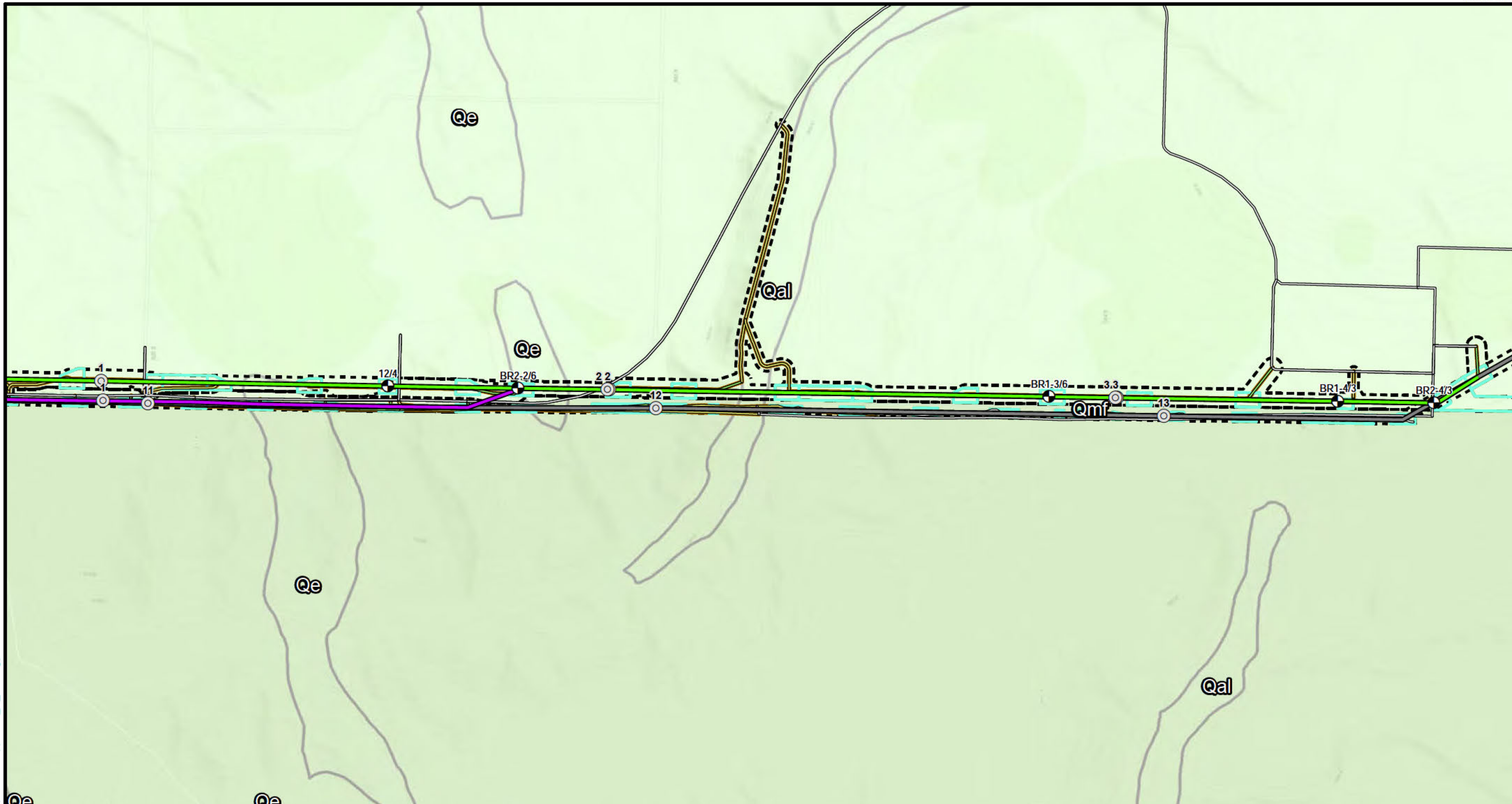

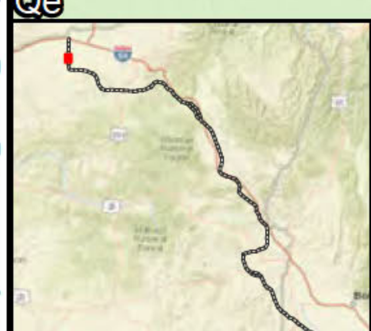

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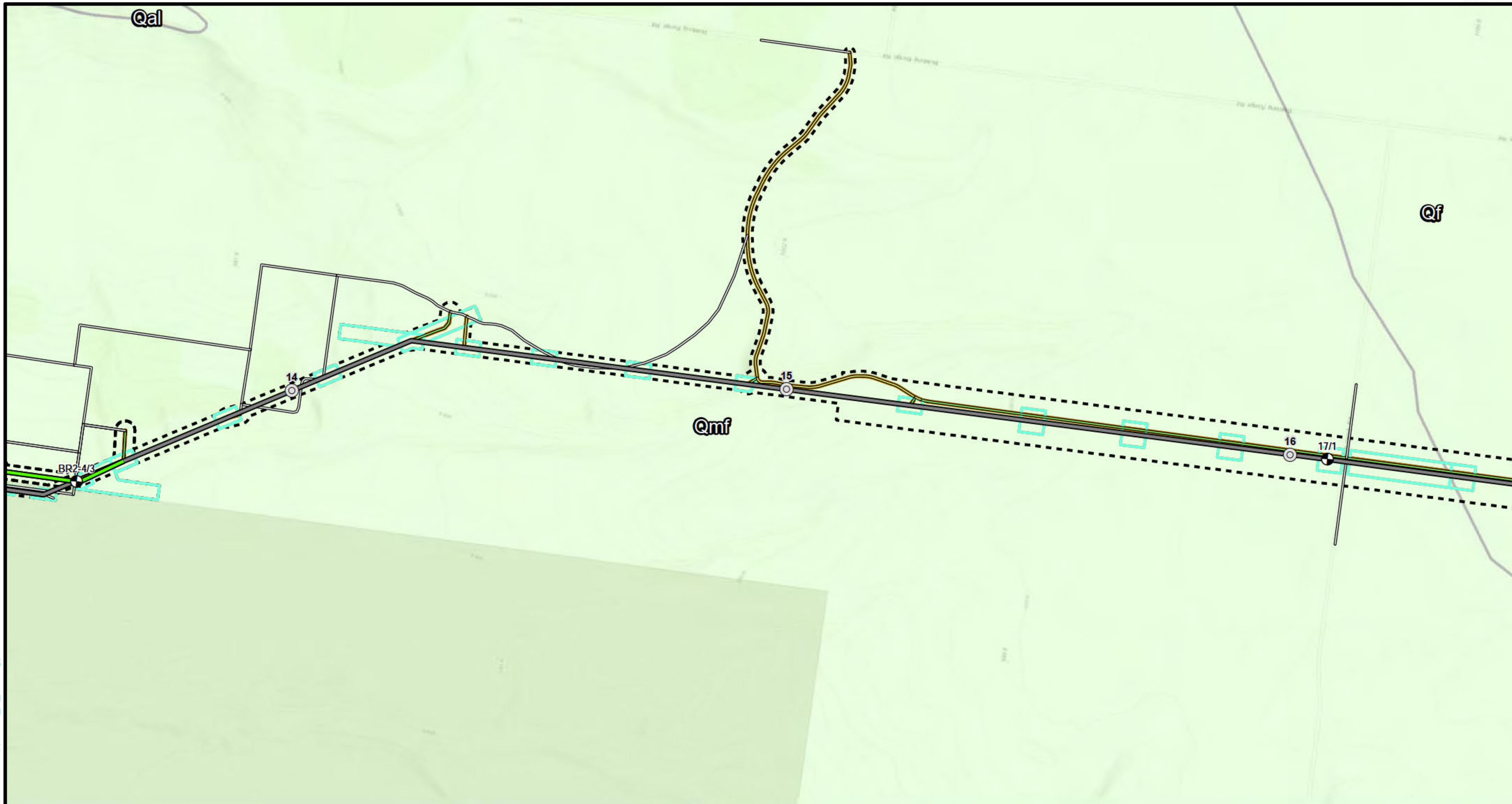

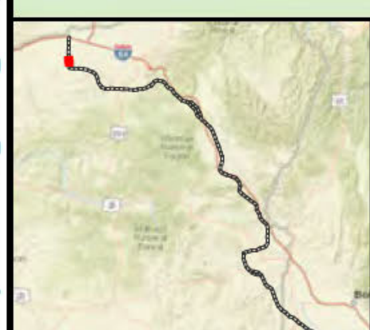

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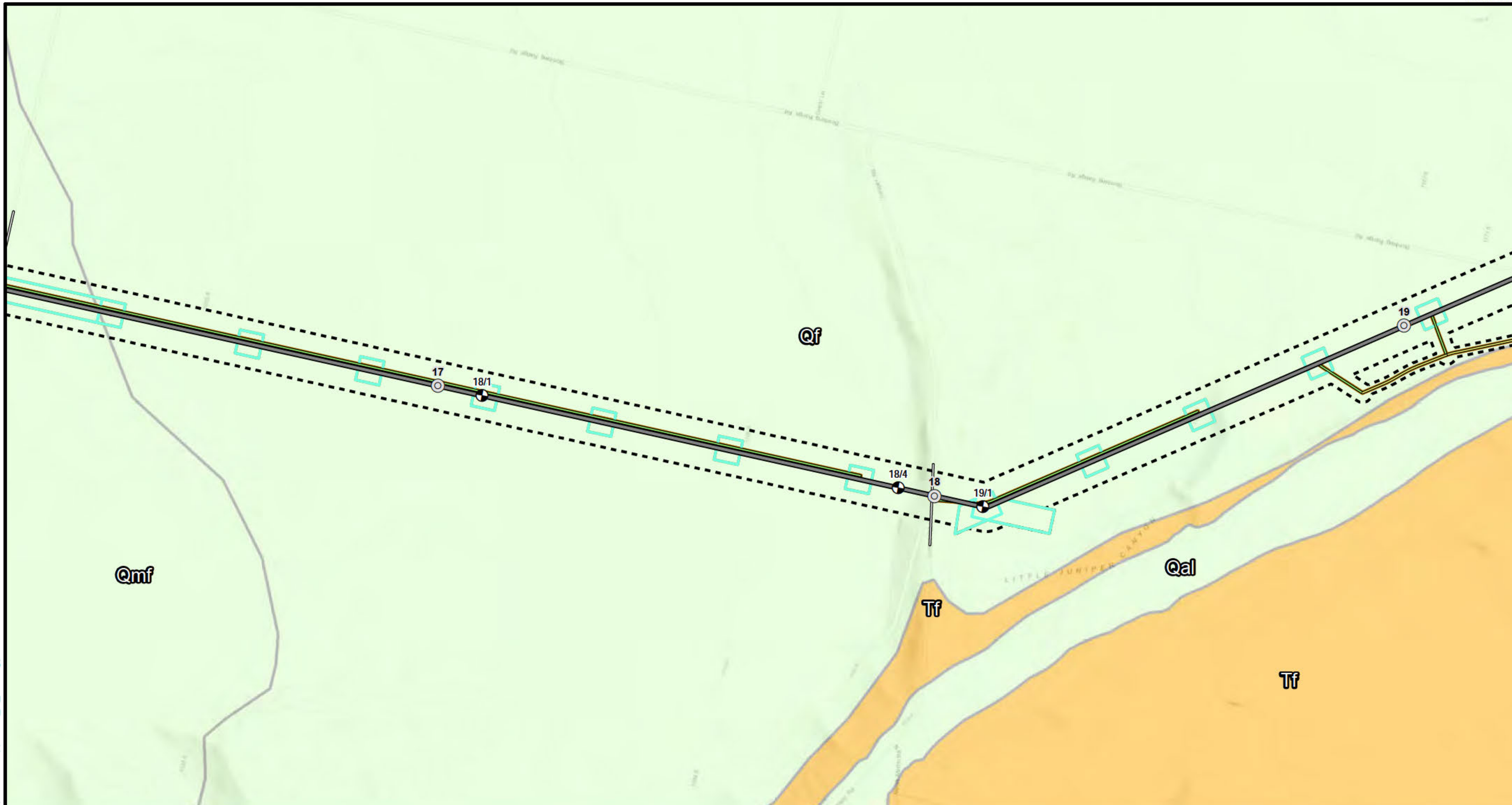

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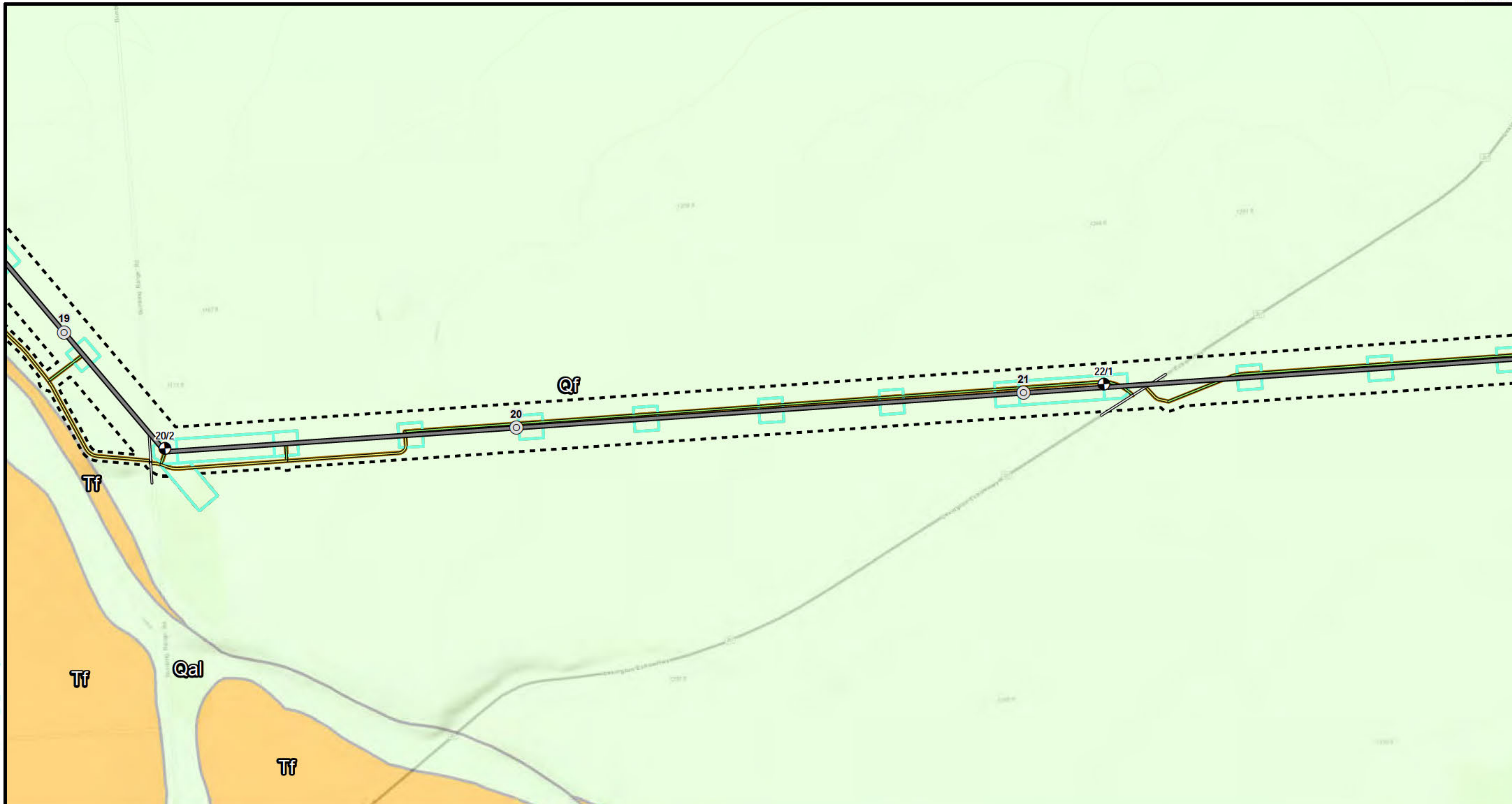

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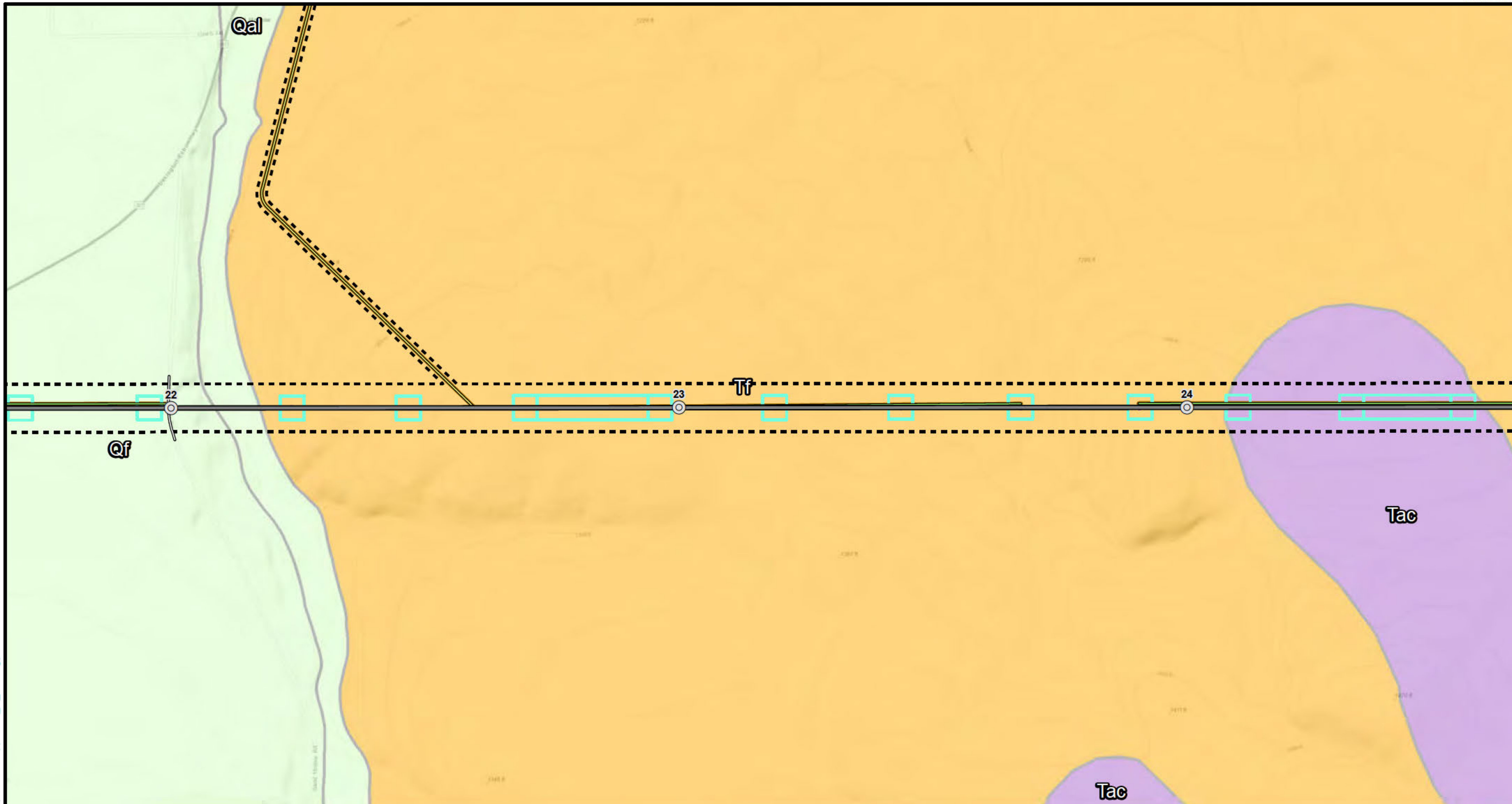

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Boardman - Hemingway
500kV Transmission Line
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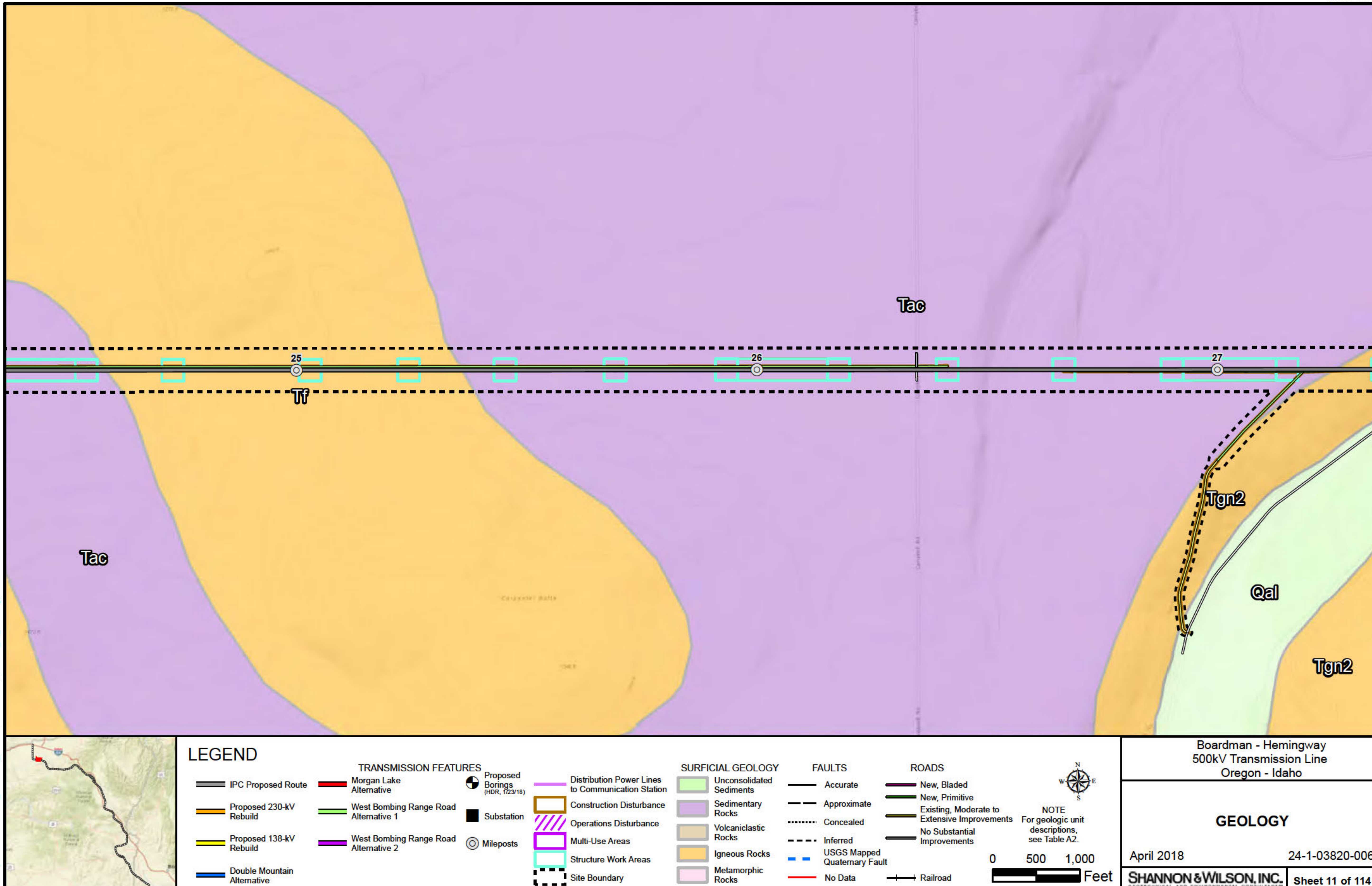
Tac
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Tgn2
Qal
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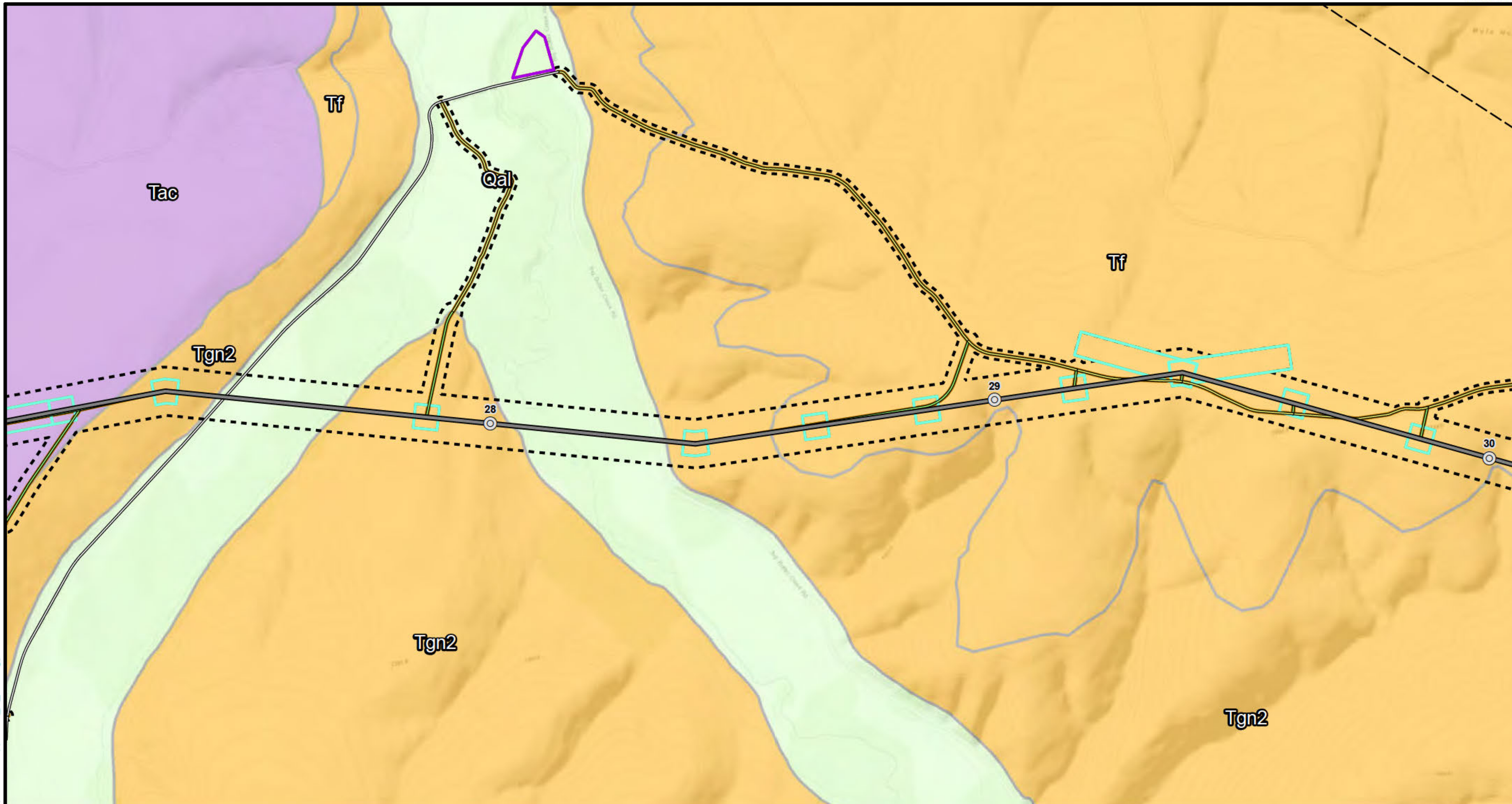

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LEGEND

TRANSMISSION FEATURES
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FAULTS
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ROADS
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- New, Primitive
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- Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000
Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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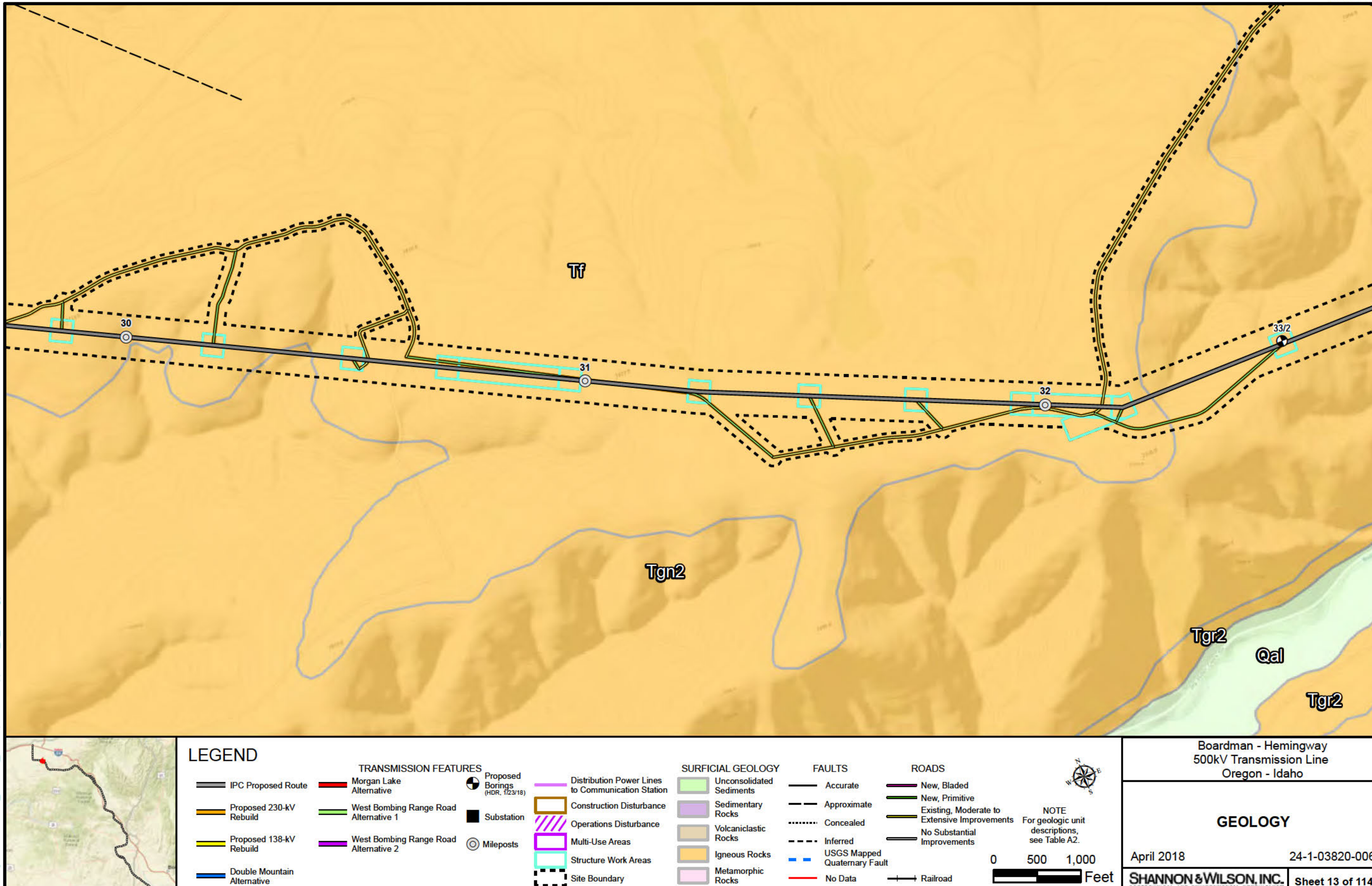

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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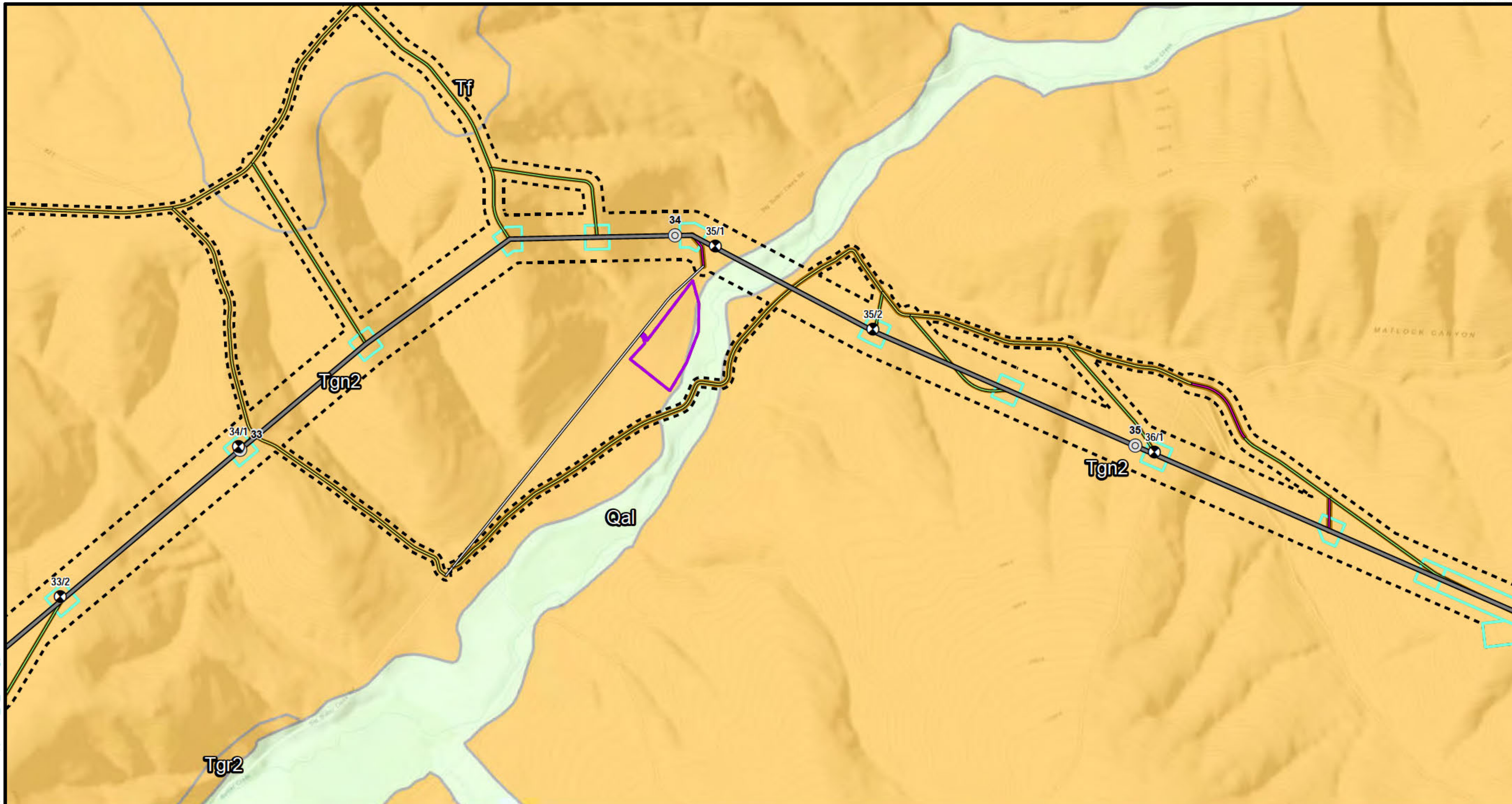

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Oregon - Idaho

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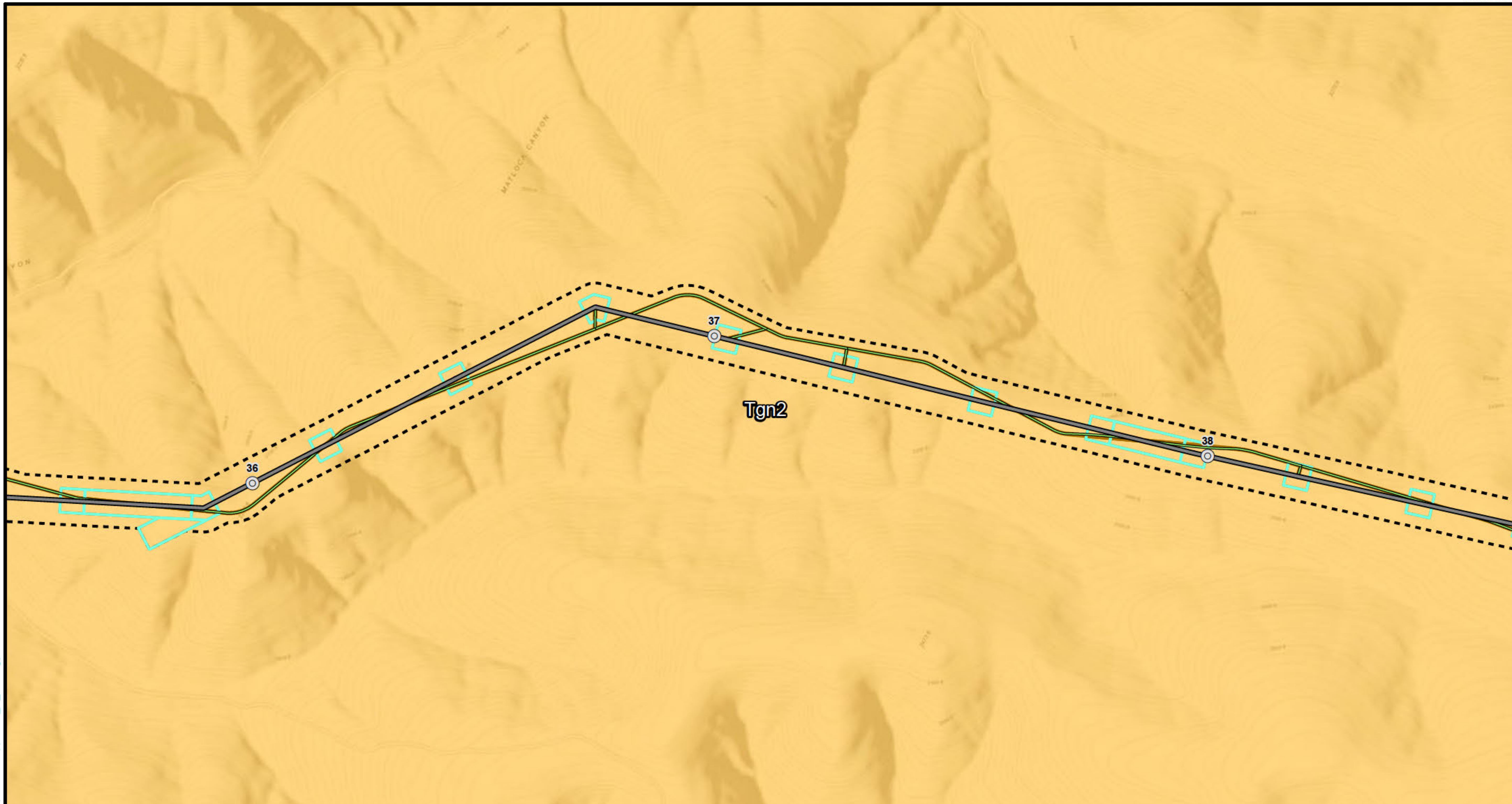

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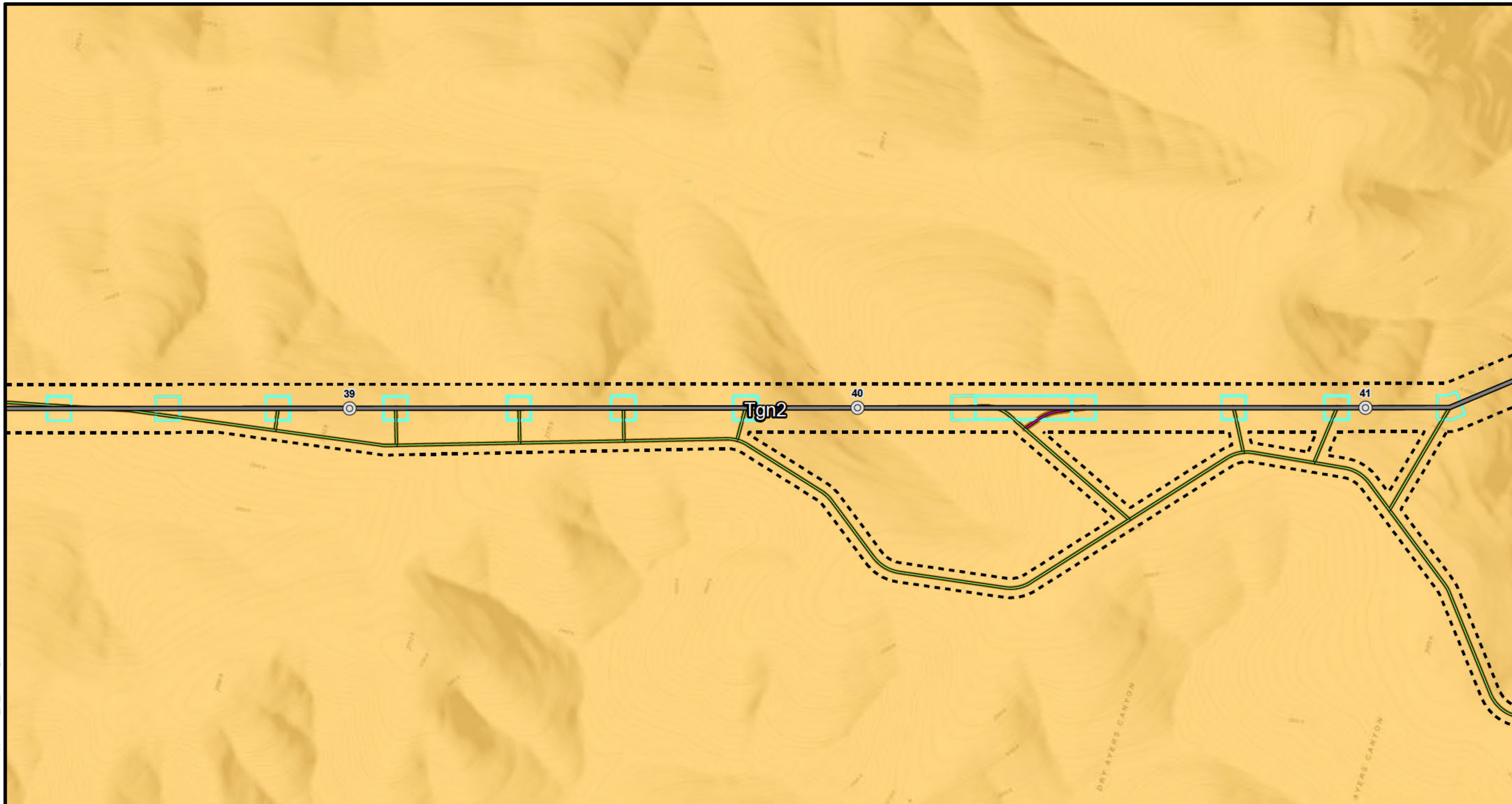

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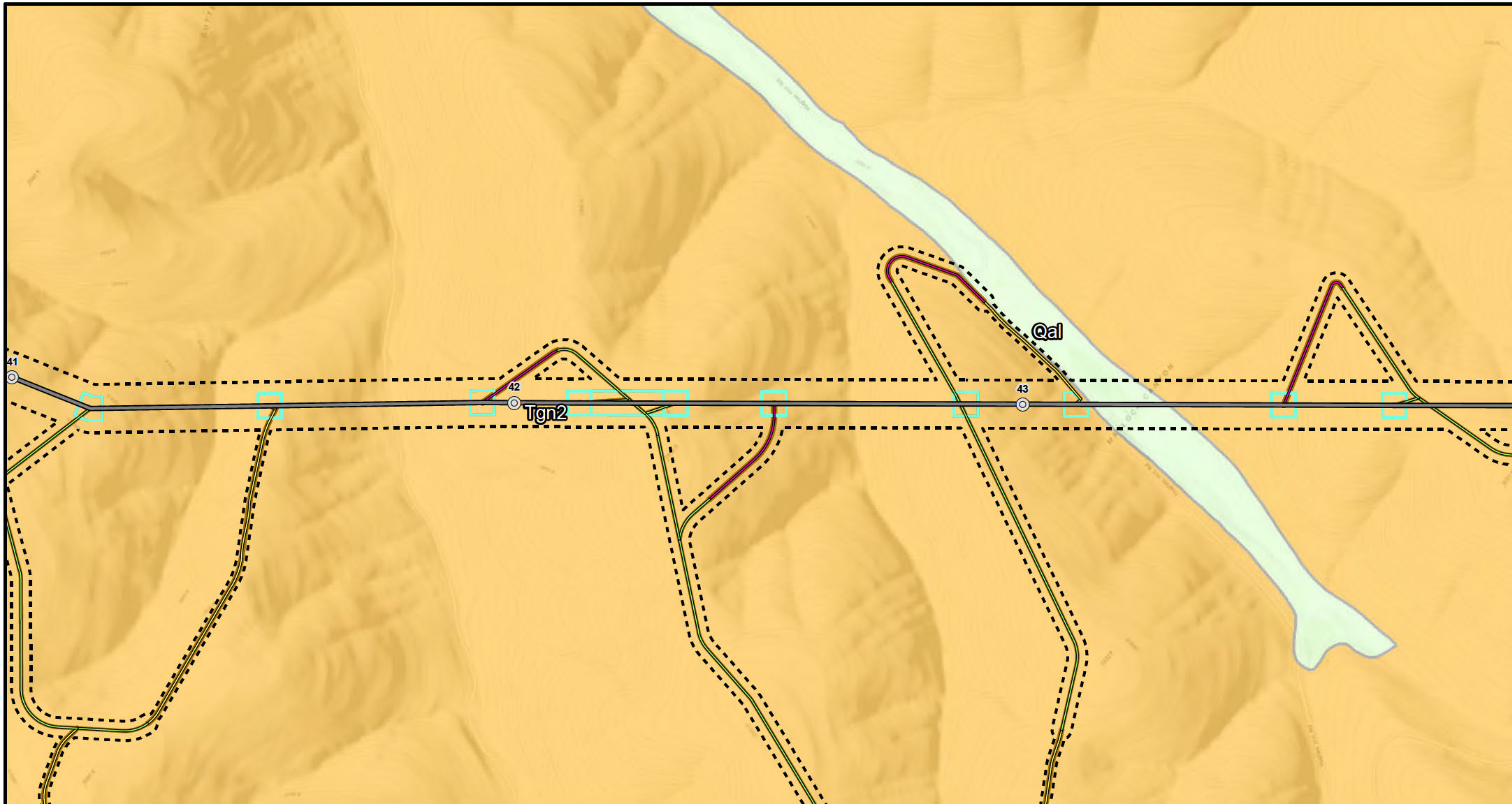

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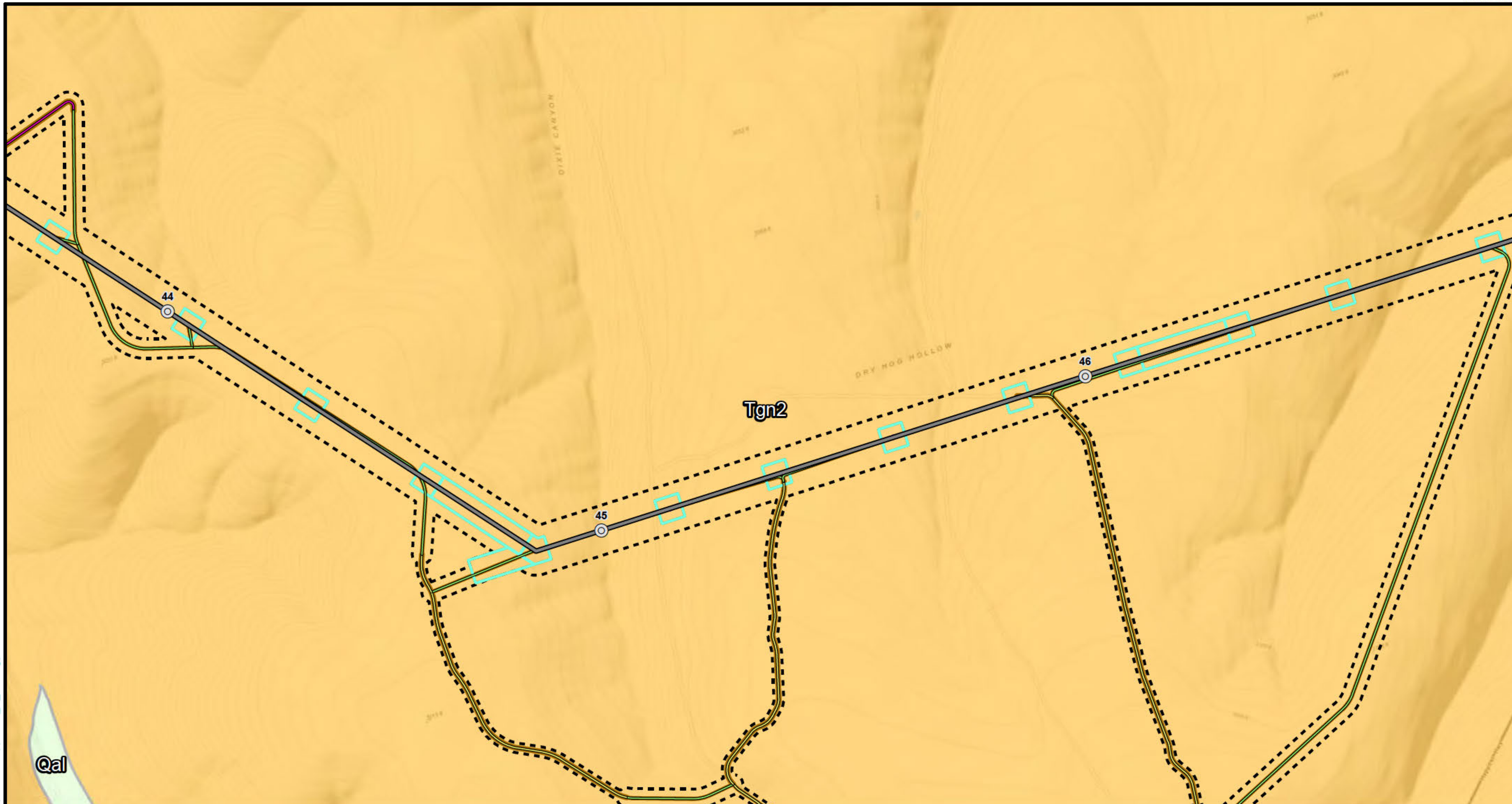

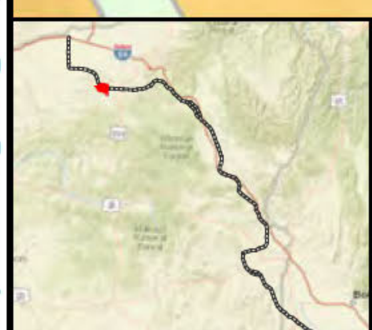

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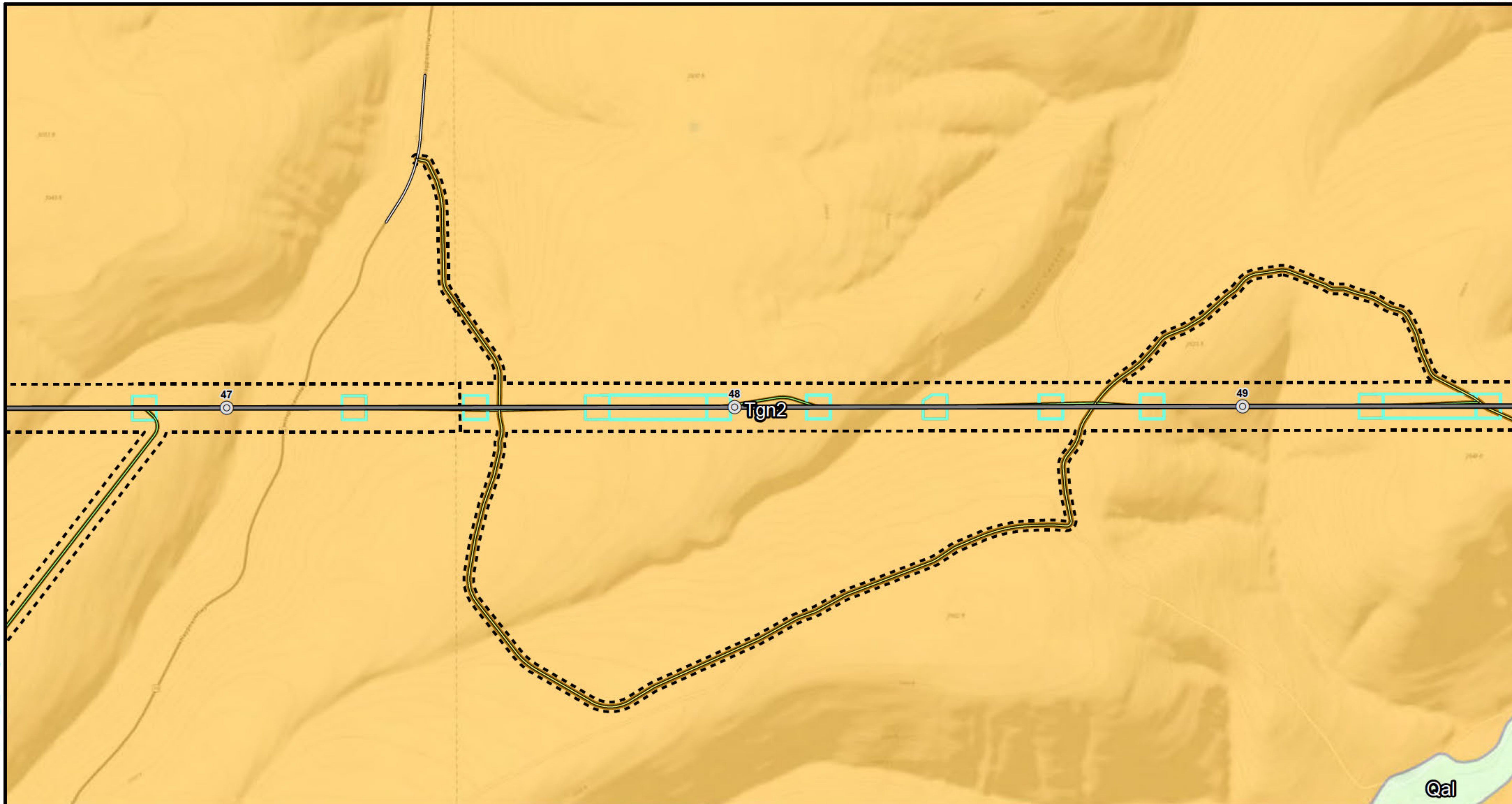

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Boardman - Hemingway
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Oregon - Idaho

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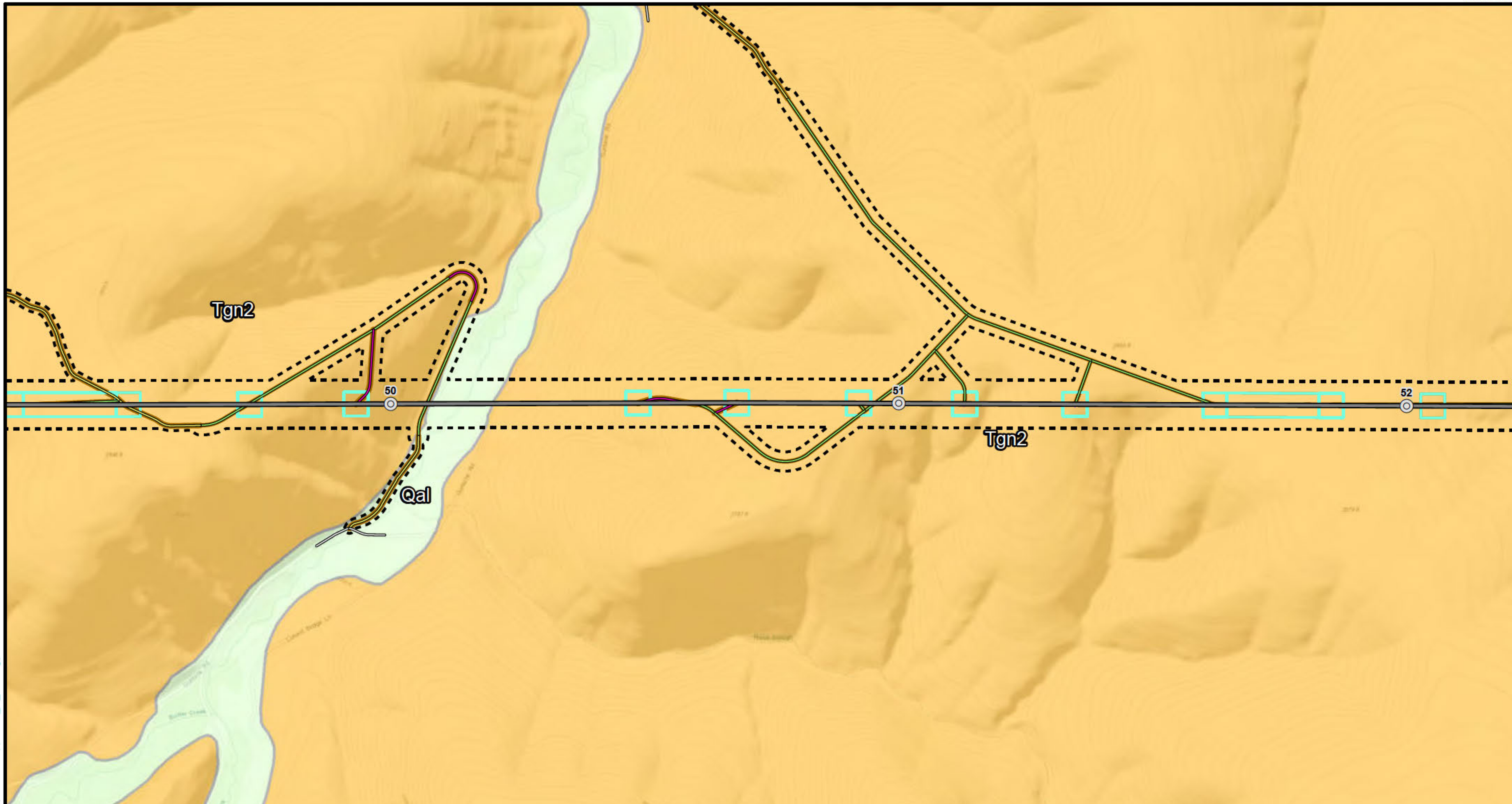

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Oregon - Idaho

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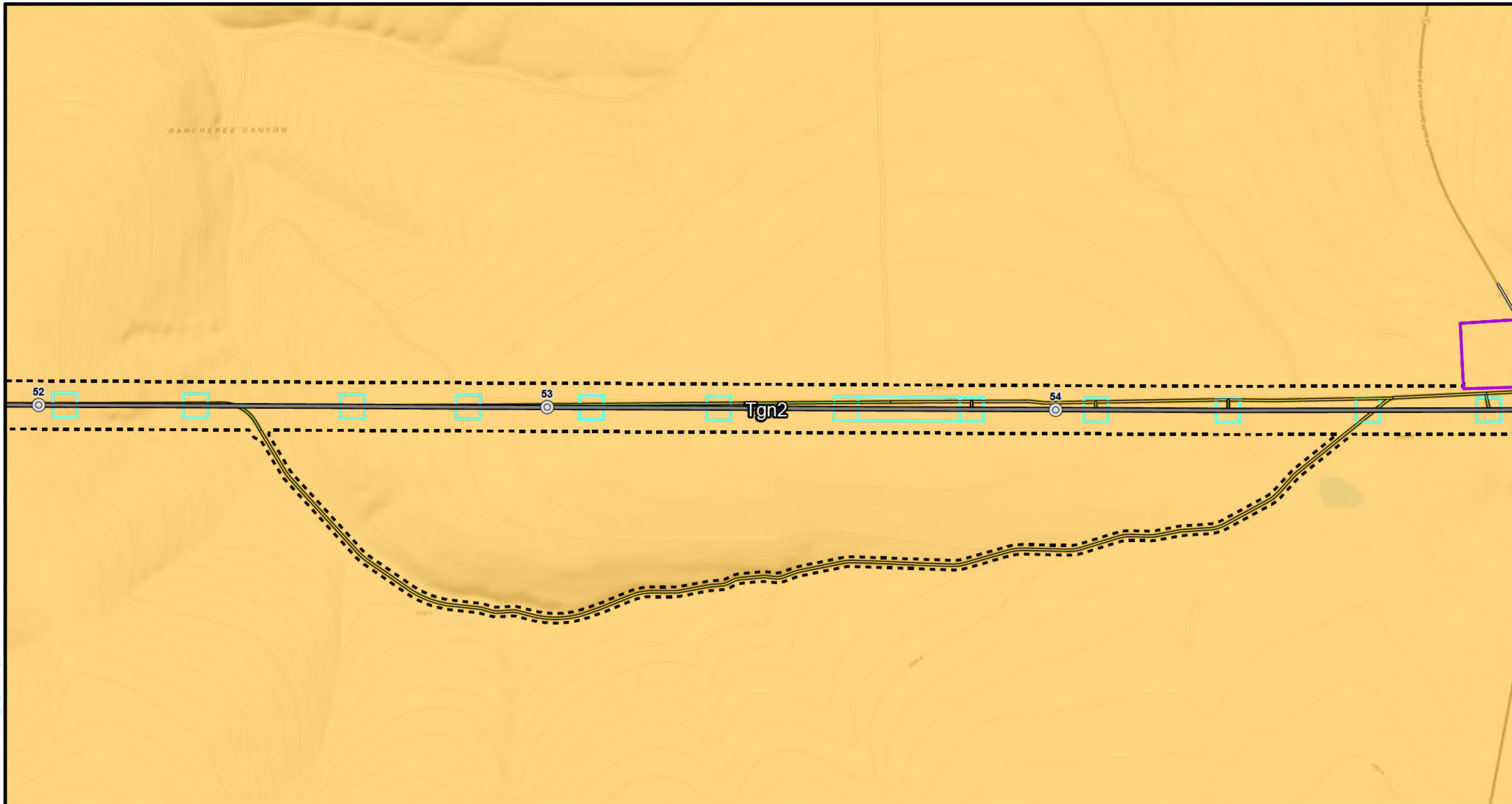

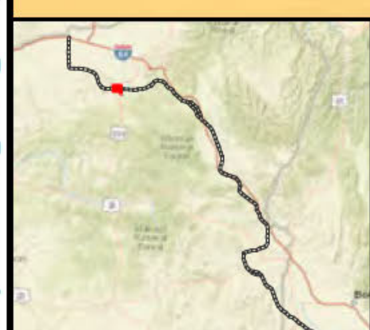

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
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Railroad

NOTE
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Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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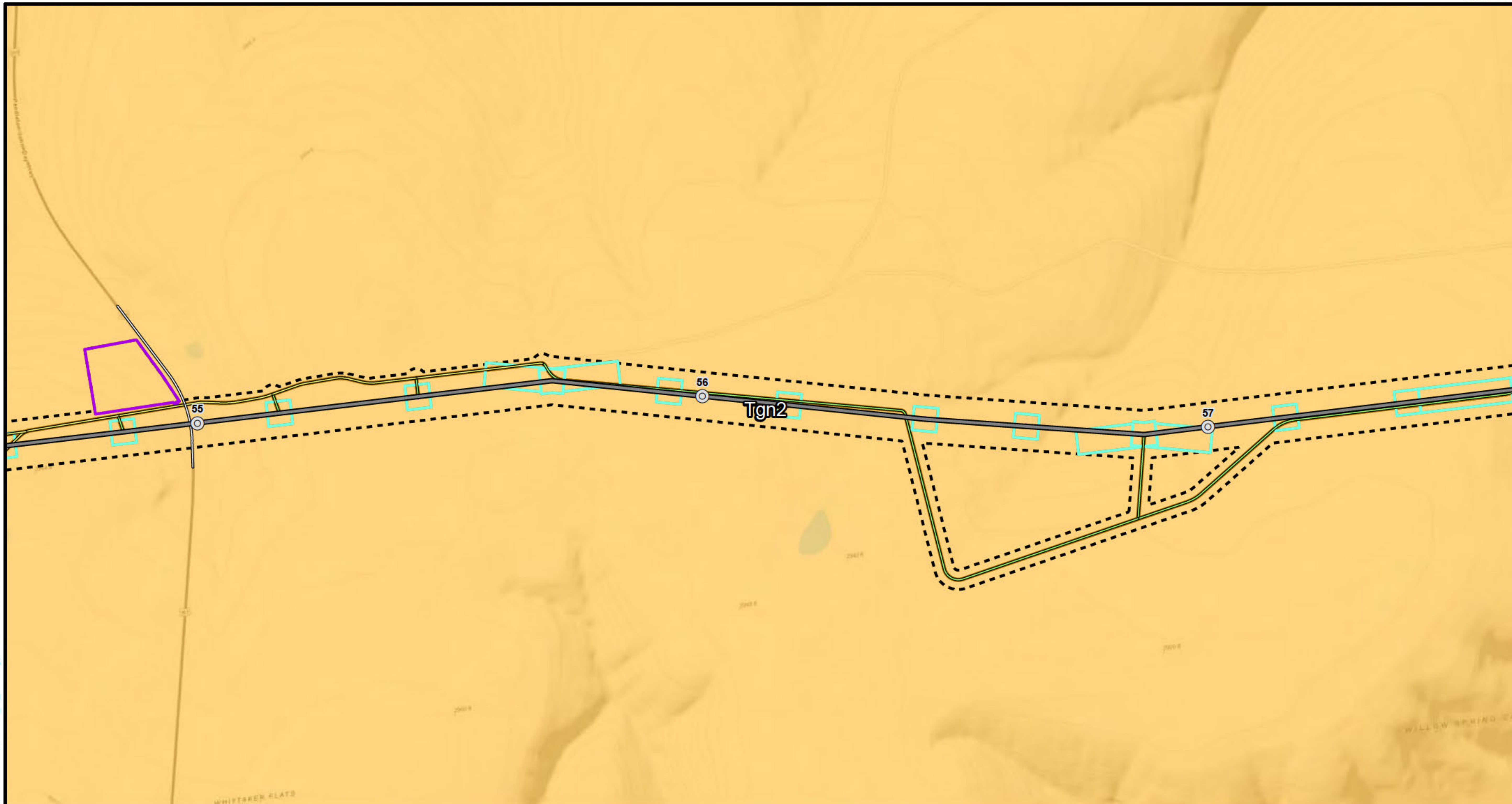

LEGEND

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Oregon - Idaho

GEOLOGY

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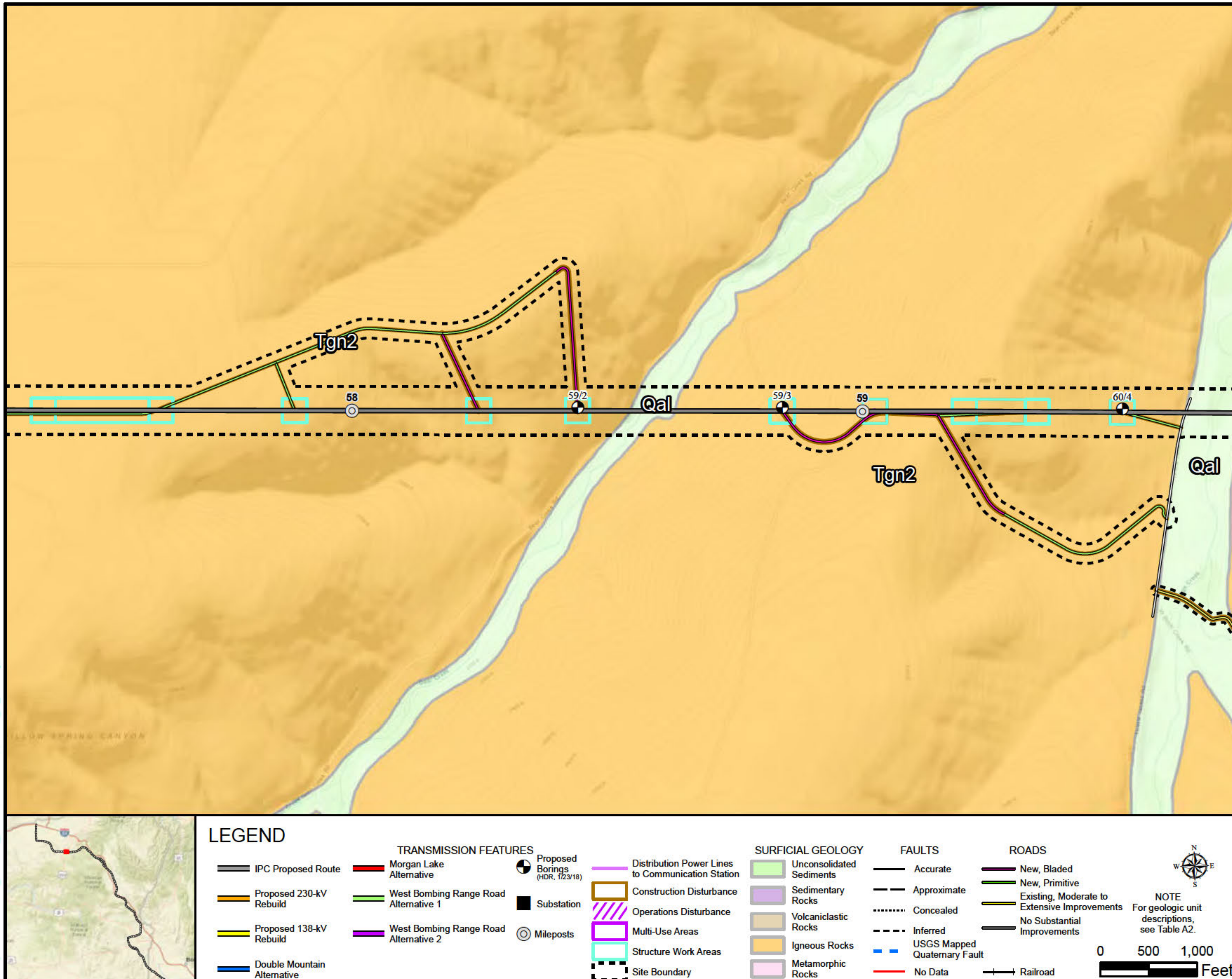

Boardman - Hemingway
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Oregon - Idaho

GEOLOGY

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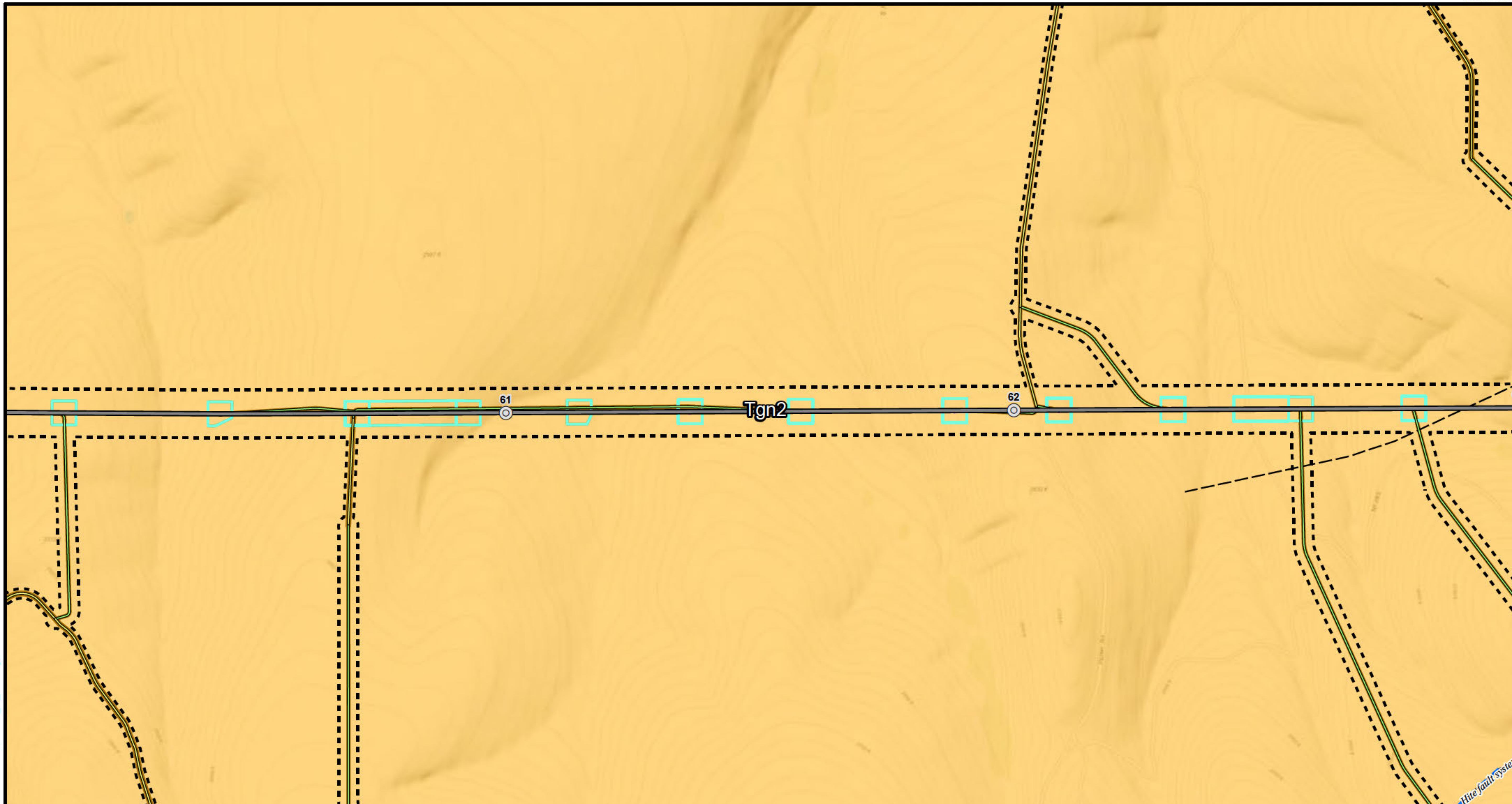

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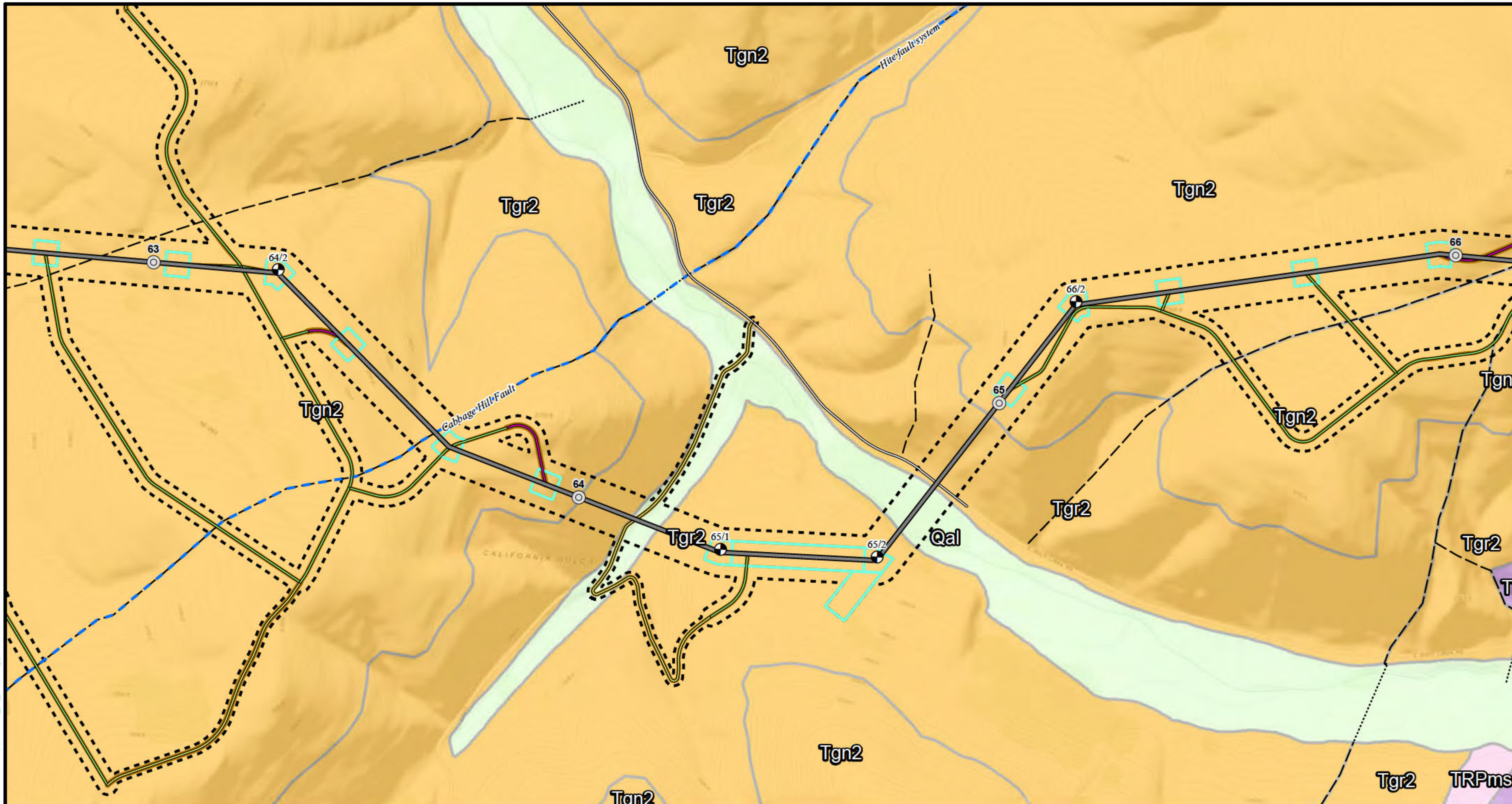

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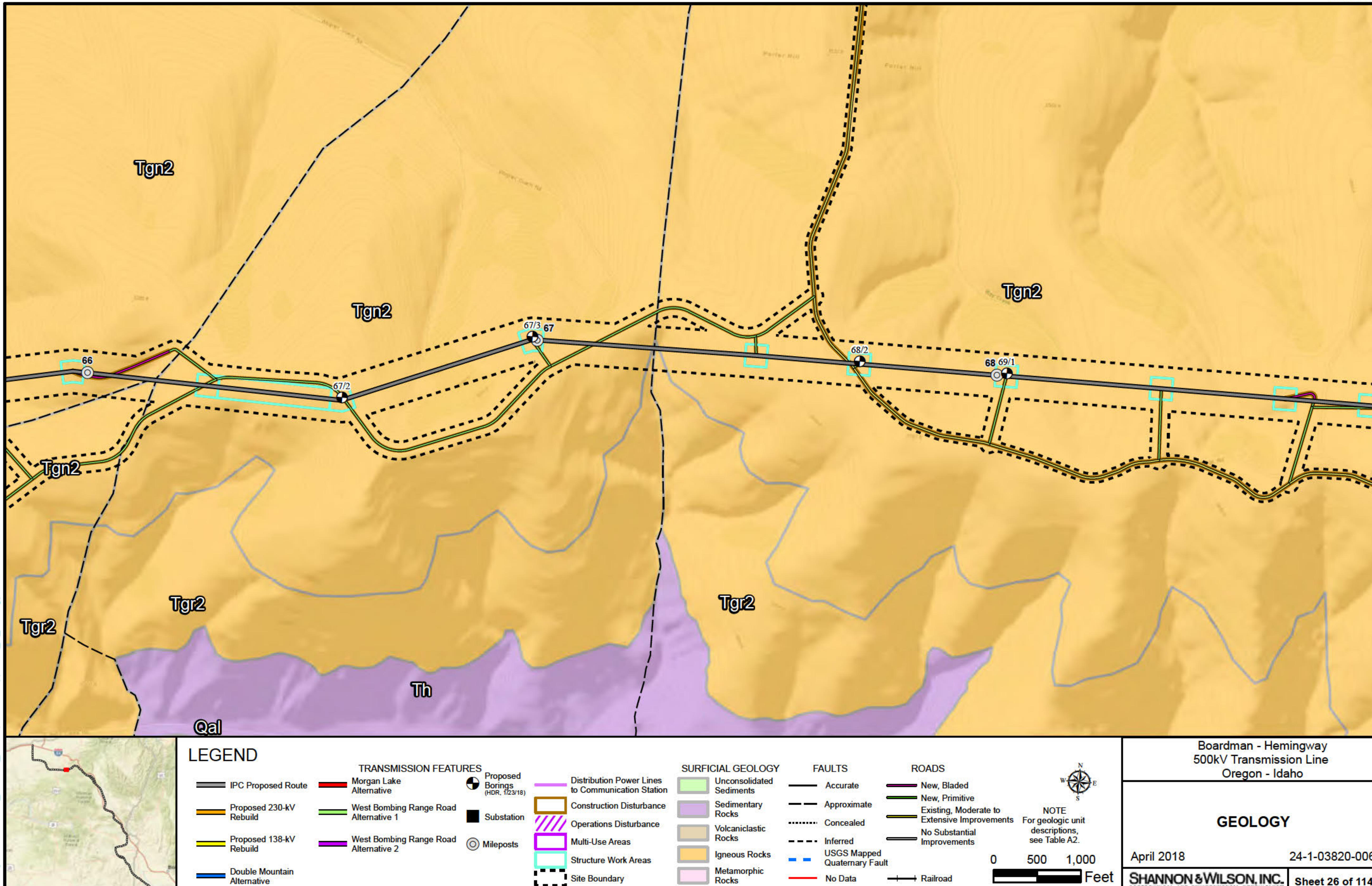

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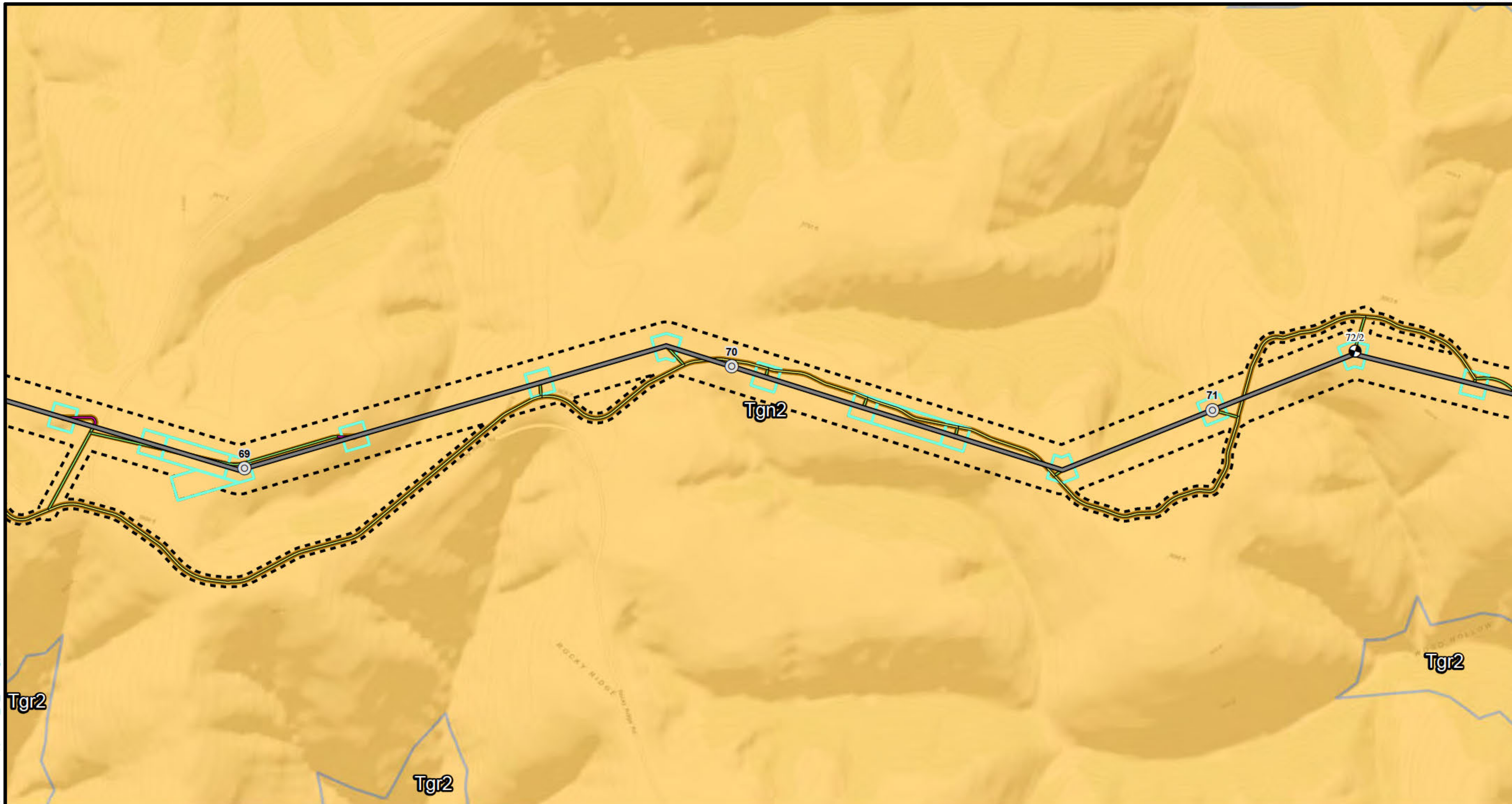

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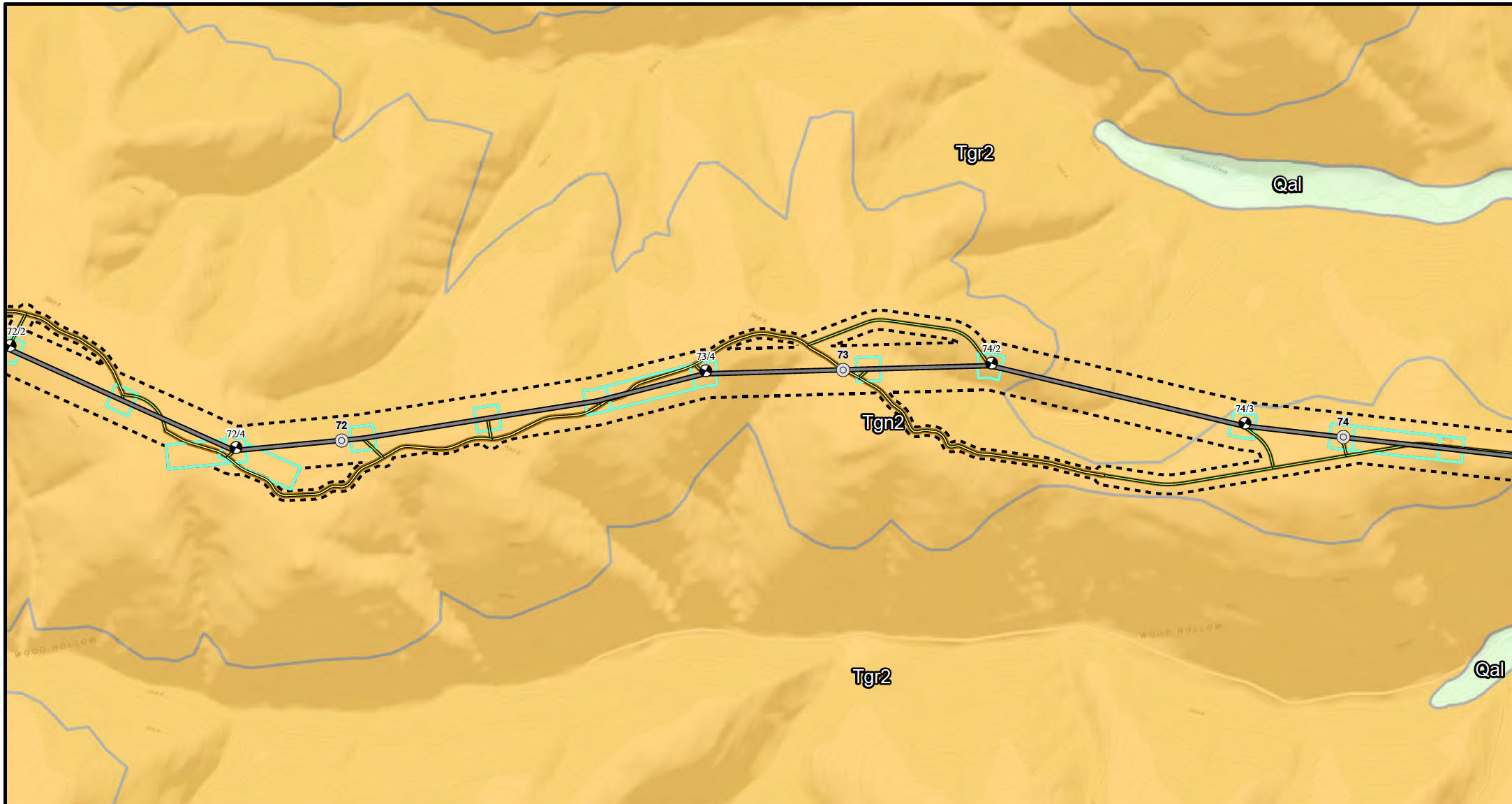

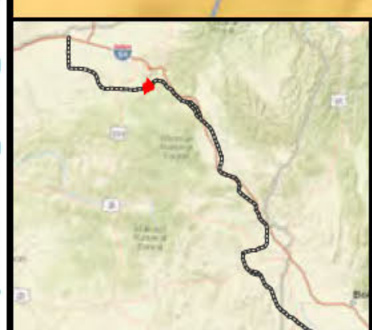

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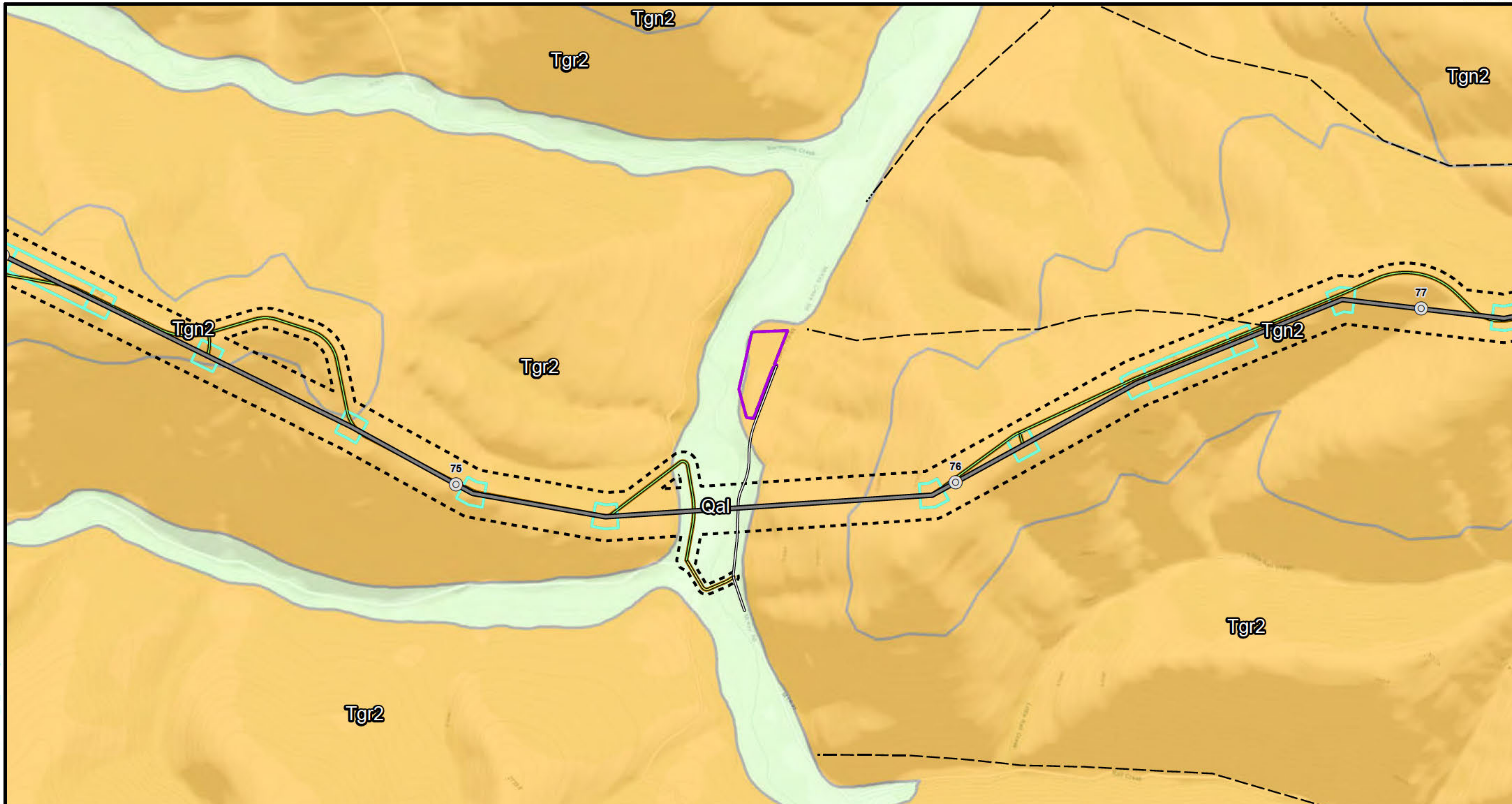

LEGEND

TRANSMISSION FEATURES
- IPC Proposed Route
- Proposed 230-kV Rebuild
- Proposed 138-kV Rebuild
- Double Mountain Alternative
- Morgan Lake Alternative
- West Bombing Range Road Alternative 1
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- Substation
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- Structure Work Areas
- Site Boundary

SURFICIAL GEOLOGY
- Unconsolidated Sediments
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FAULTS
- Accurate
- Approximate
- Concealed
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- USGS Mapped Quaternary Fault
- No Data

ROADS
- New, Bladed
- New, Primitive
- Existing, Moderate to Extensive Improvements
- No Substantial Improvements
- Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000
Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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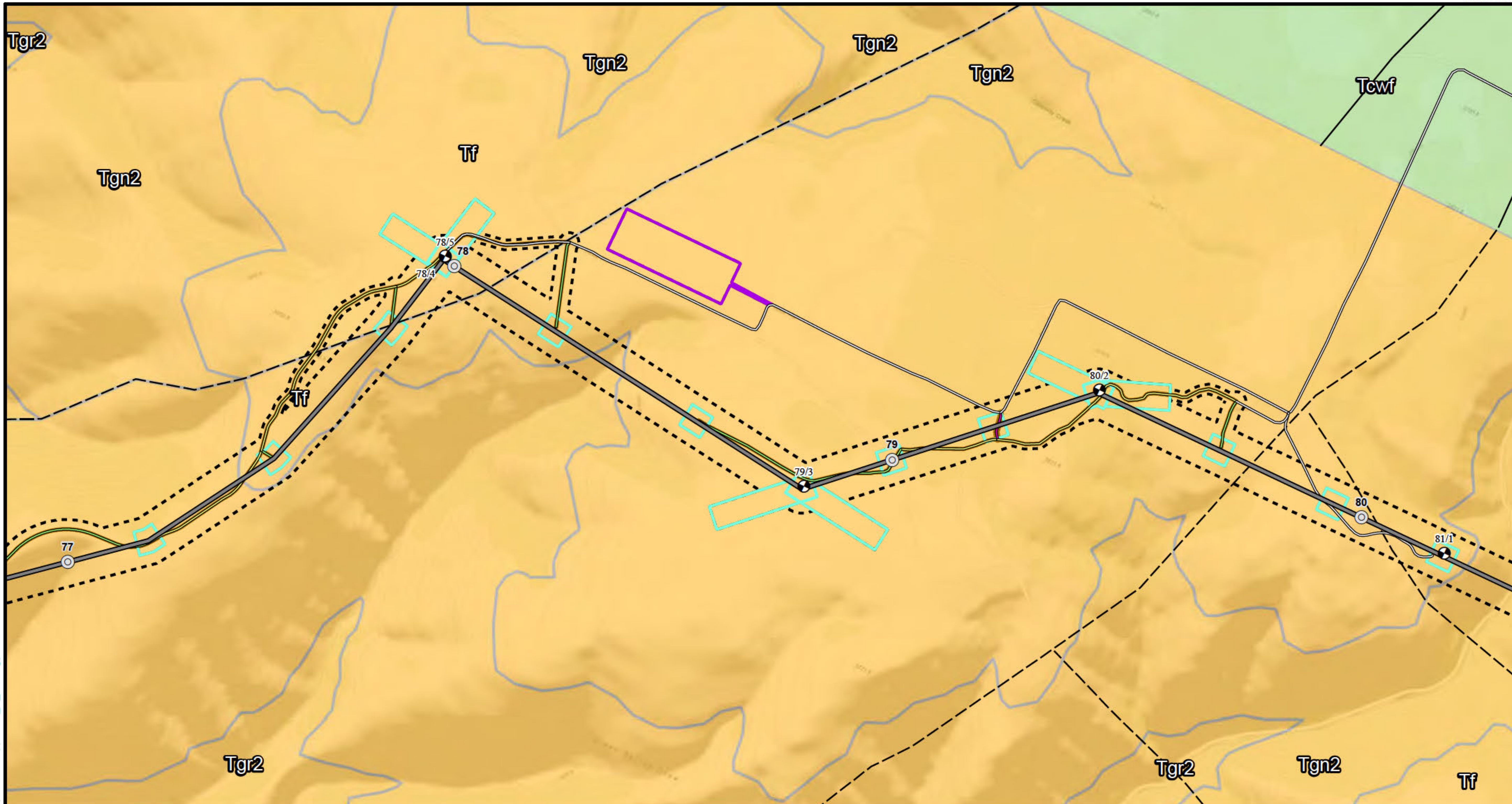

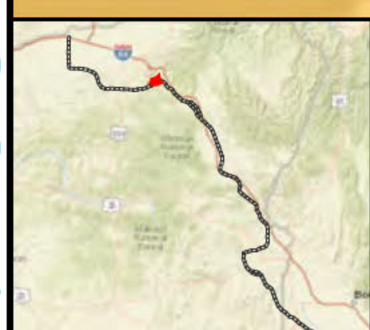

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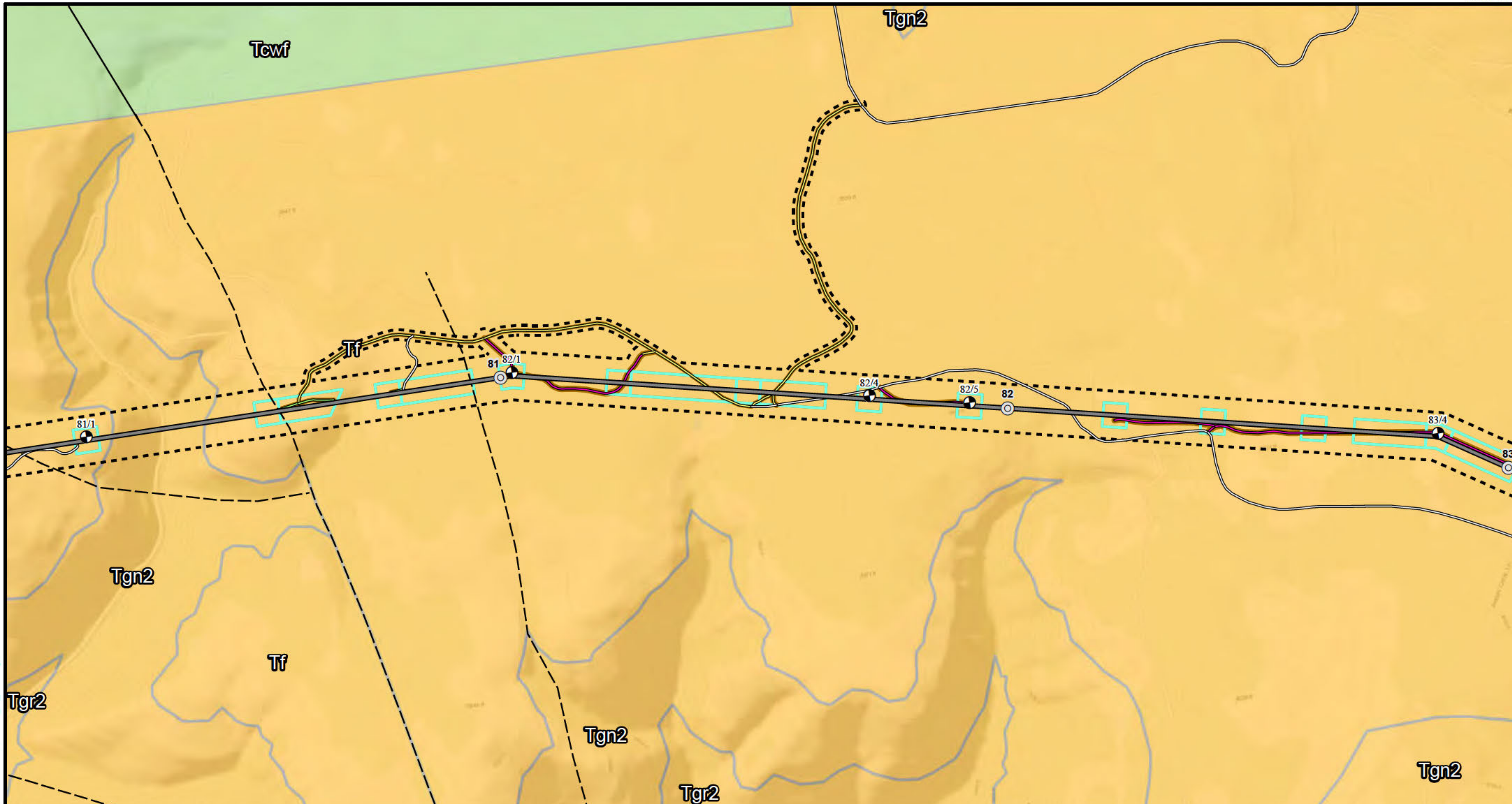

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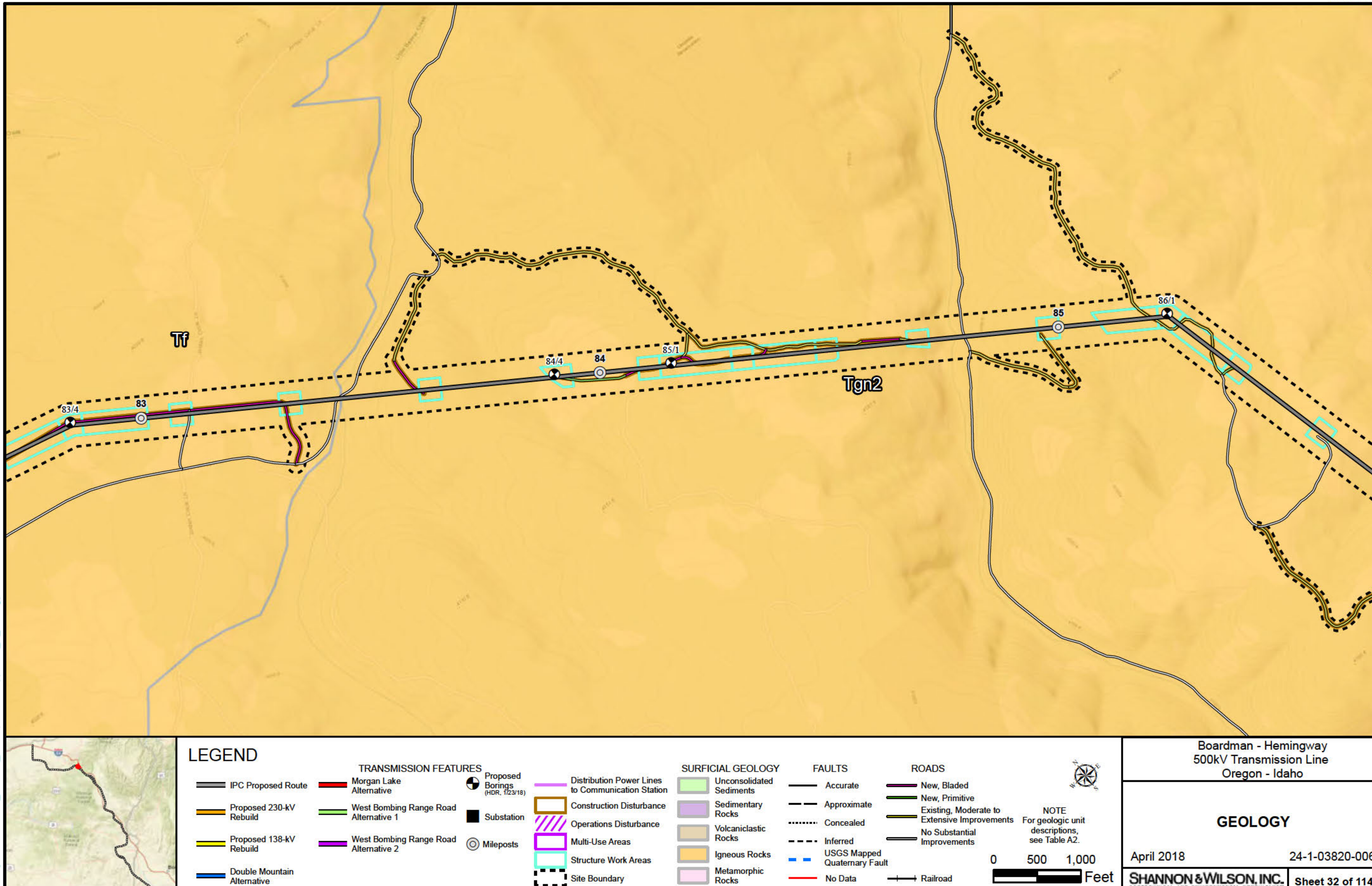

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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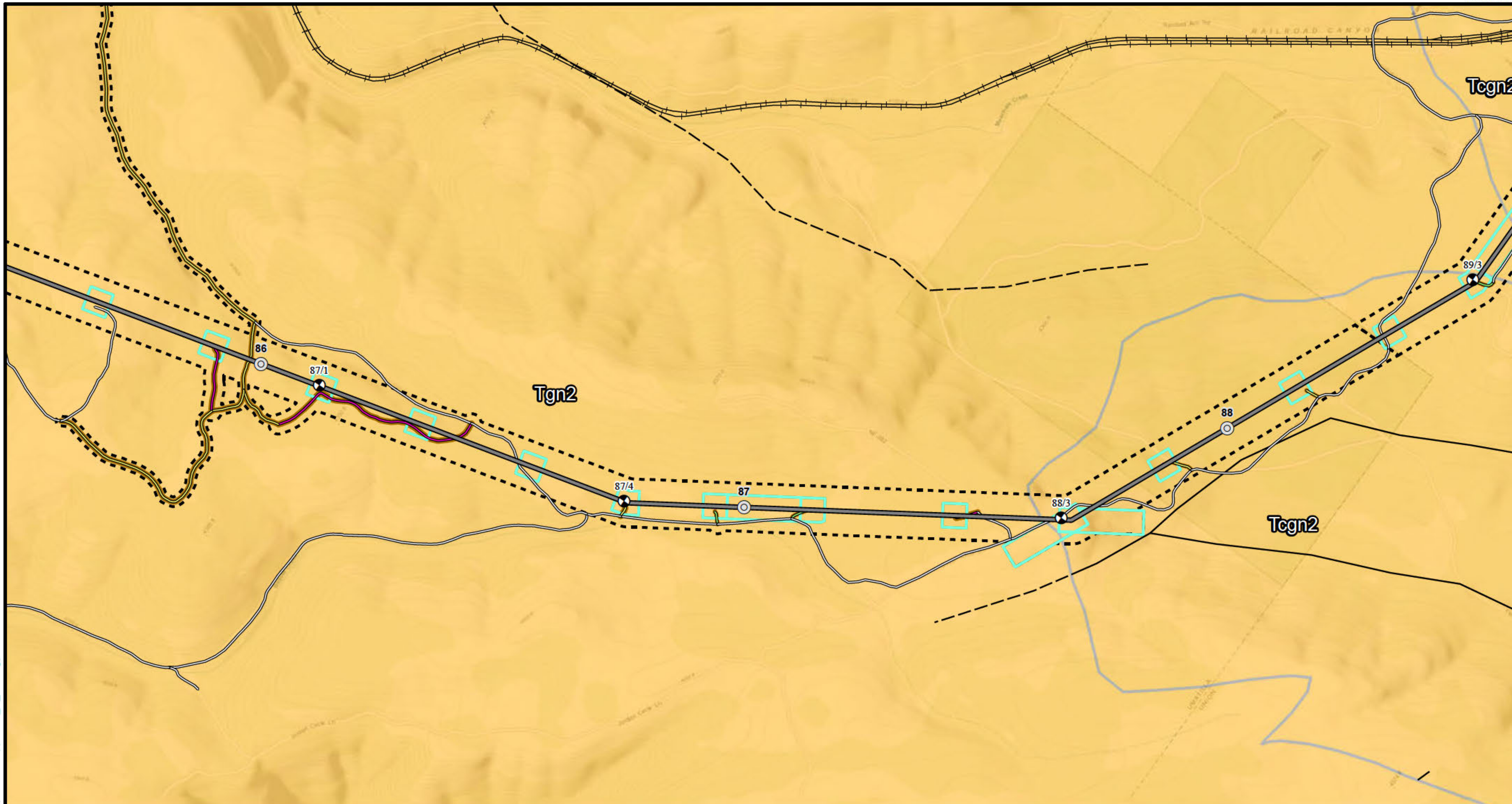

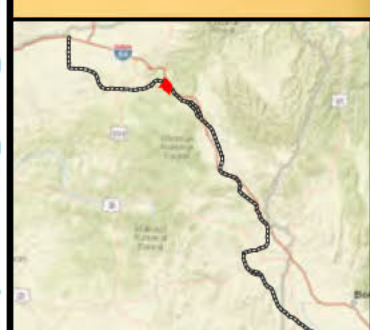

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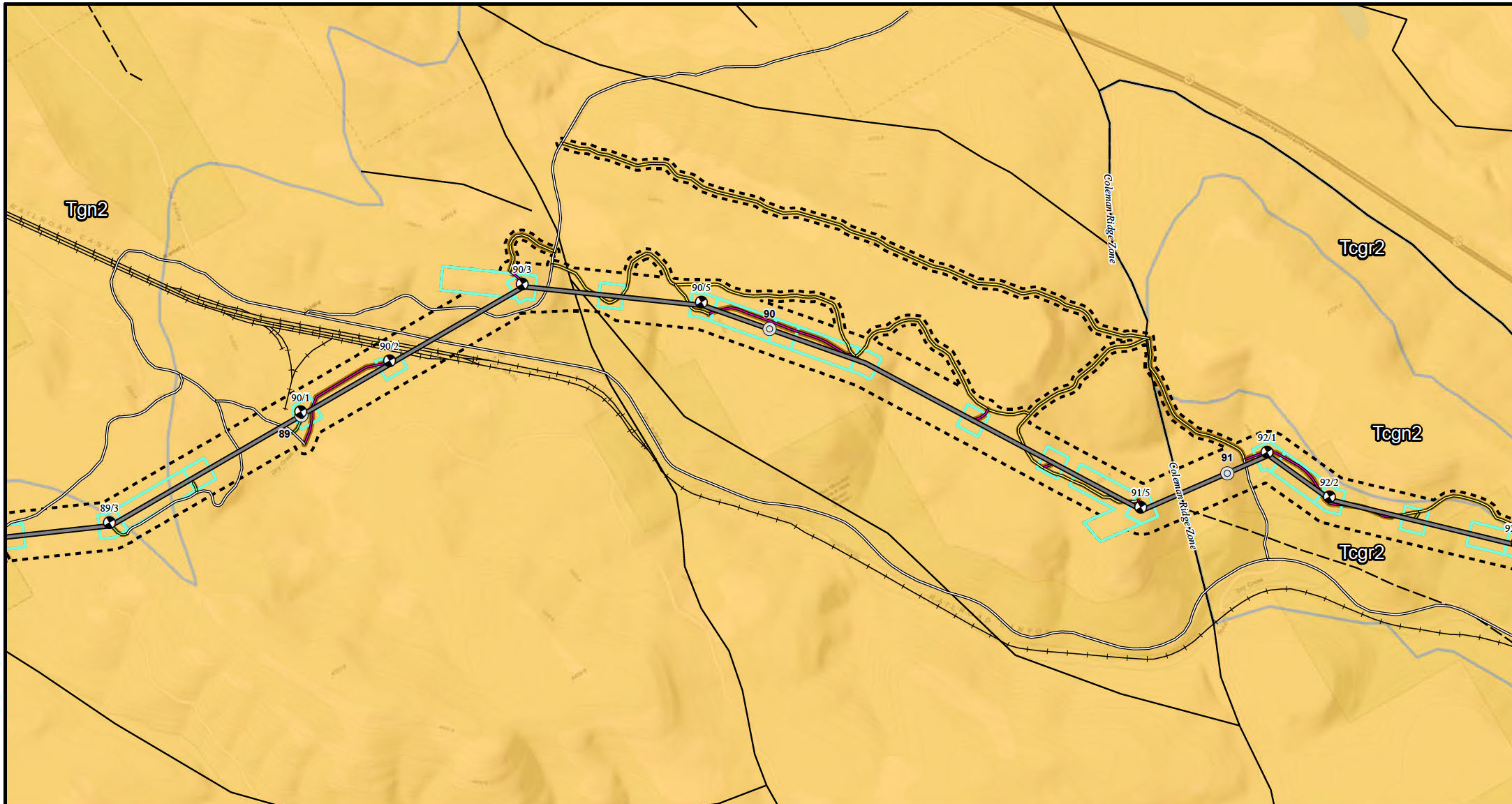

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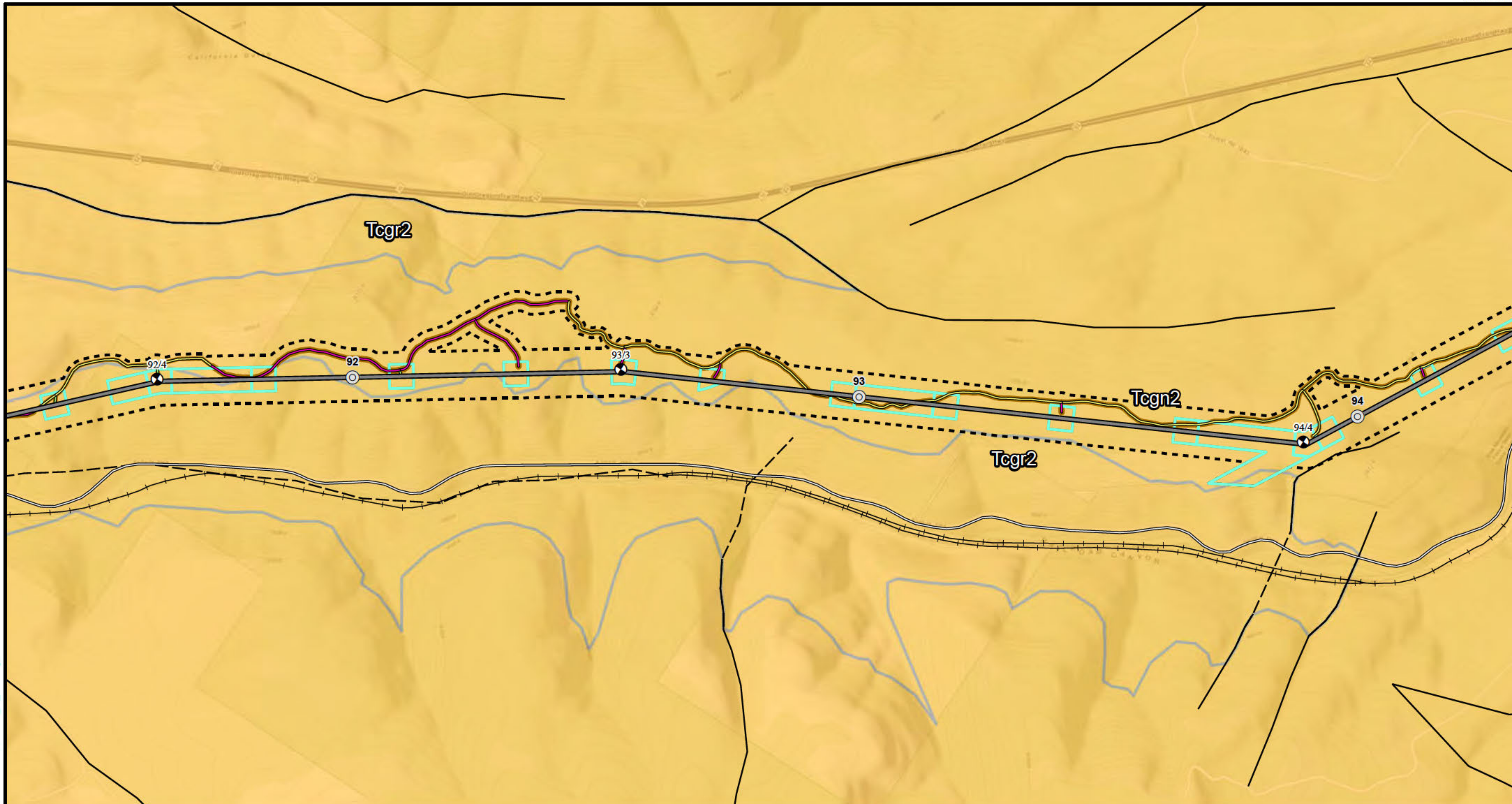

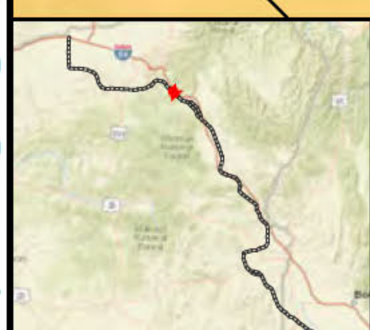

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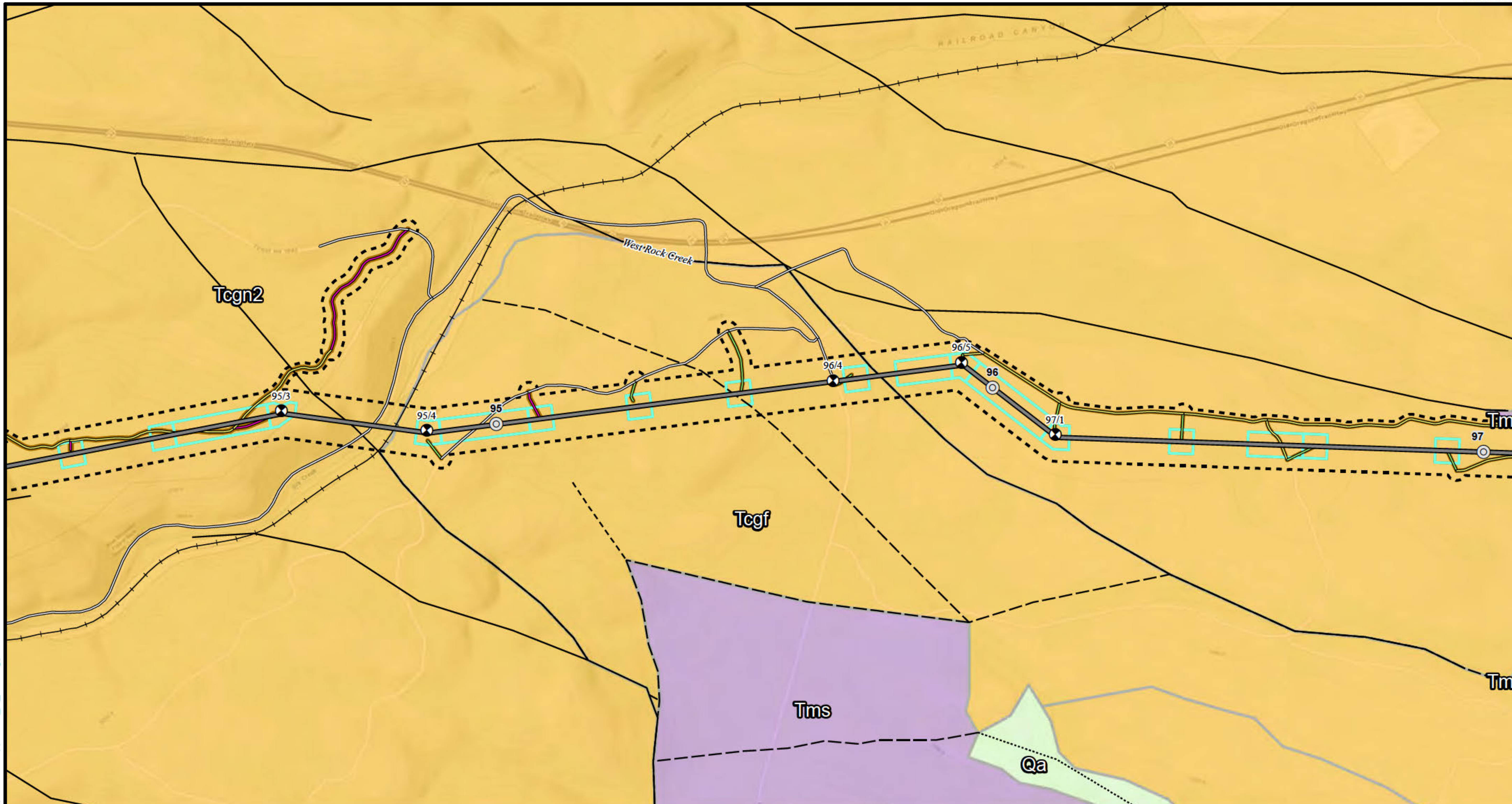

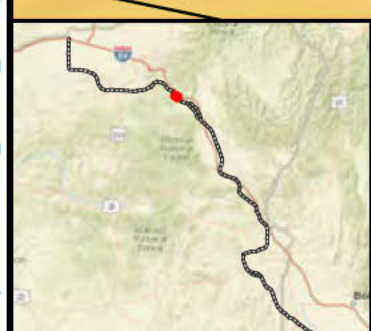

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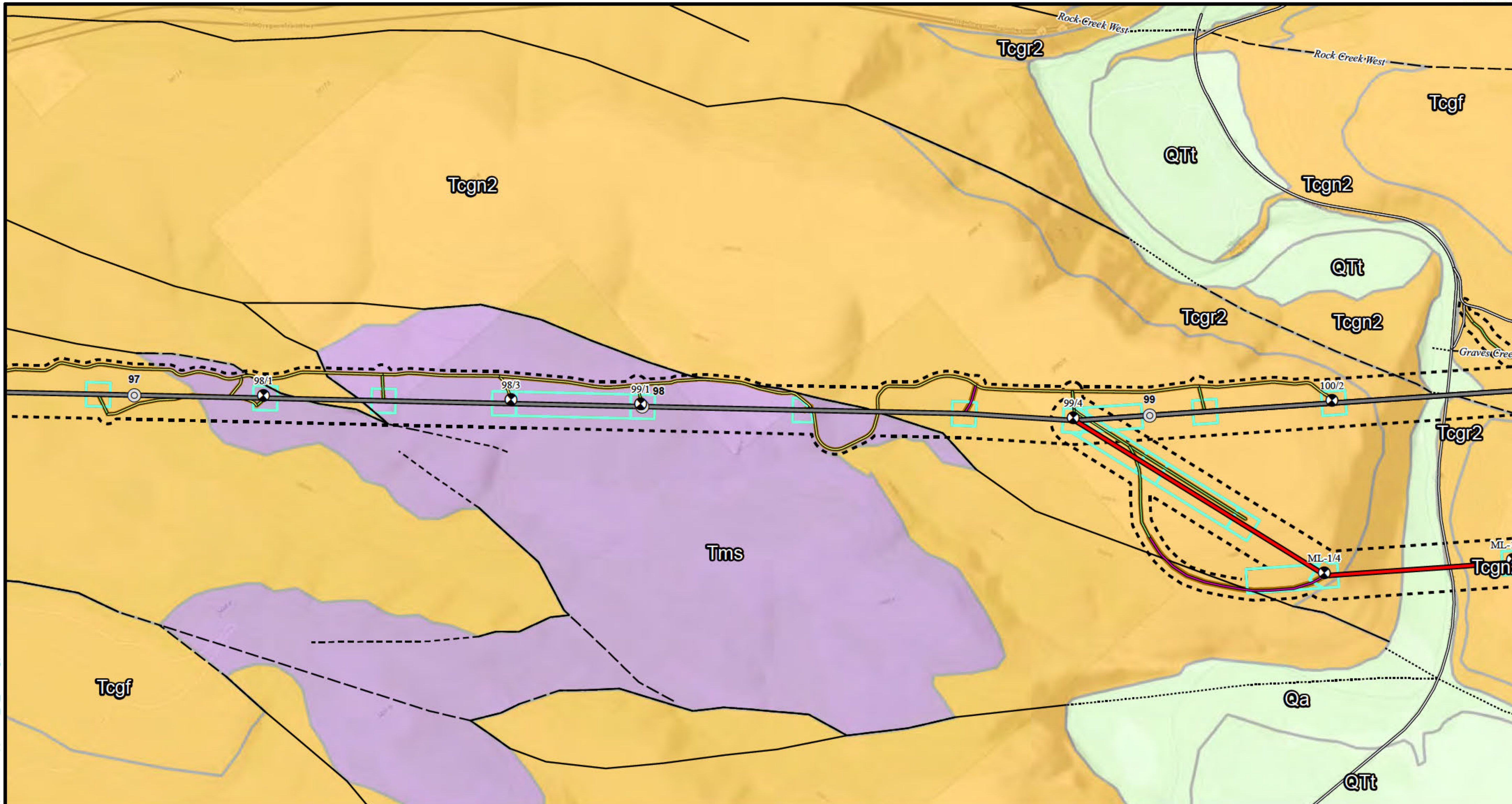

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500kV Transmission Line
Oregon - Idaho

GEOLOGY

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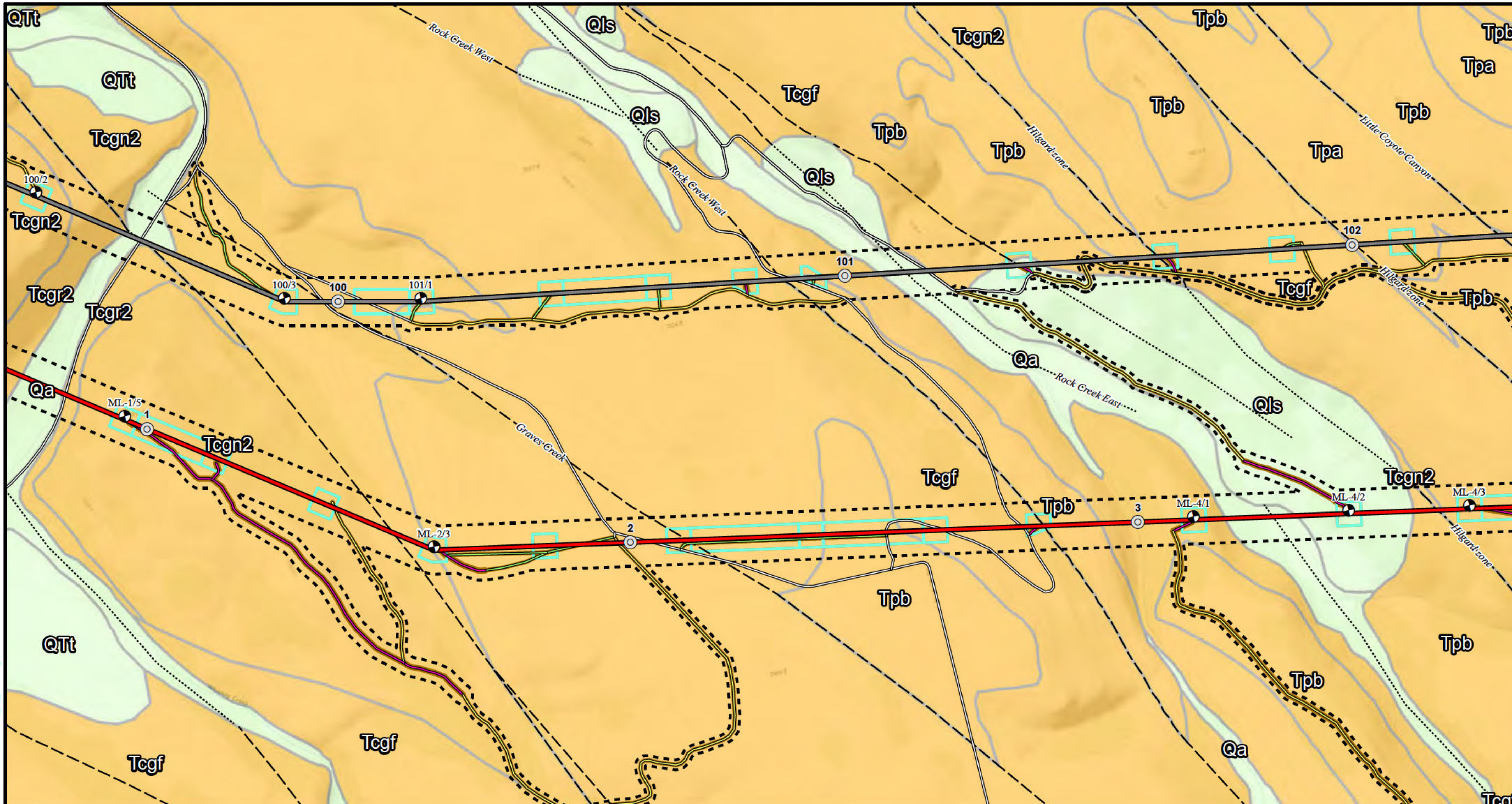

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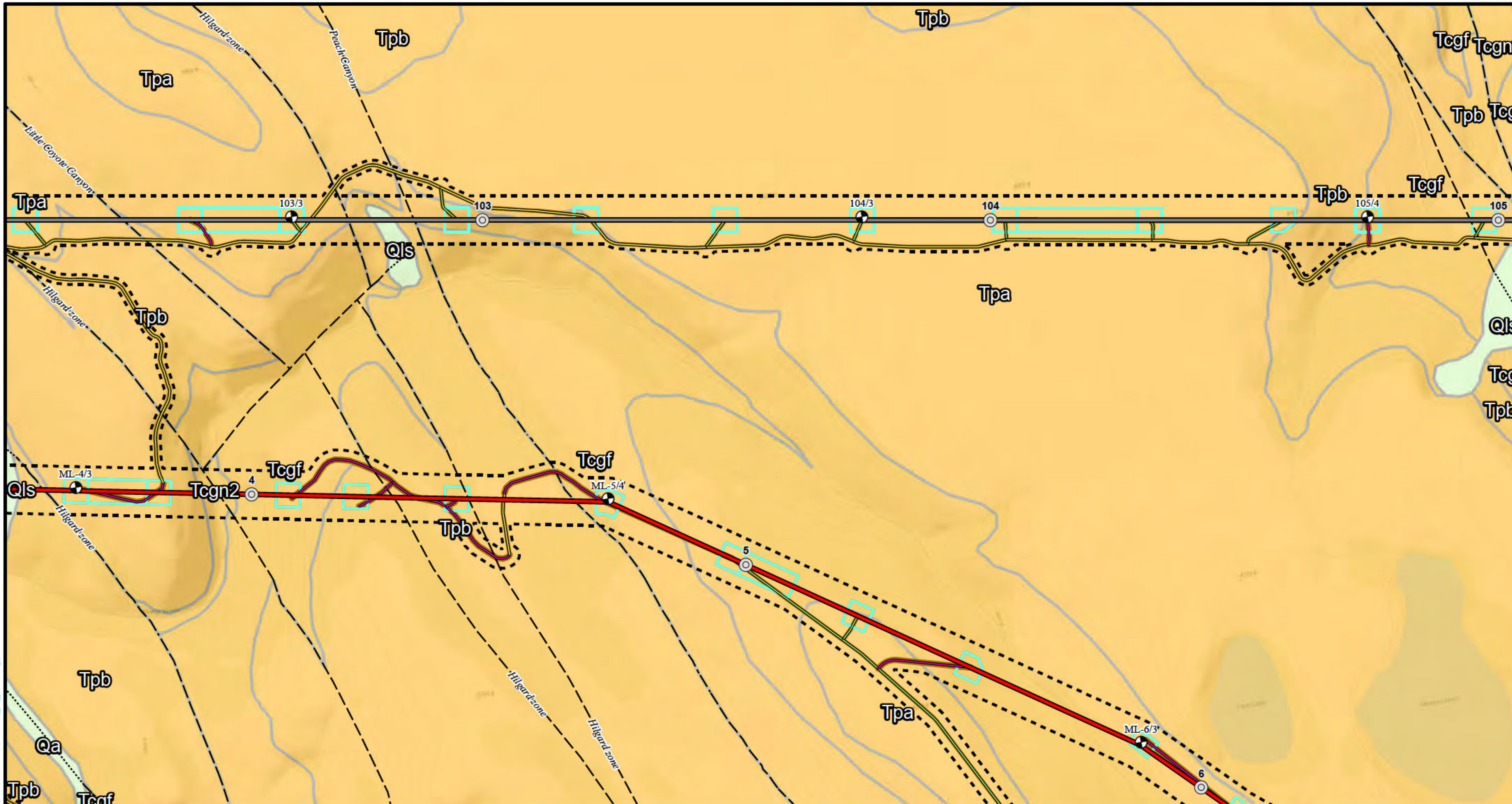

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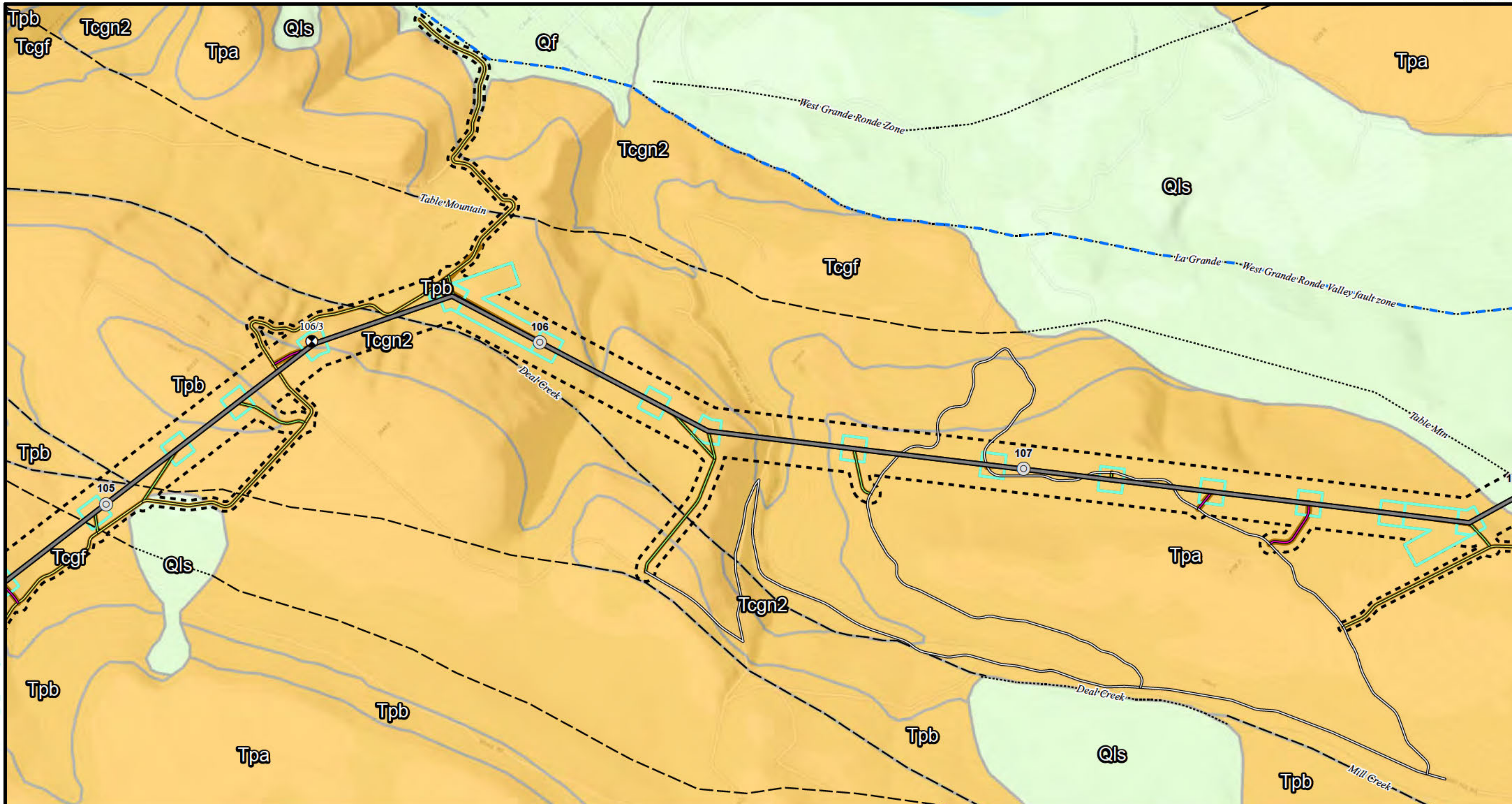

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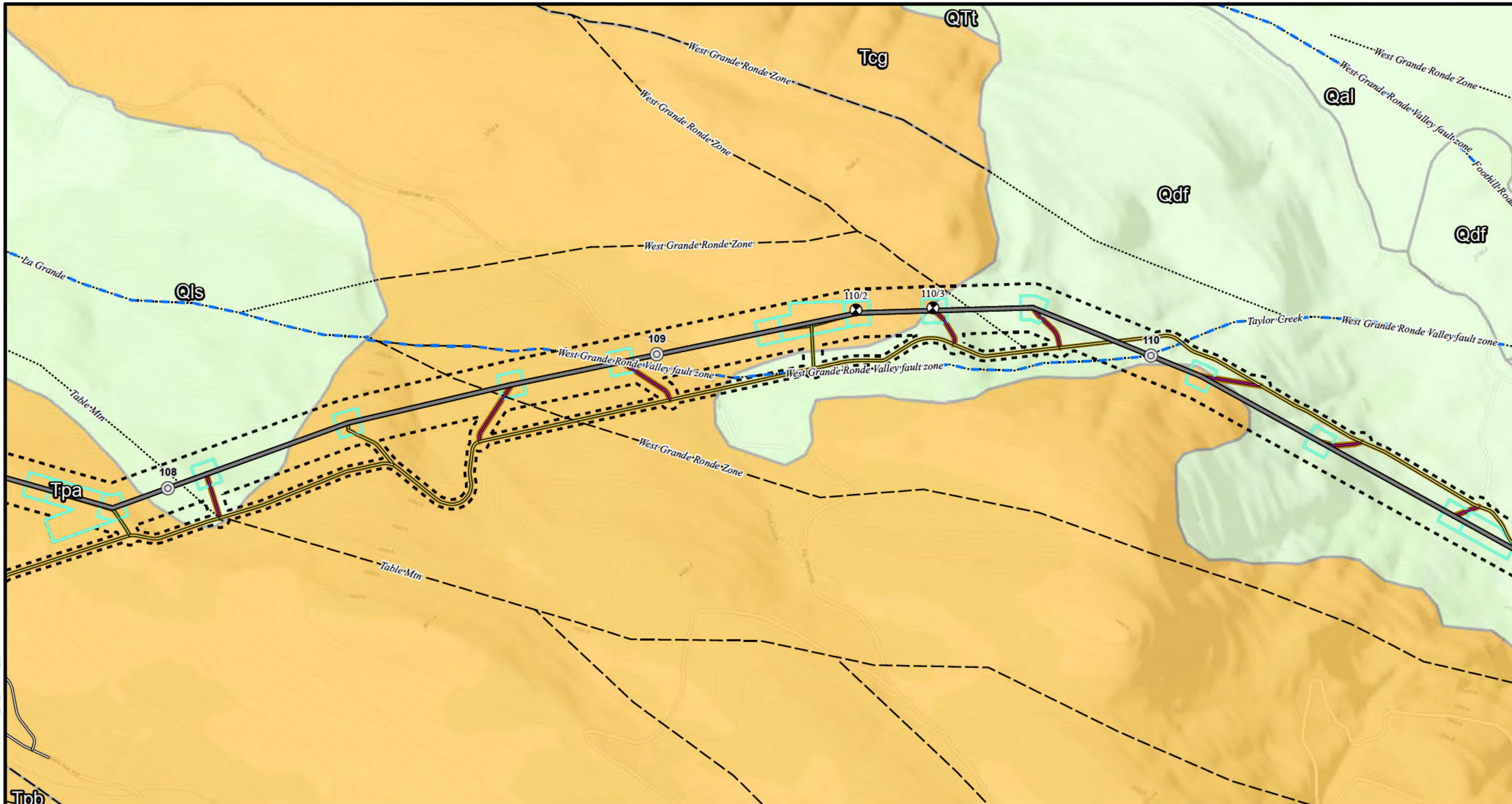

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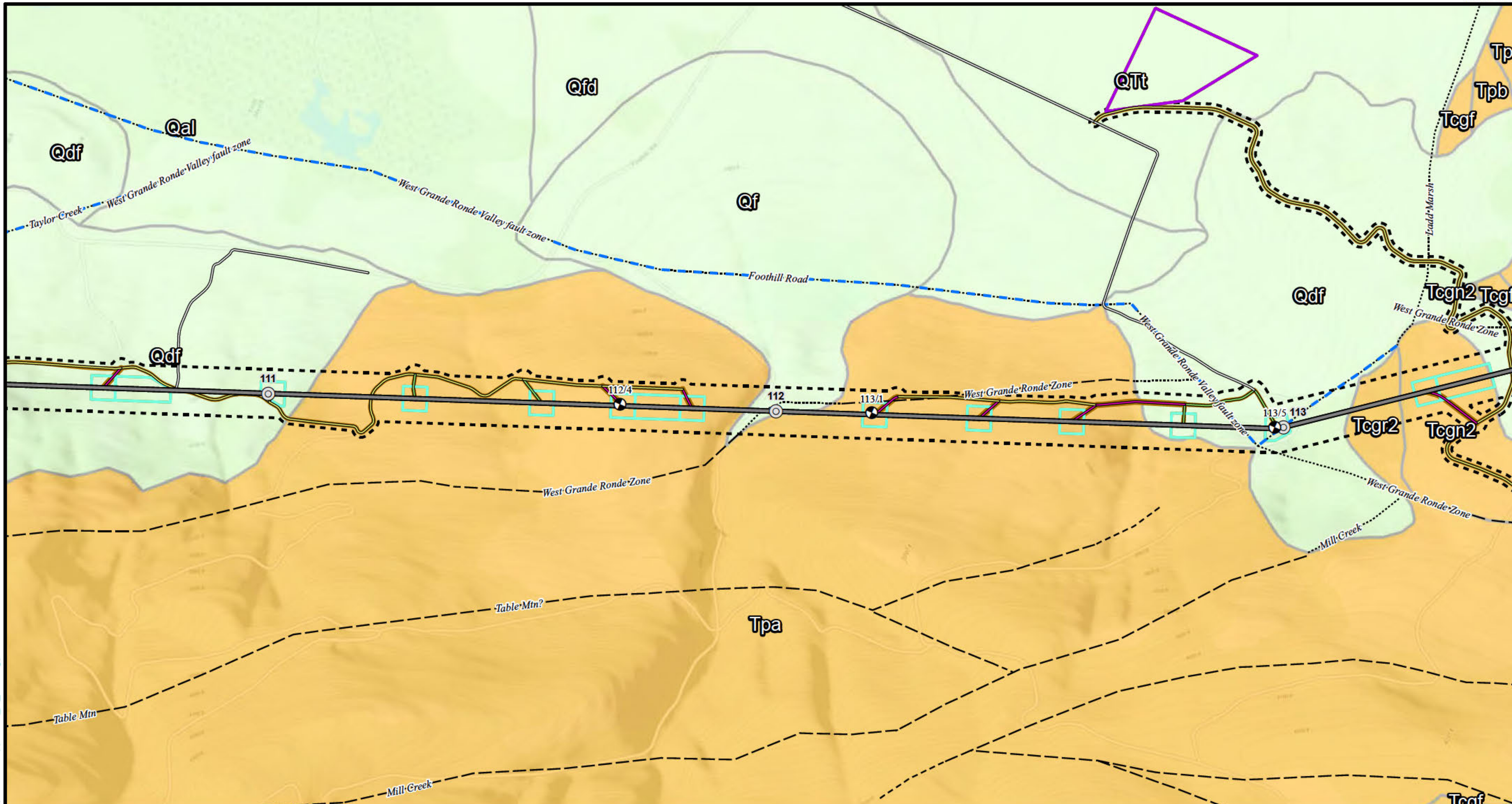

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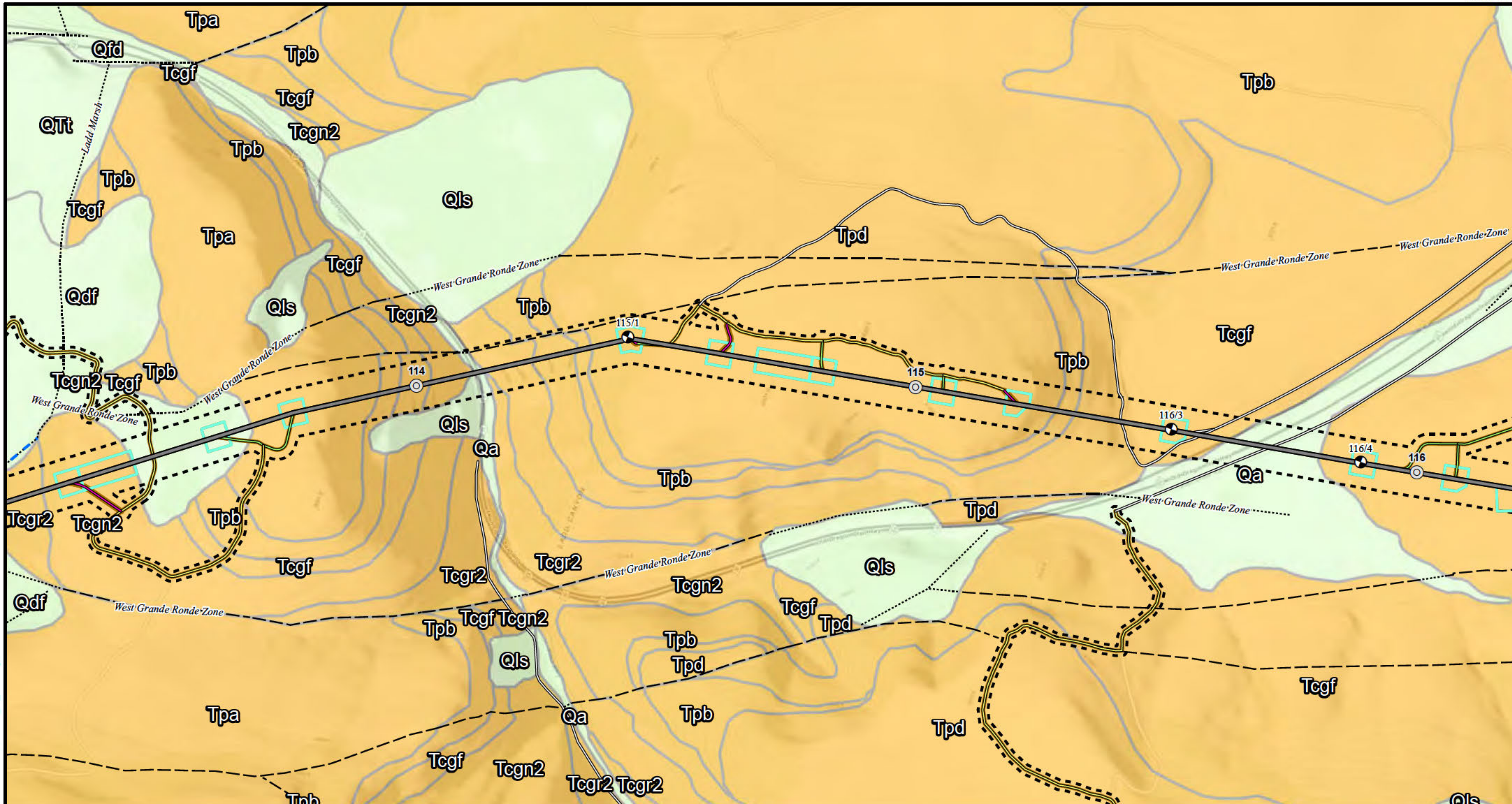

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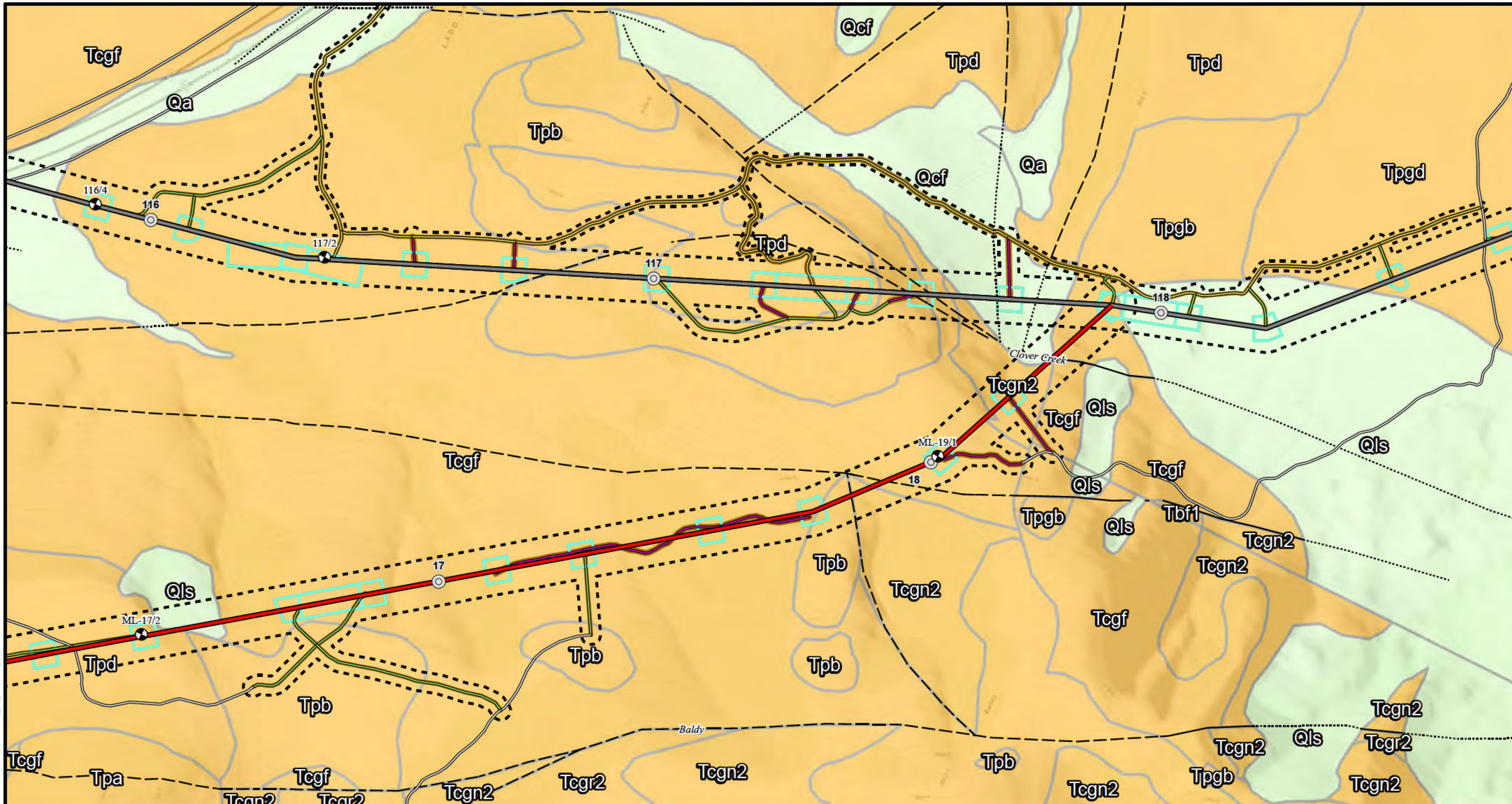

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- Operations Disturbance
- Multi-Use Areas
- Structure Work Areas
- Site Boundary

SURFICIAL GEOLOGY
- Unconsolidated Sediments
- Sedimentary Rocks
- Volcaniclastic Rocks
- Igneous Rocks
- Metamorphic Rocks

FAULTS
- Accurate
- Approximate
- Concealed
- Inferred
- USGS Mapped Quaternary Fault
- No Data

ROADS
- New, Bladed
- New, Primitive
- Existing, Moderate to Extensive Improvements
- No Substantial Improvements
- Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000
Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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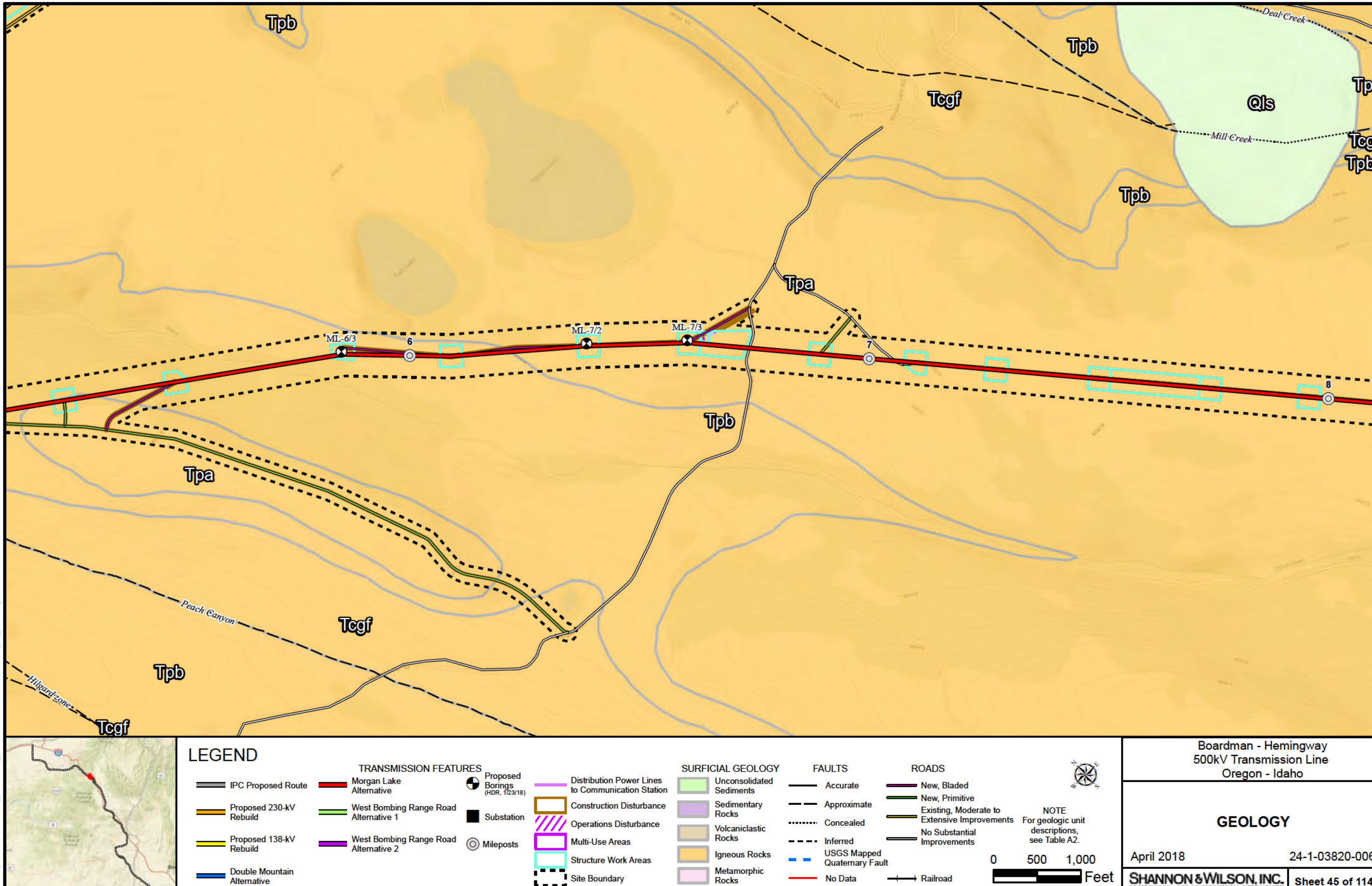

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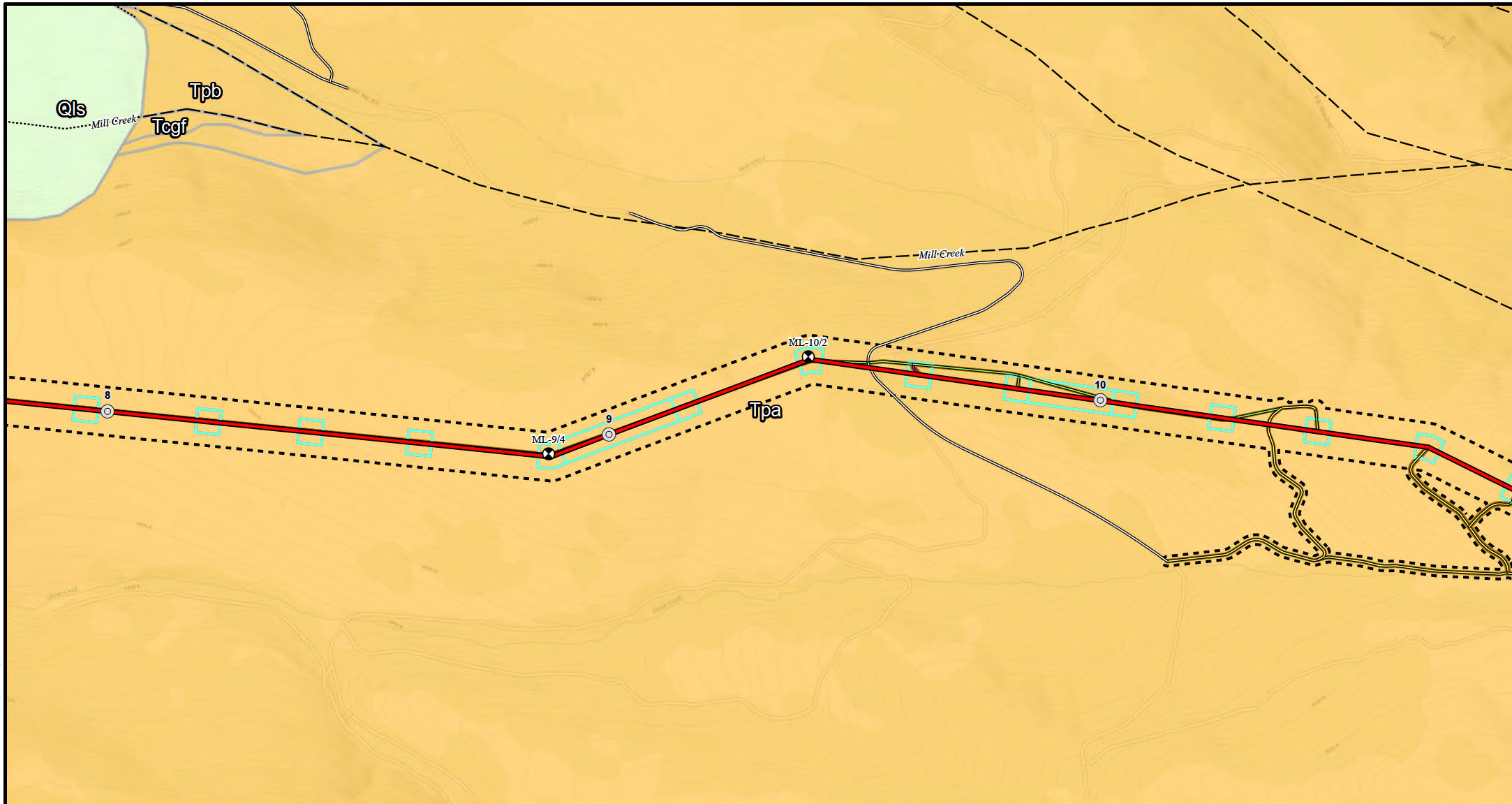

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
Proposed 230-kV Rebuild
Proposed 138-kV Rebuild
Double Mountain Alternative
Morgan Lake Alternative
West Bombing Range Road Alternative 1
West Bombing Range Road Alternative 2
Proposed Borings (HDR, 1/23/18)
Substation
Mileposts
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Approximate
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USGS Mapped Quaternary Fault
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ROADS
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No Substantial Improvements
Railroad

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0 500 1,000 Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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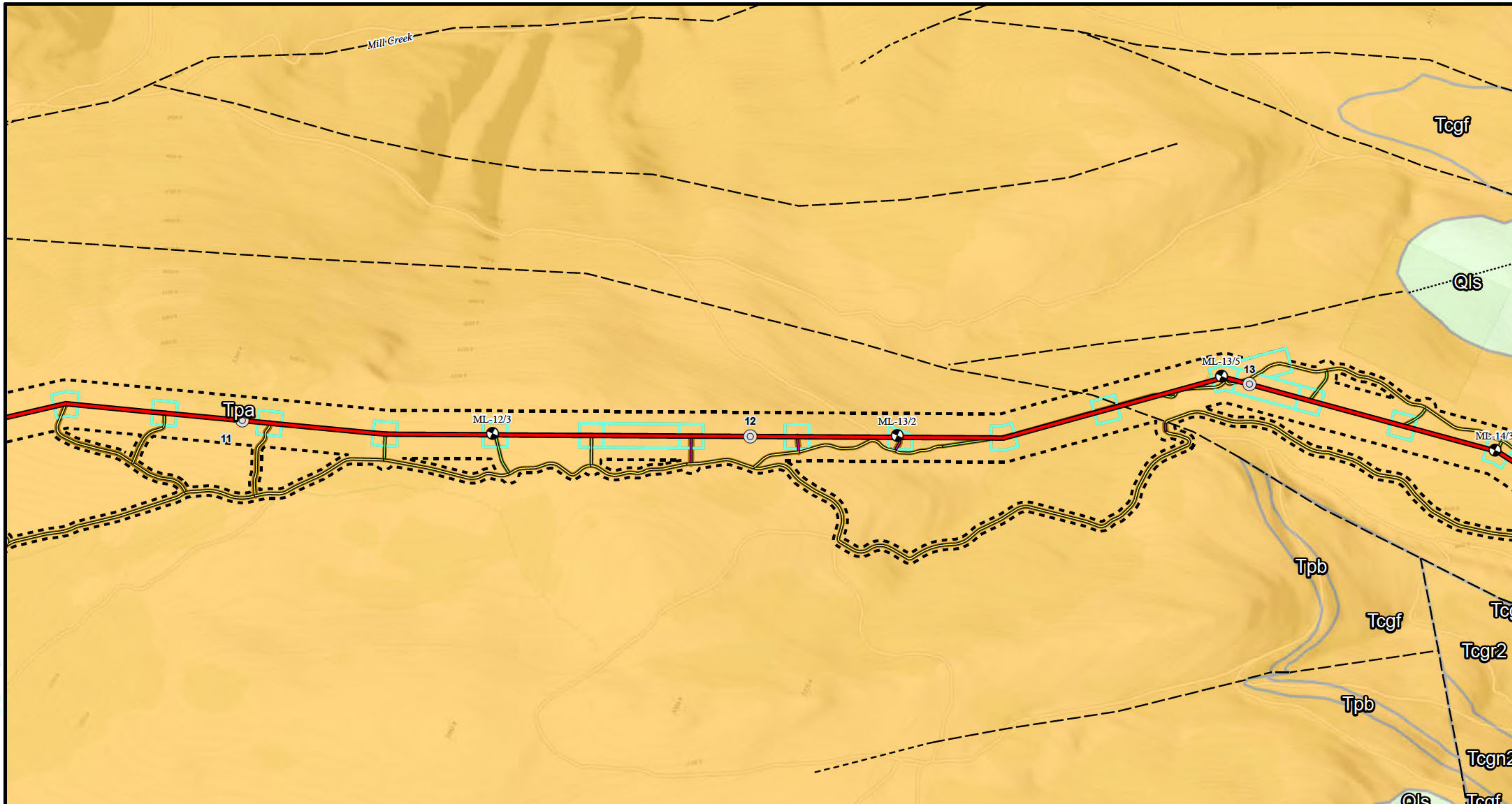

LEGEND

TRANSMISSION FEATURES
- IPC Proposed Route
- Proposed 230-kV Rebuild
- Proposed 138-kV Rebuild
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- Morgan Lake Alternative
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Oregon - Idaho

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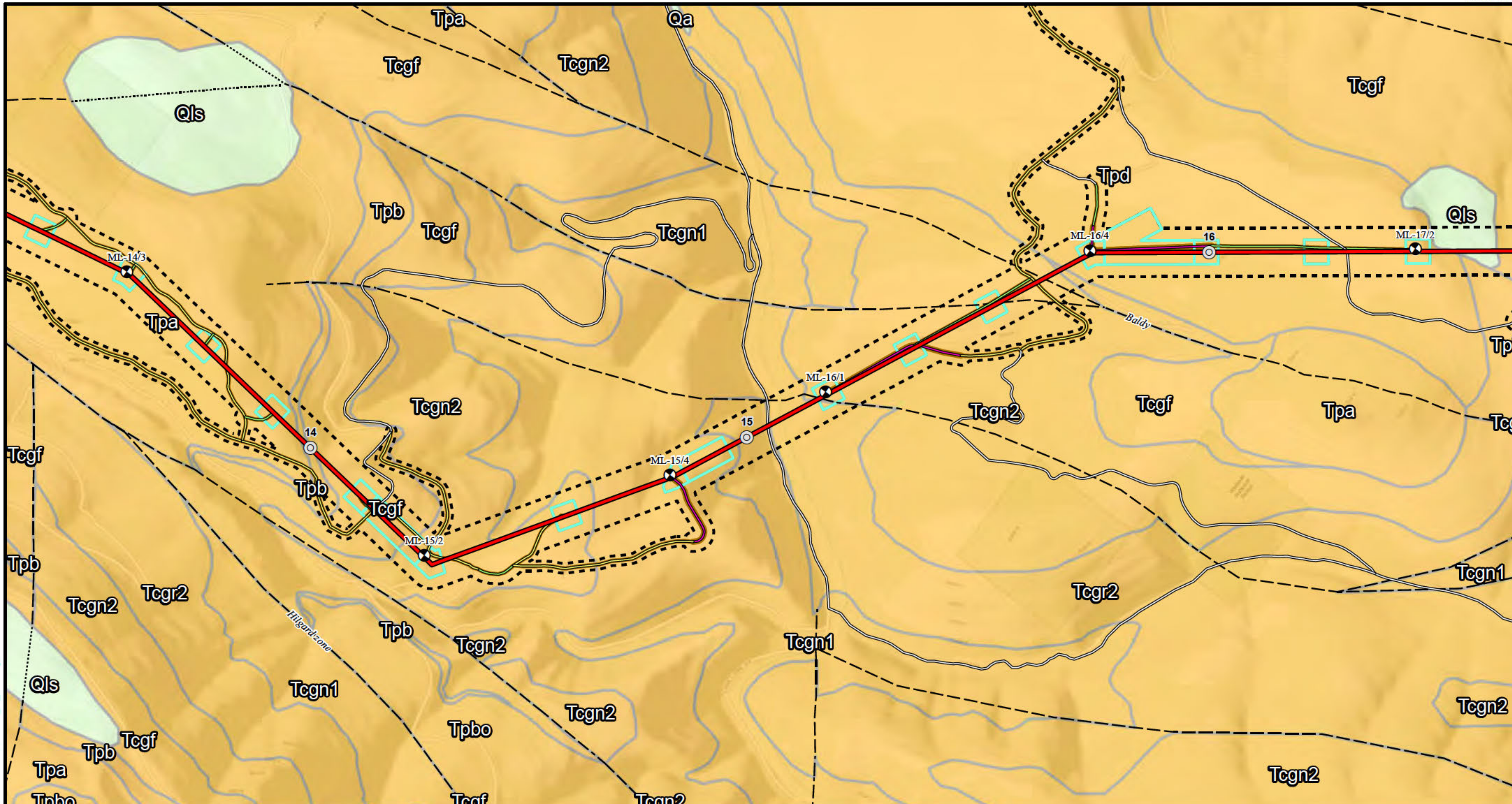

LEGEND

TRANSMISSION FEATURES			SURFICIAL GEOLOGY	FAULTS	ROADS
IPC Proposed Route	Morgan Lake Alternative	Proposed Borings (HDR, 1/23/18)	Unconsolidated Sediments	Accurate	New, Bladed
Proposed 230-kV Rebuild	West Bombing Range Road Alternative 1	Substation	Sedimentary Rocks	Approximate	New, Primitive
Proposed 138-kV Rebuild	West Bombing Range Road Alternative 2	Mileposts	Volcaniclastic Rocks	Concealed	Existing, Moderate to Extensive Improvements
Double Mountain Alternative			Igneous Rocks	Inferred	No Substantial Improvements
			Metamorphic Rocks	USGS Mapped Quaternary Fault	Railroad
				No Data	

Distribution Power Lines to Communication Station
Construction Disturbance
Operations Disturbance
Multi-Use Areas
Structure Work Areas
Site Boundary

NOTE
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0 500 1,000 Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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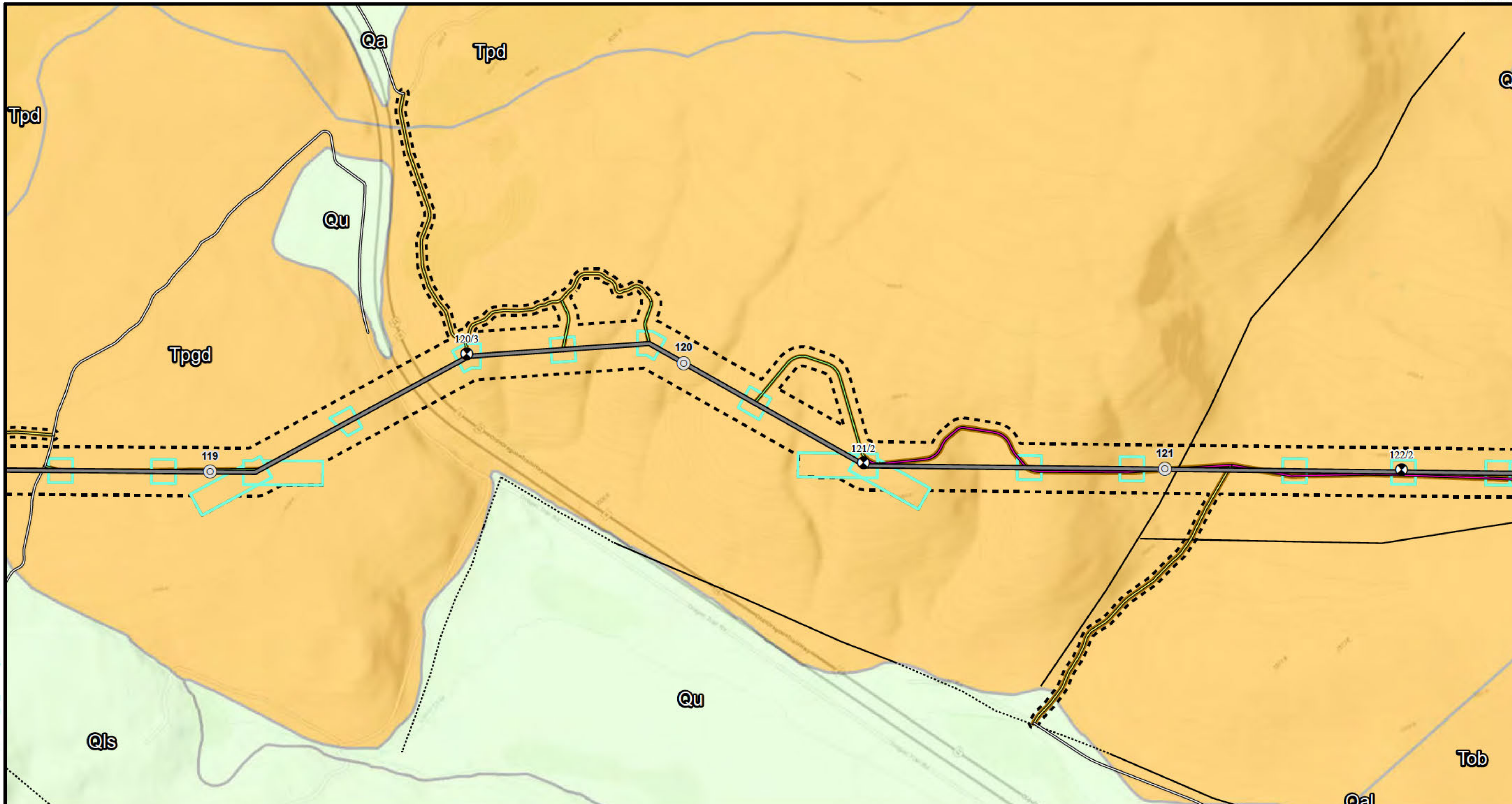

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
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Proposed 138-kV Rebuild
Double Mountain Alternative
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Boardman - Hemingway
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Oregon - Idaho

GEOLOGY

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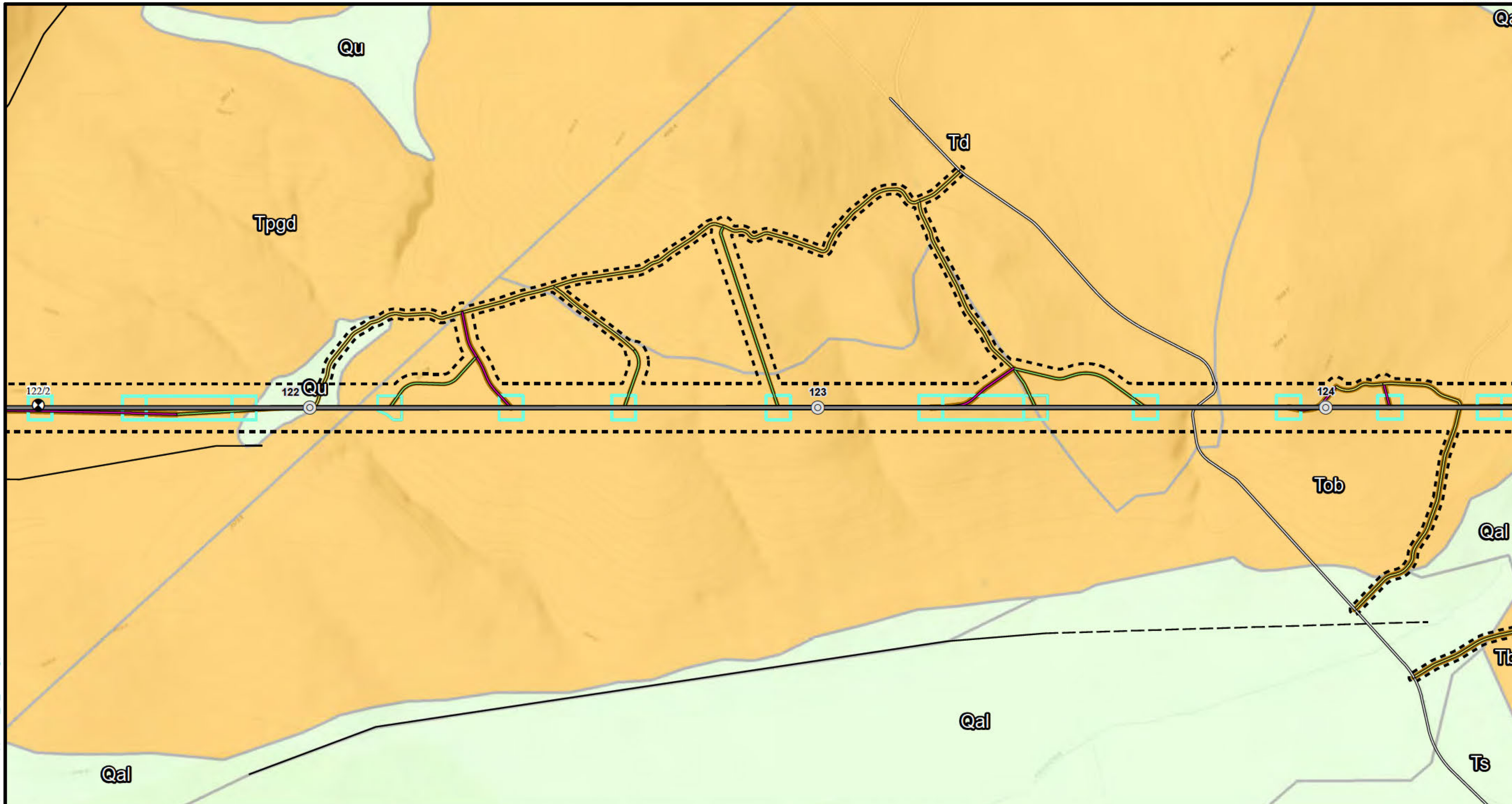

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
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Proposed 138-kV Rebuild
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Boardman - Hemingway
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Oregon - Idaho

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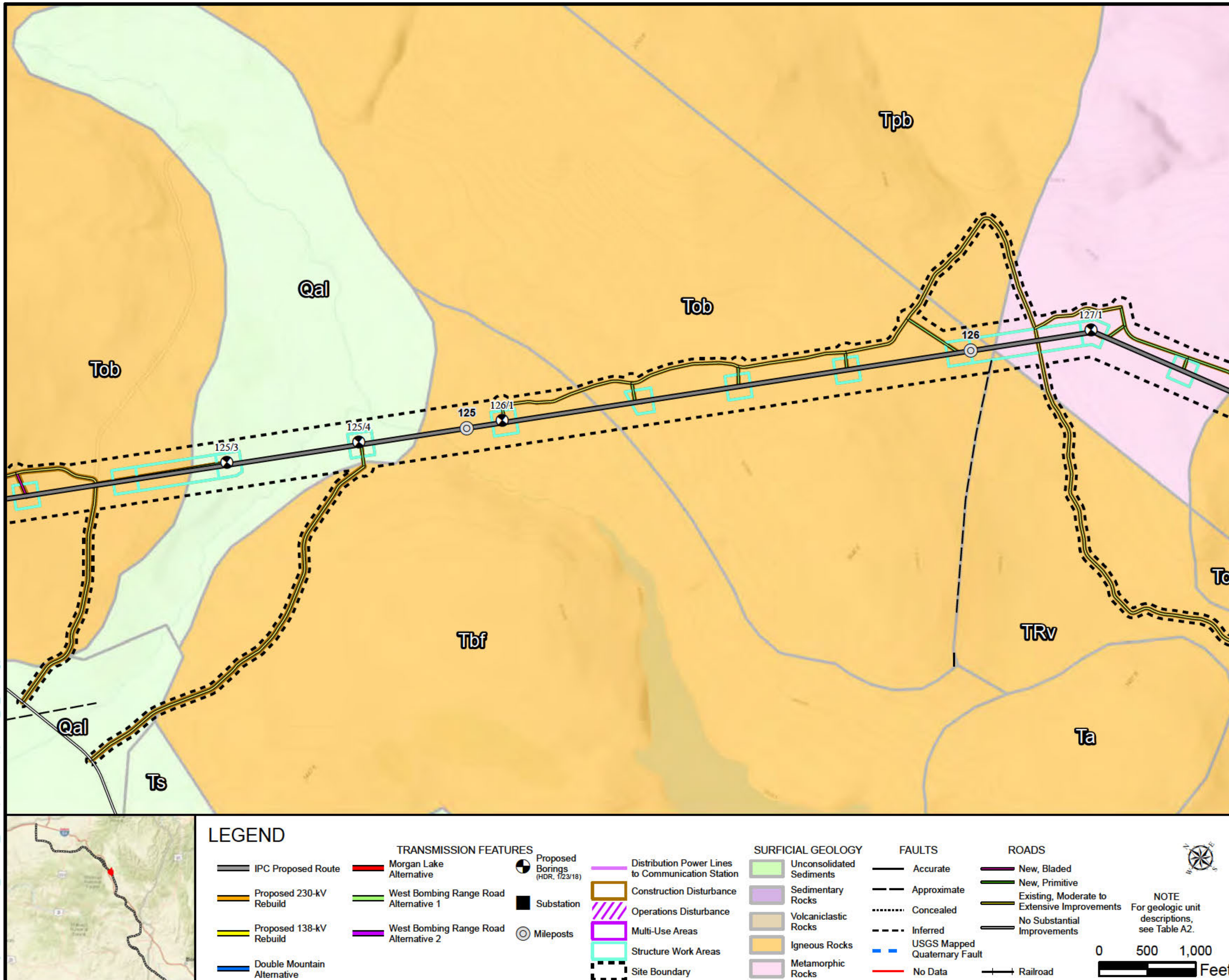

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Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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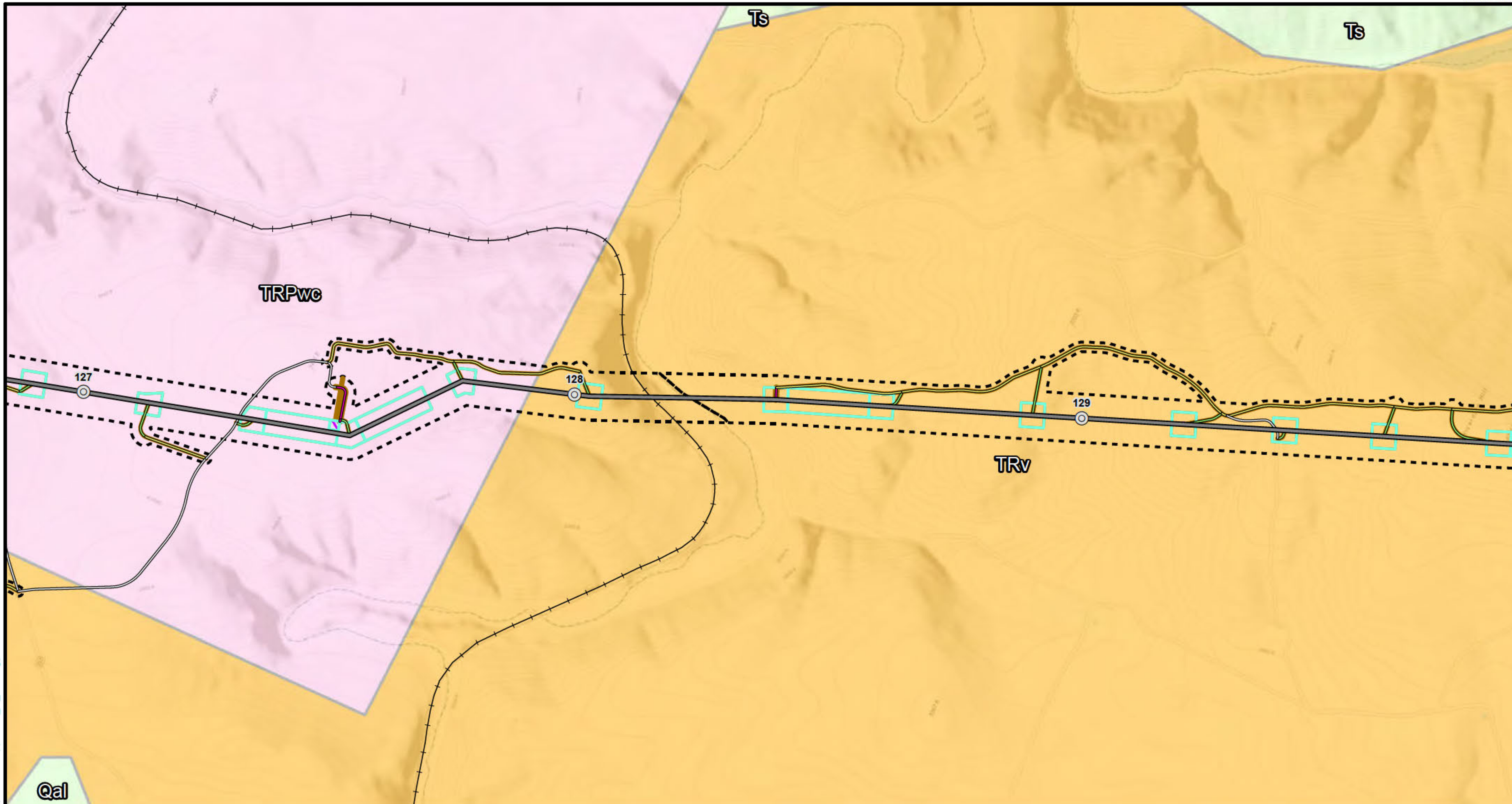

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TRANSMISSION FEATURES
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Oregon - Idaho

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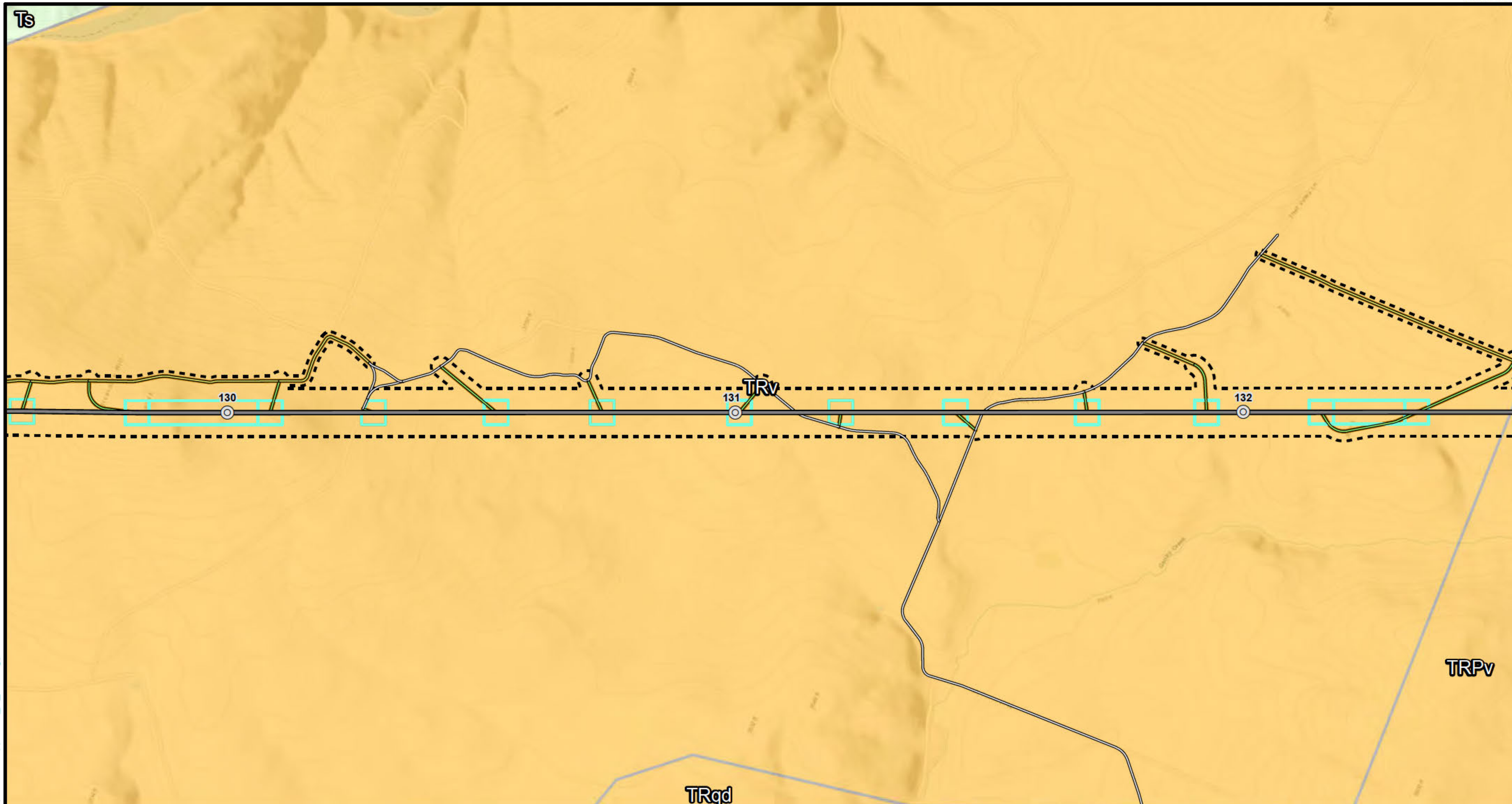

LEGEND

TRANSMISSION FEATURES
- IPC Proposed Route
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Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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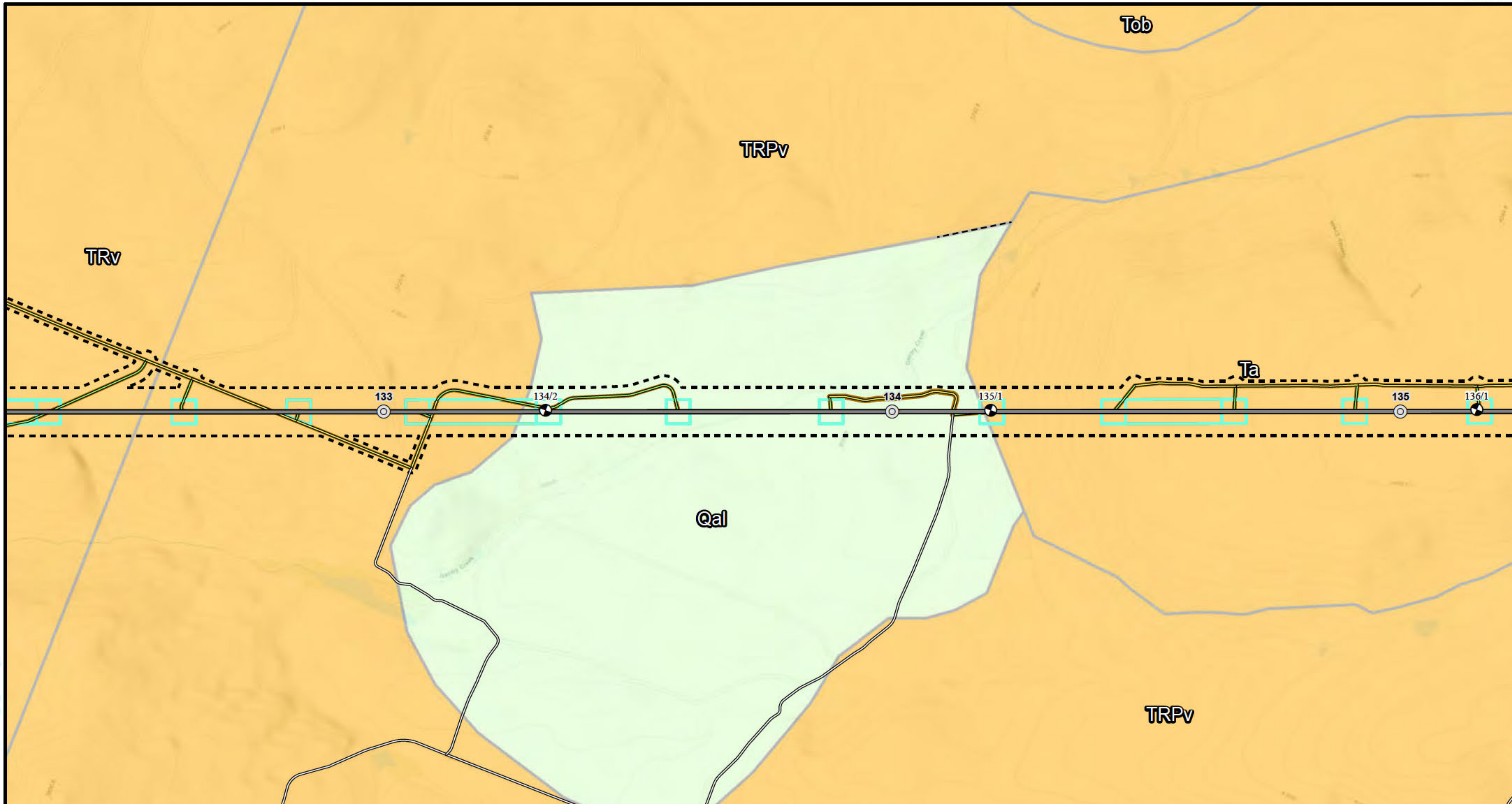

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
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Proposed 138-kV Rebuild
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No Substantial Improvements
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NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000 Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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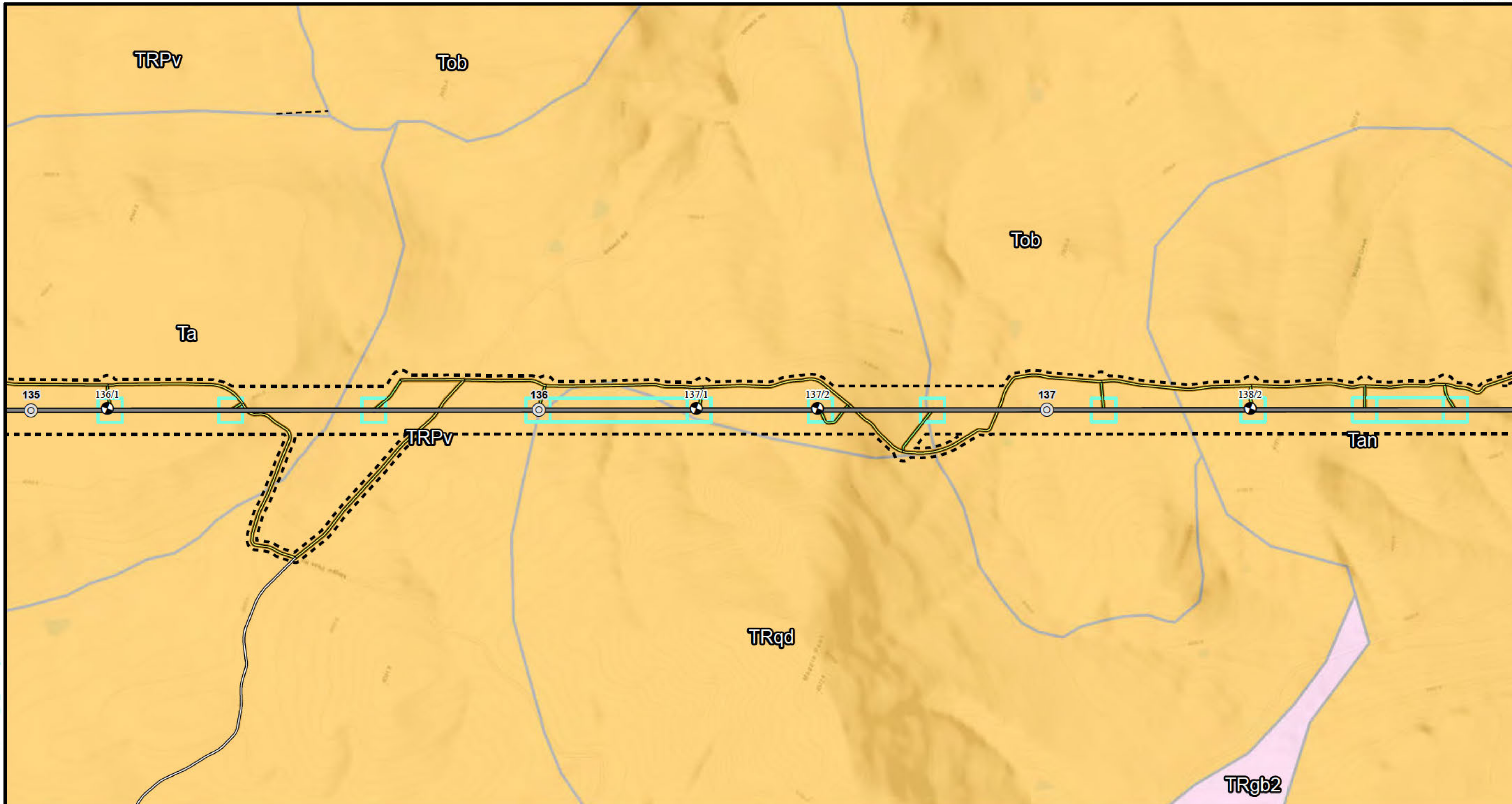

LEGEND

TRANSMISSION FEATURES

- IPC Proposed Route
- Proposed 230-kV Rebuild
- Proposed 138-kV Rebuild
- Double Mountain Alternative
- Morgan Lake Alternative
- West Bombing Range Road Alternative 1
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SURFICIAL GEOLOGY

- Unconsolidated Sediments
- Sedimentary Rocks
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NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000
Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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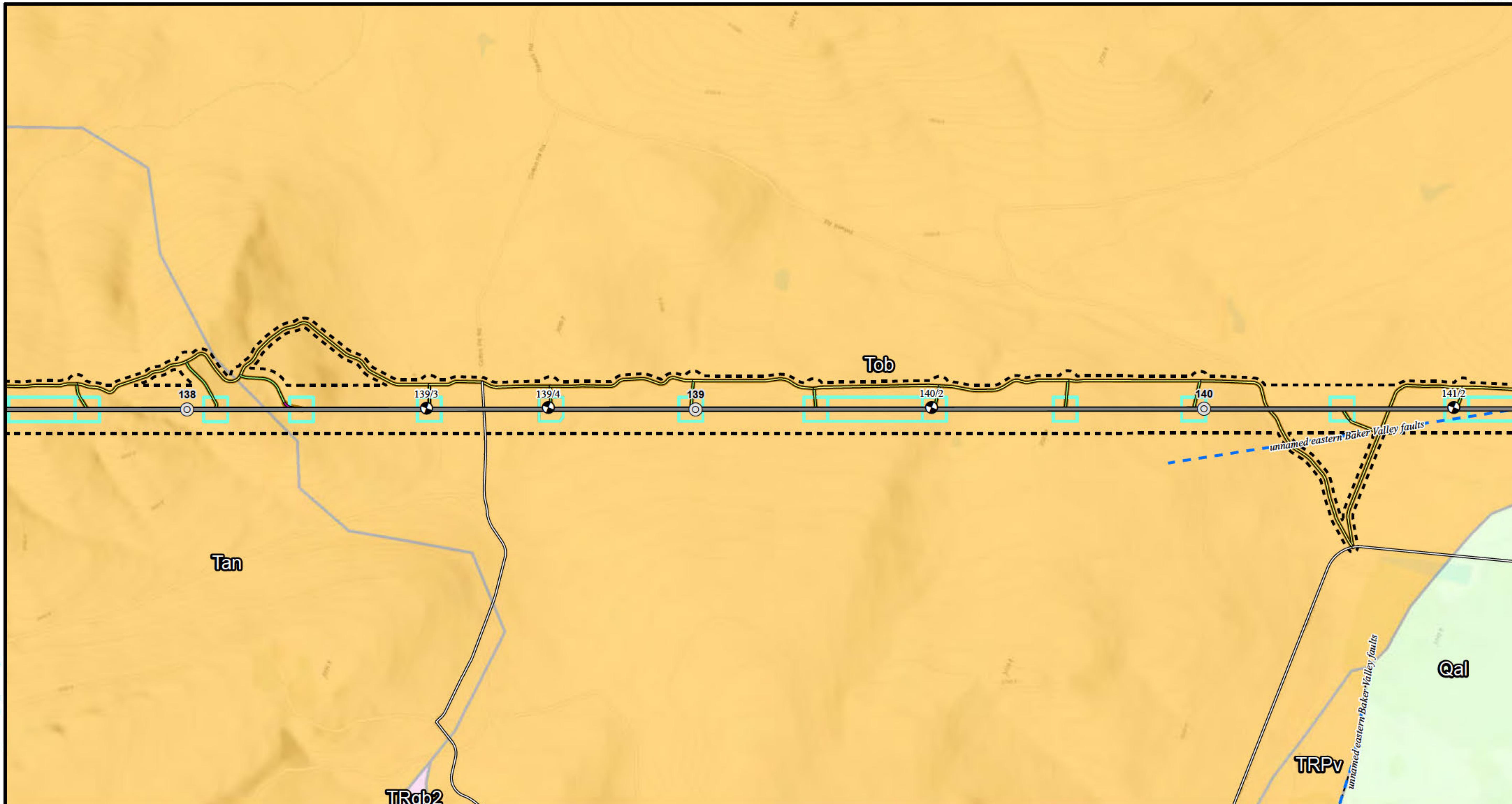

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
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Proposed 138-kV Rebuild
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NOTE
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0 500 1,000
Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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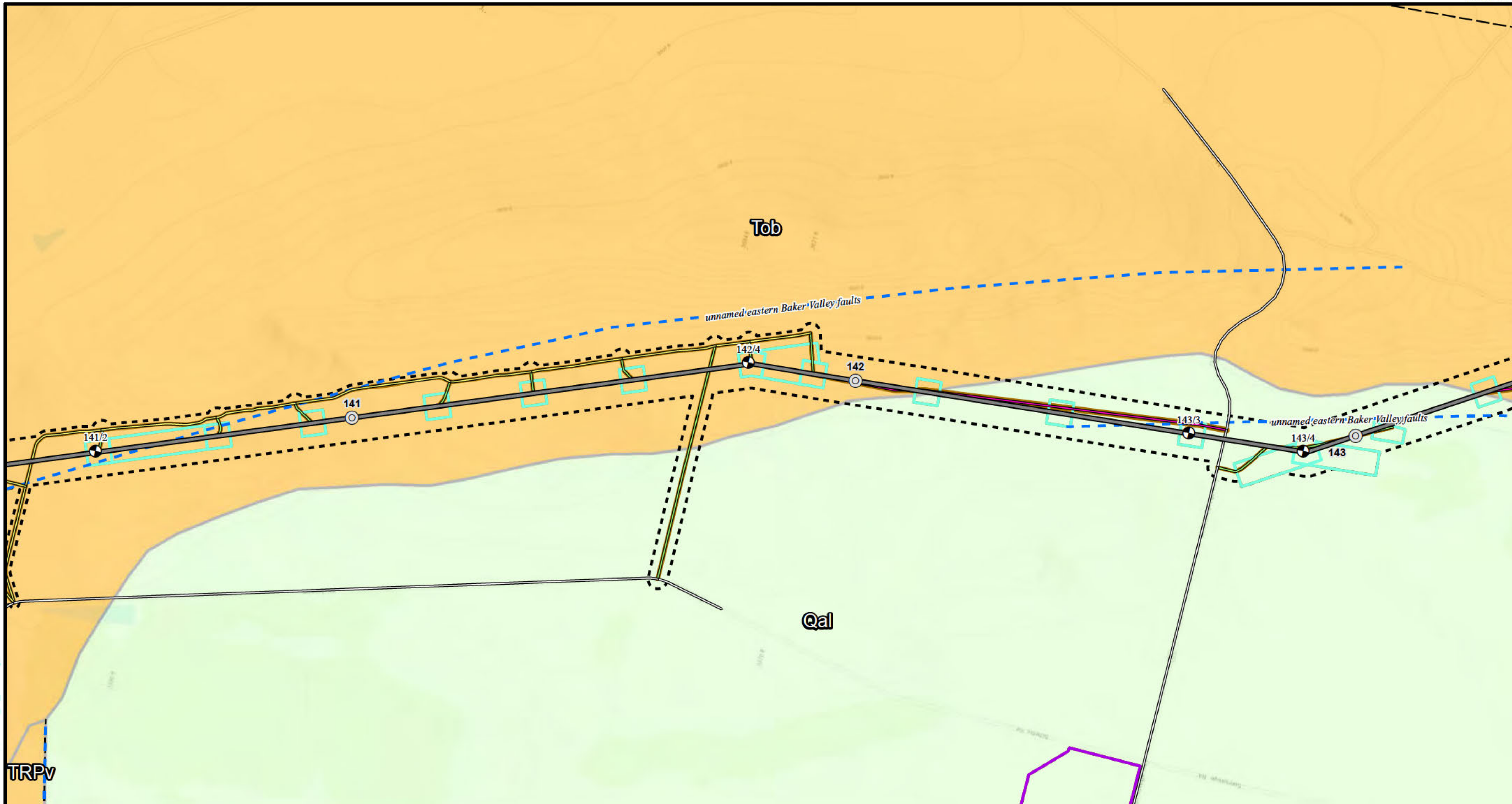

LEGEND

TRANSMISSION FEATURES

- IPC Proposed Route
- Proposed 230-kV Rebuild
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- Double Mountain Alternative
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Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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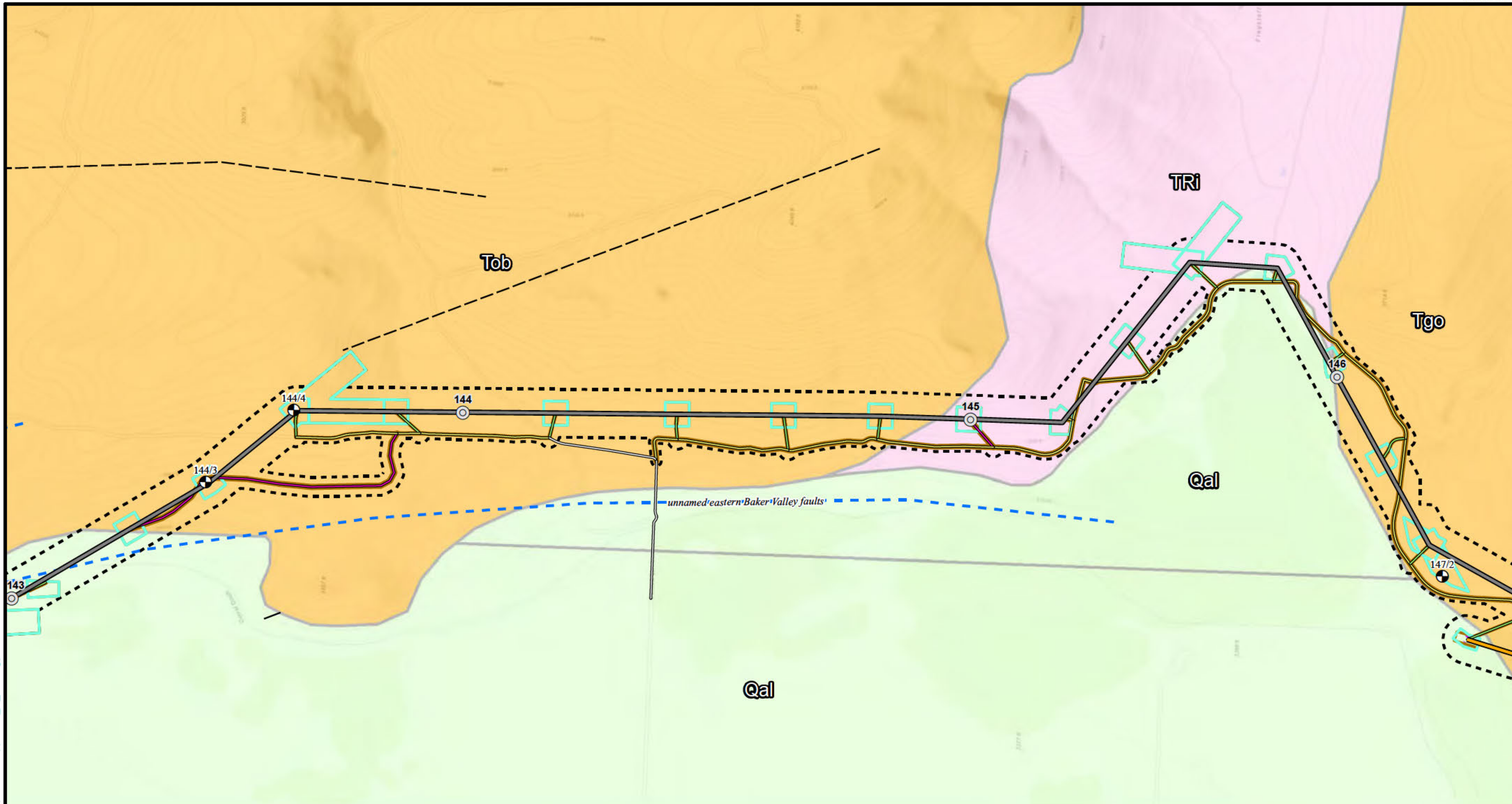

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TRANSMISSION FEATURES
- IPC Proposed Route
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Oregon - Idaho

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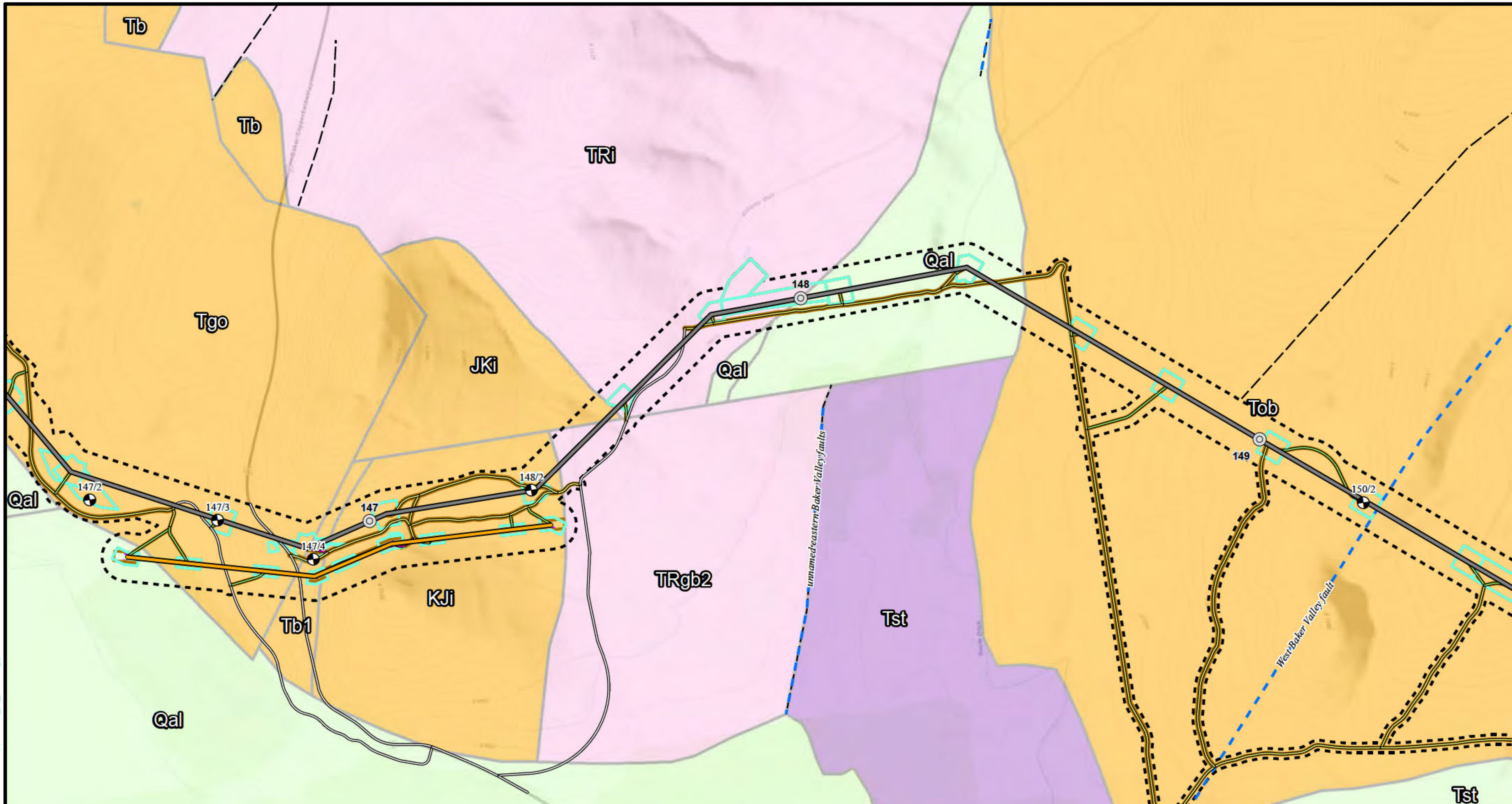

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Oregon - Idaho

GEOLOGY

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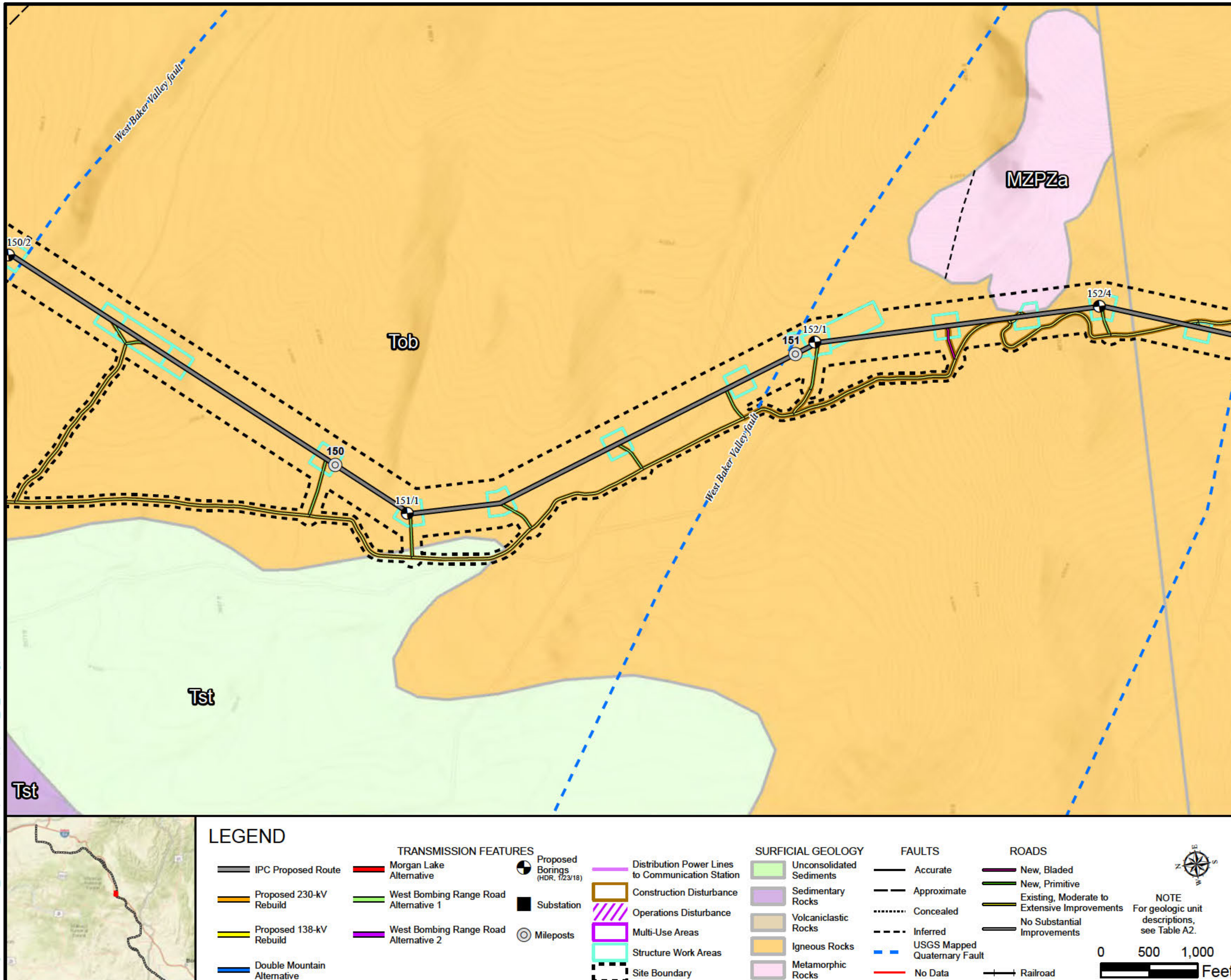

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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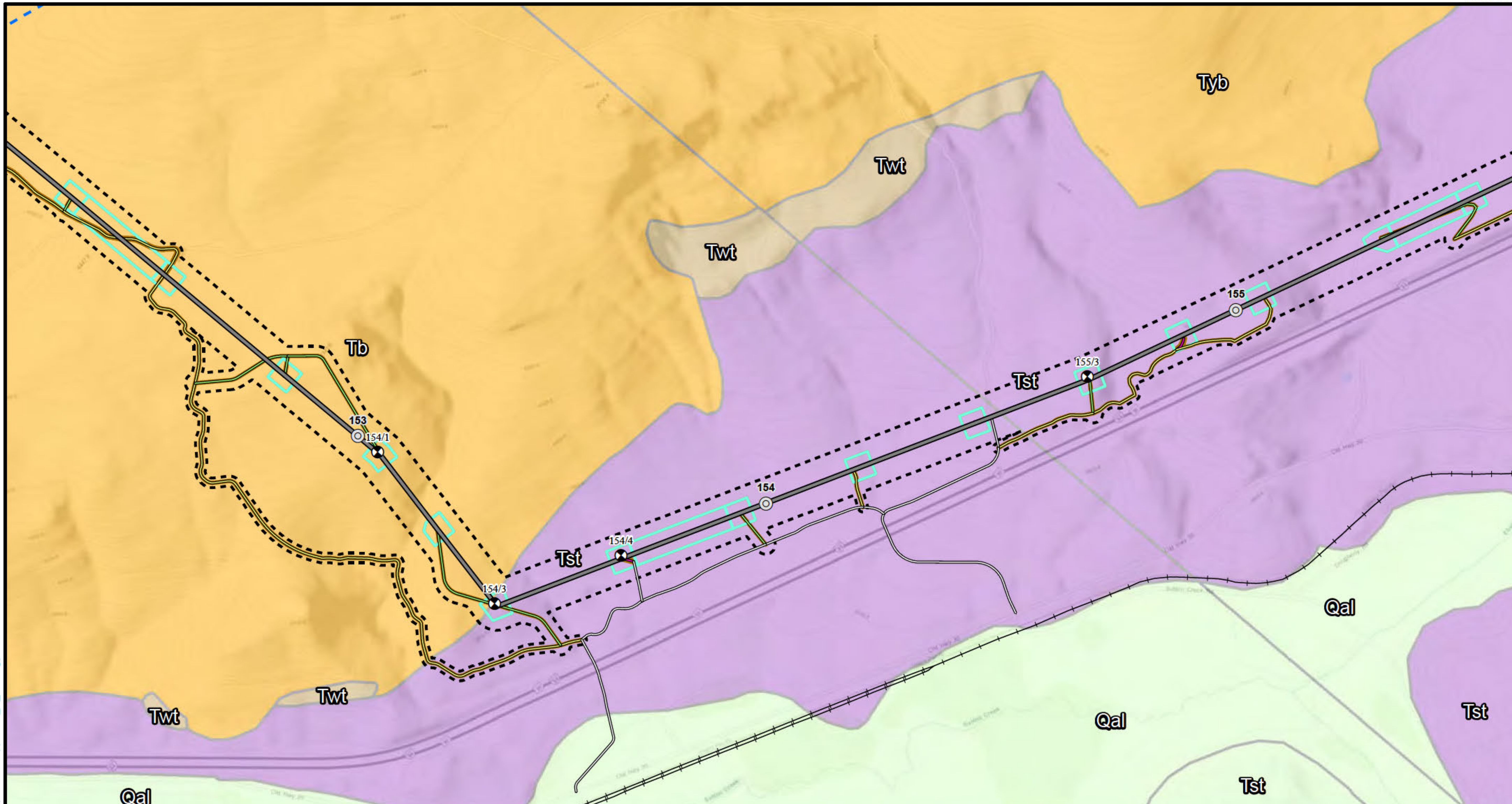

LEGEND

TRANSMISSION FEATURES
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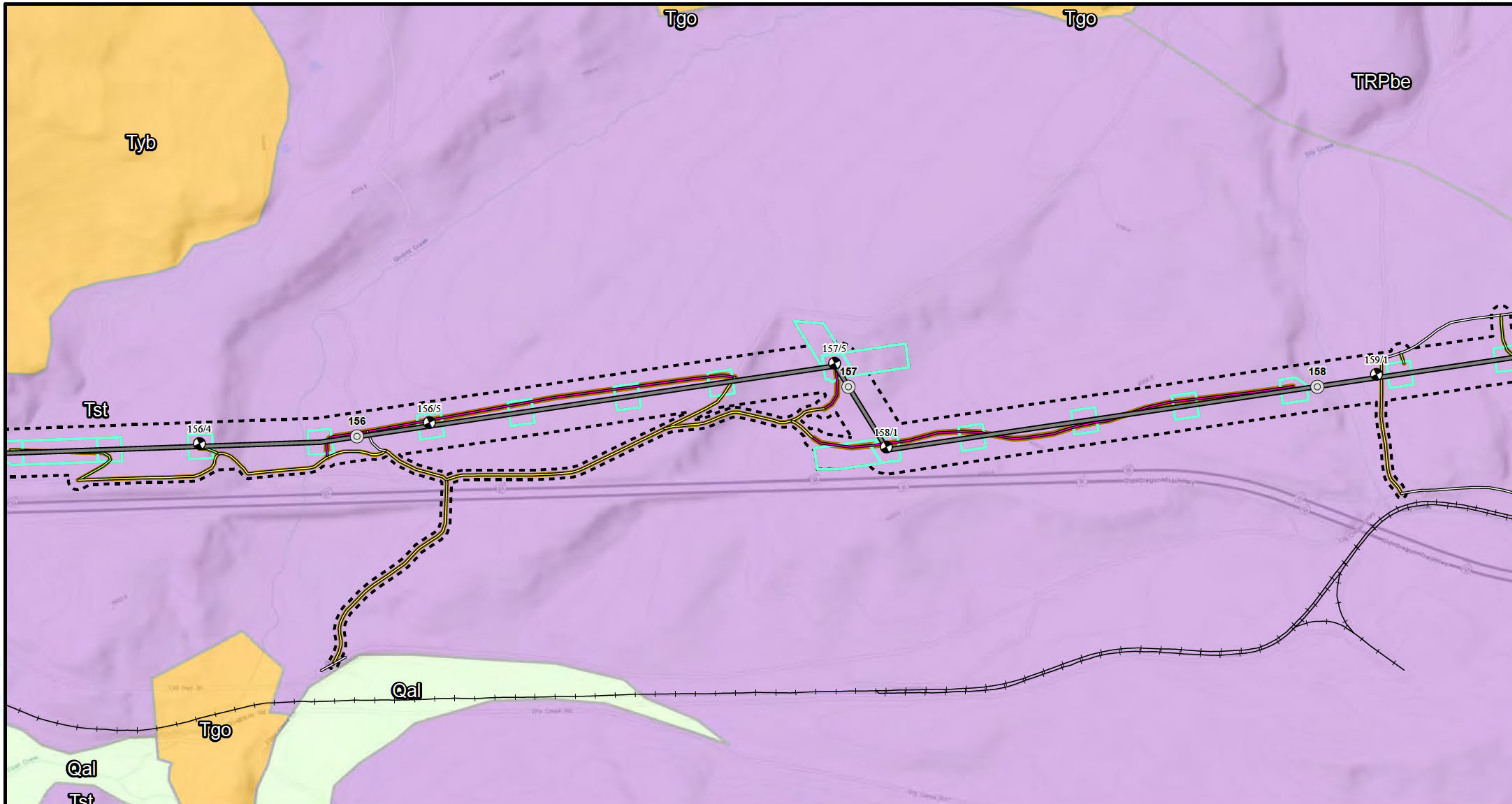

LEGEND

TRANSMISSION FEATURES
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- Site Boundary

SURFICIAL GEOLOGY
- Unconsolidated Sediments
- Sedimentary Rocks
- Volcaniclastic Rocks
- Igneous Rocks
- Metamorphic Rocks

FAULTS
- Accurate
- Approximate
- Concealed
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- USGS Mapped Quaternary Fault
- No Data

ROADS
- New, Bladed
- New, Primitive
- Existing, Moderate to Extensive Improvements
- No Substantial Improvements
- Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000 Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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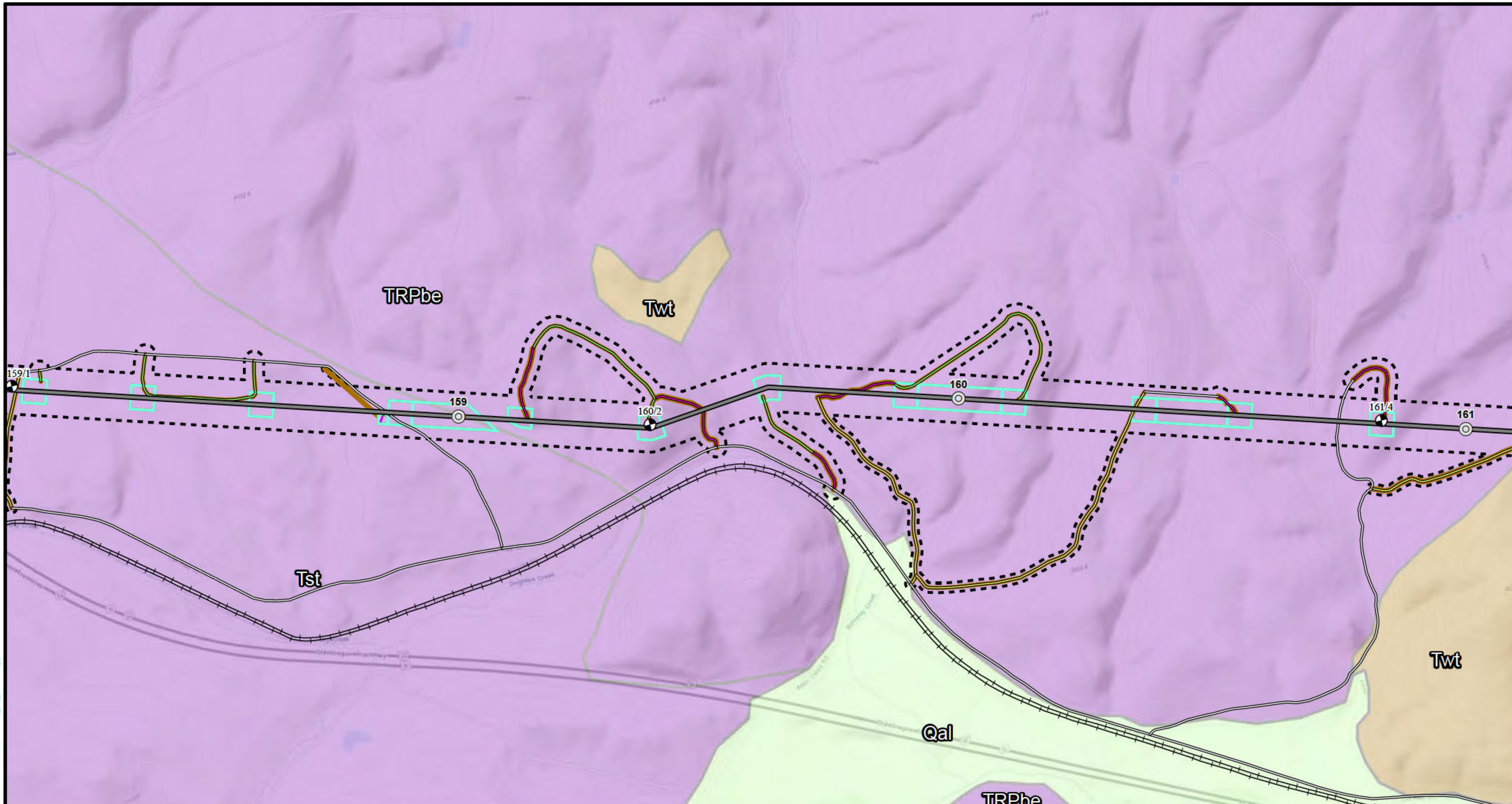

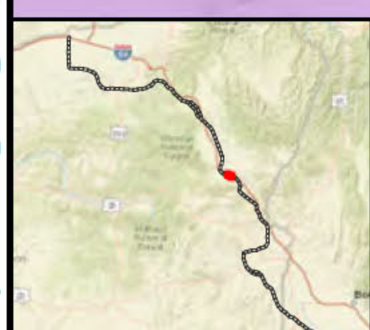

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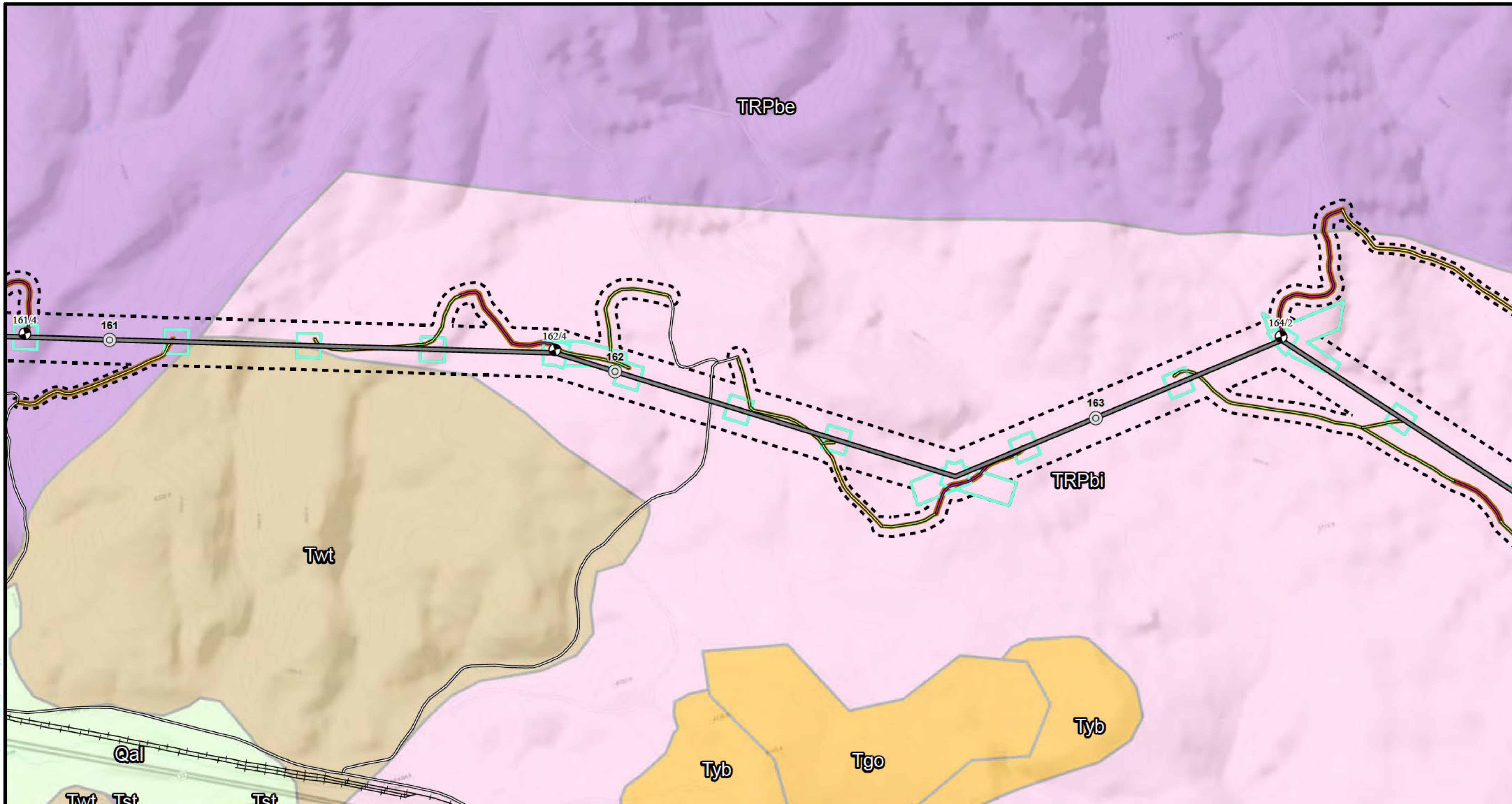

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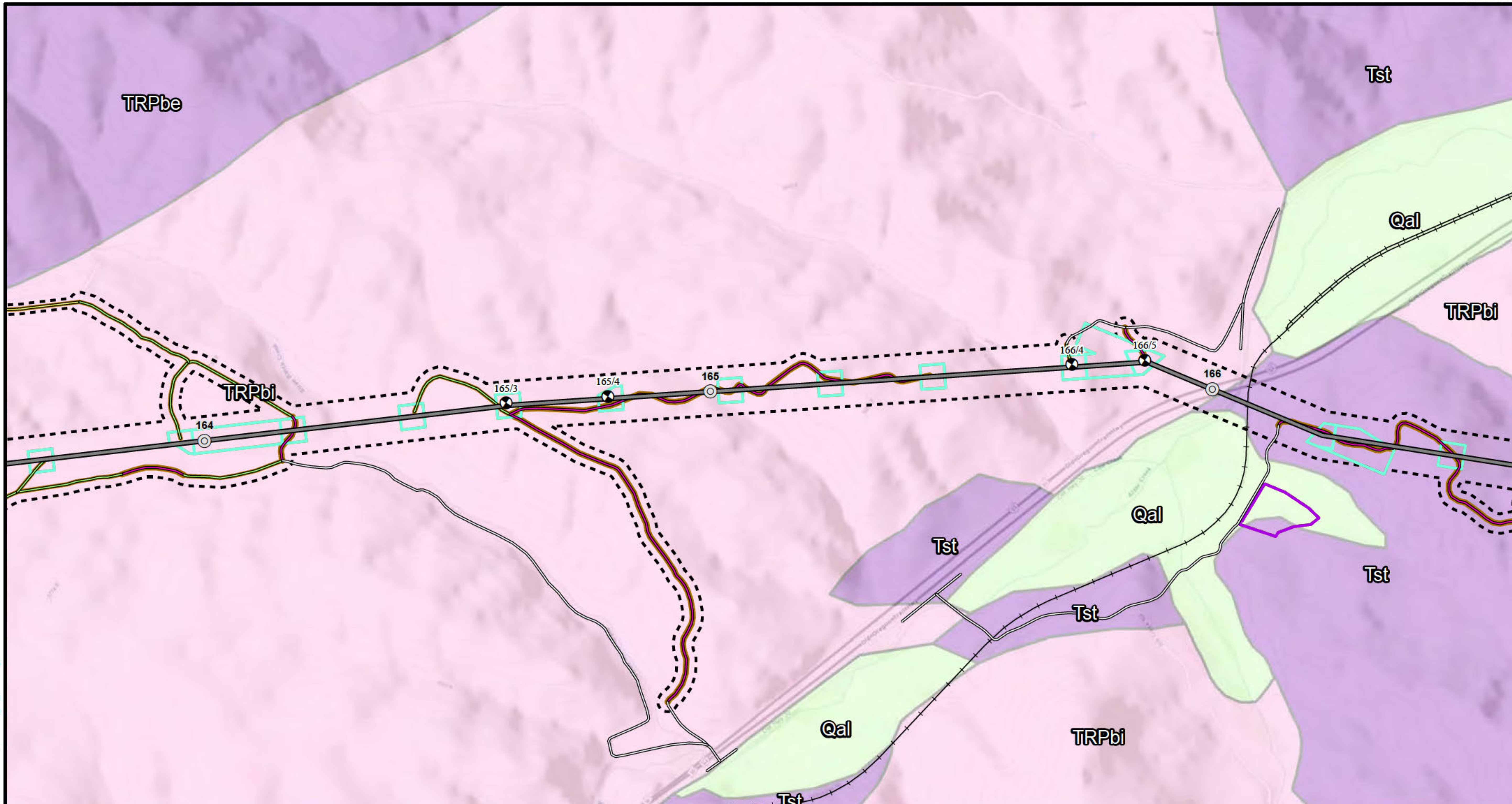

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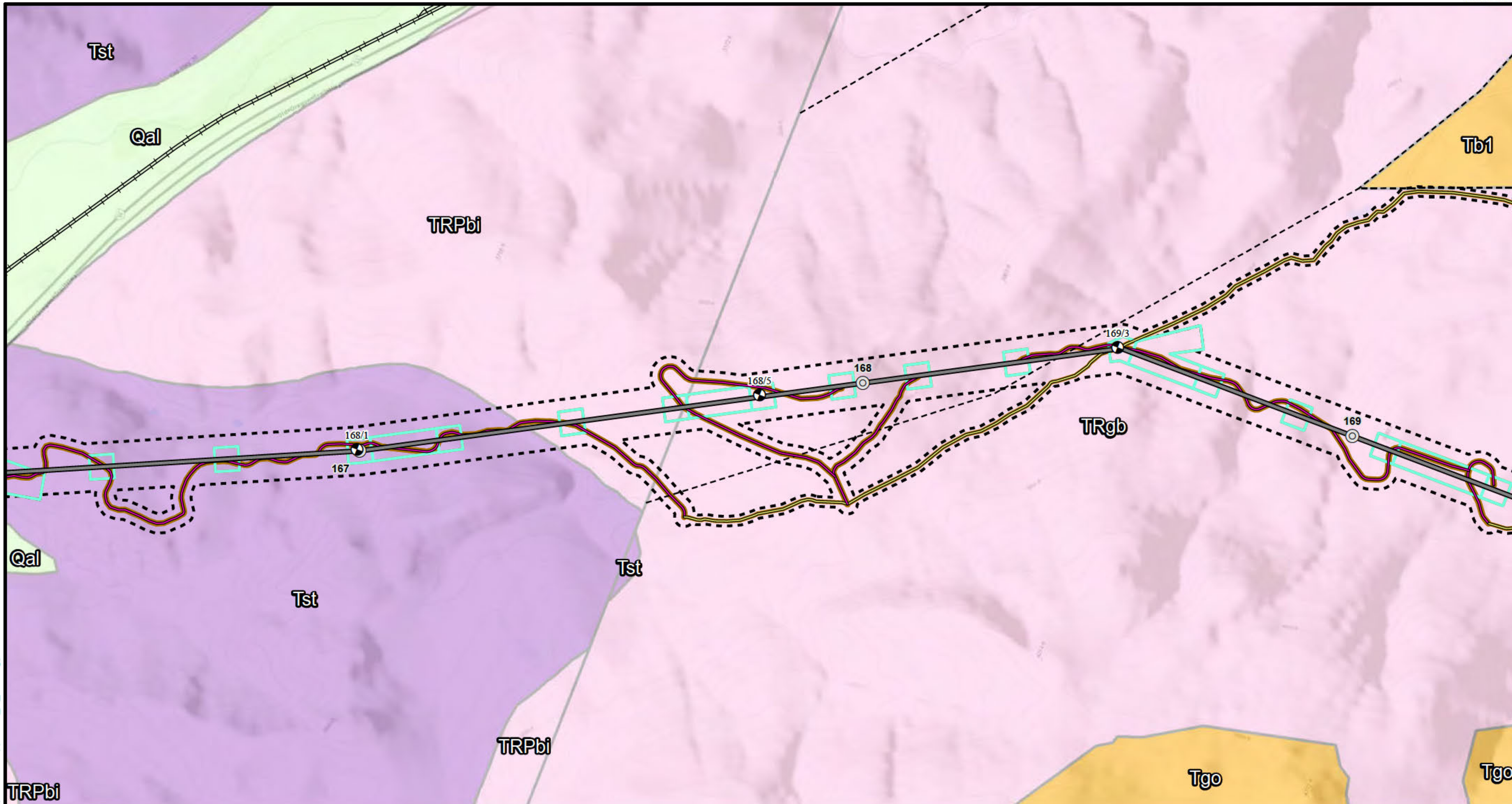

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Oregon - Idaho

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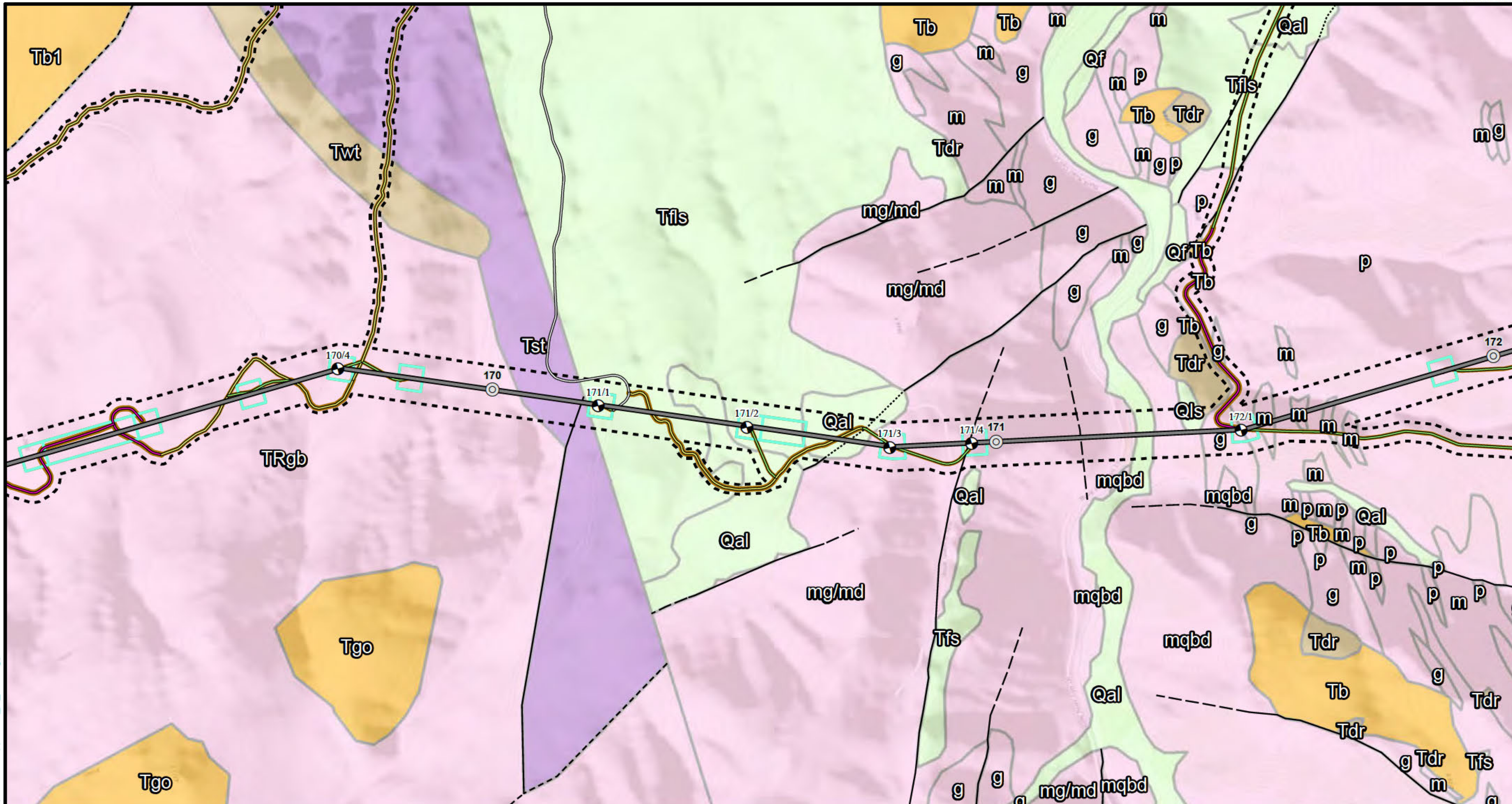

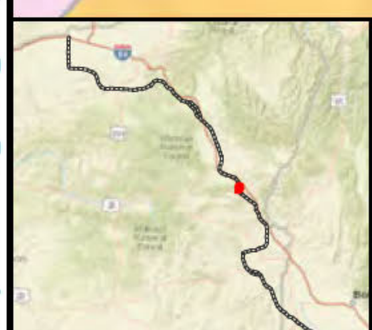

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Oregon - Idaho

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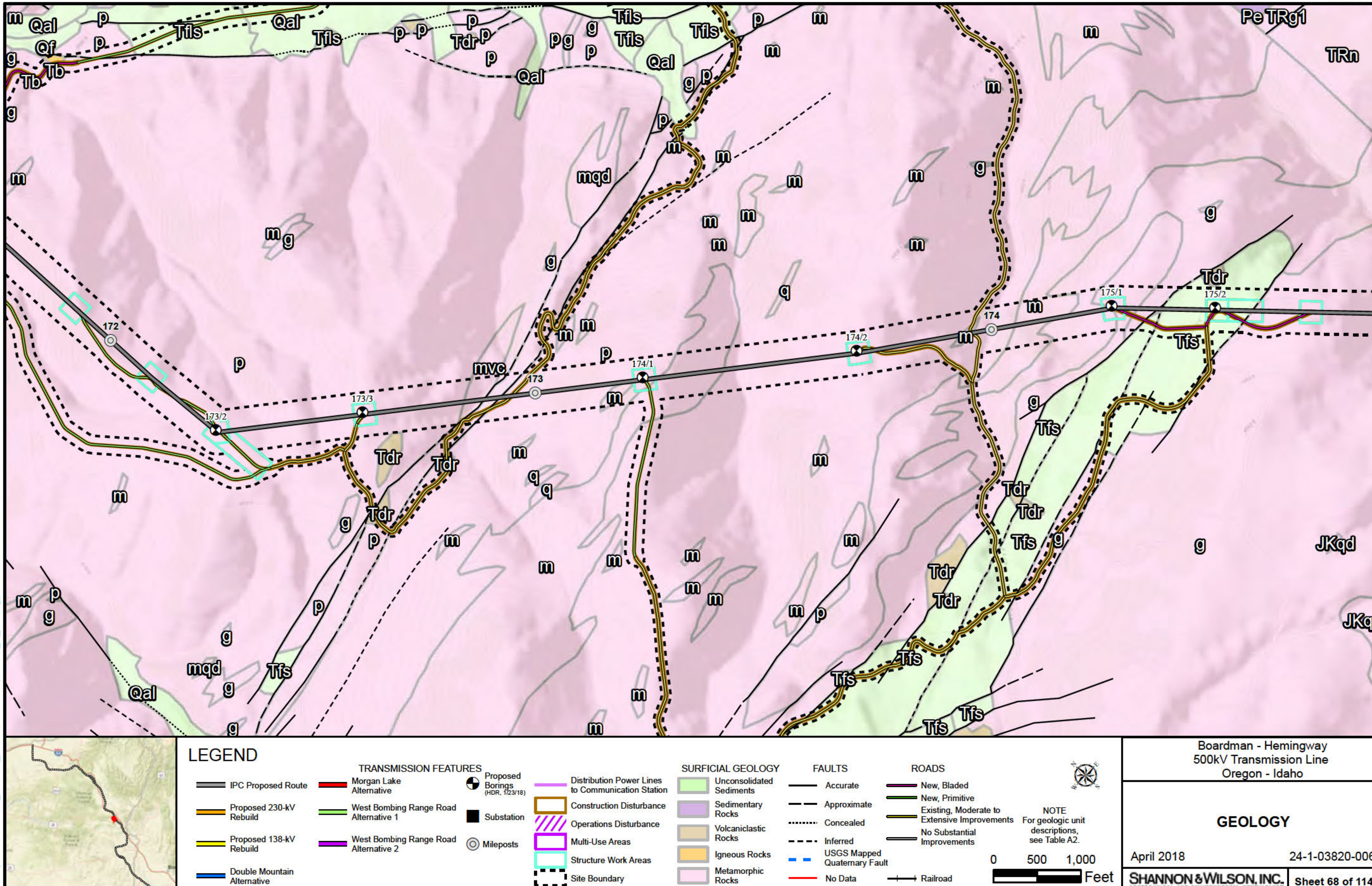

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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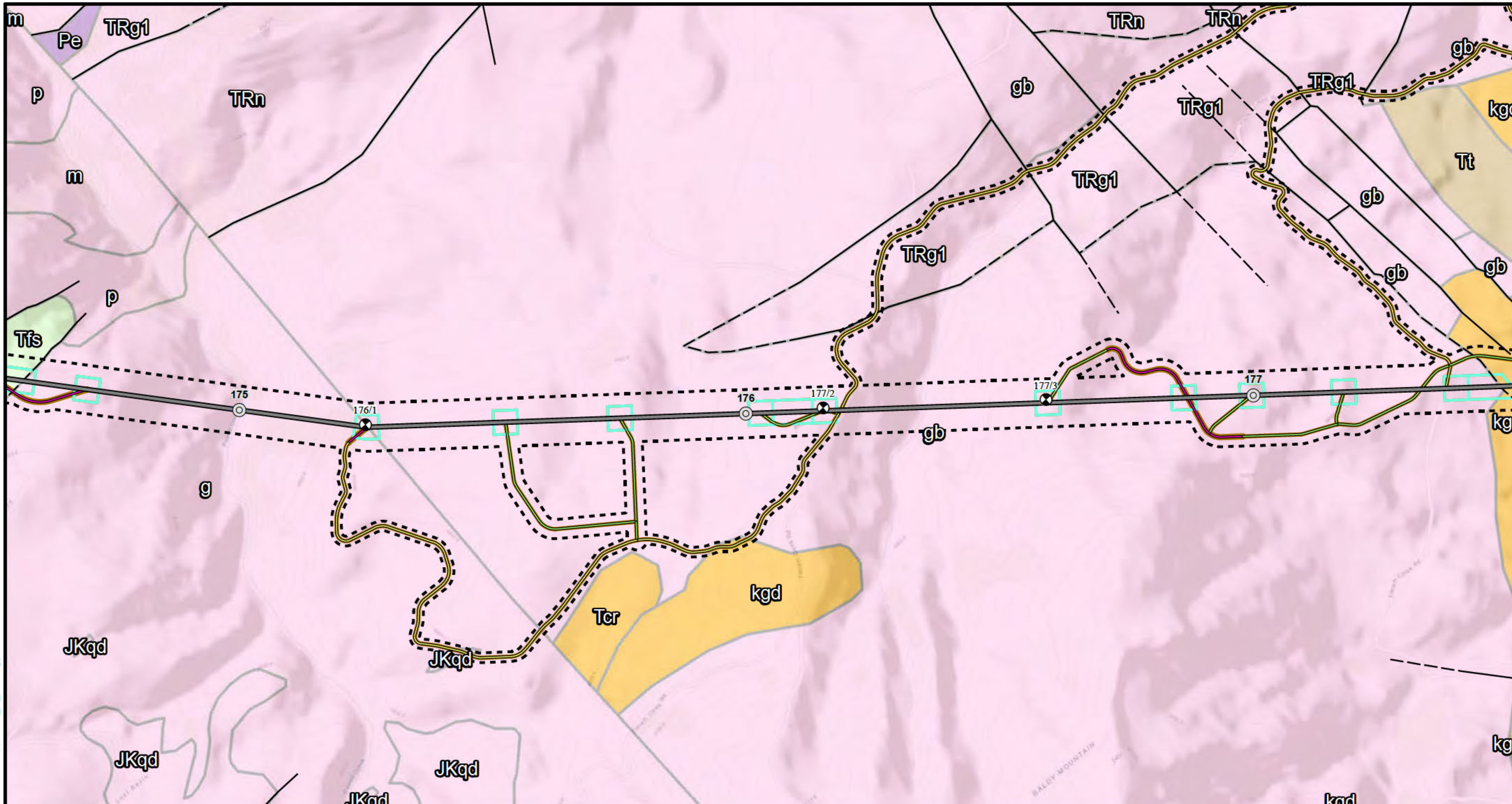

LEGEND

TRANSMISSION FEATURES
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Boardman - Hemingway
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Oregon - Idaho

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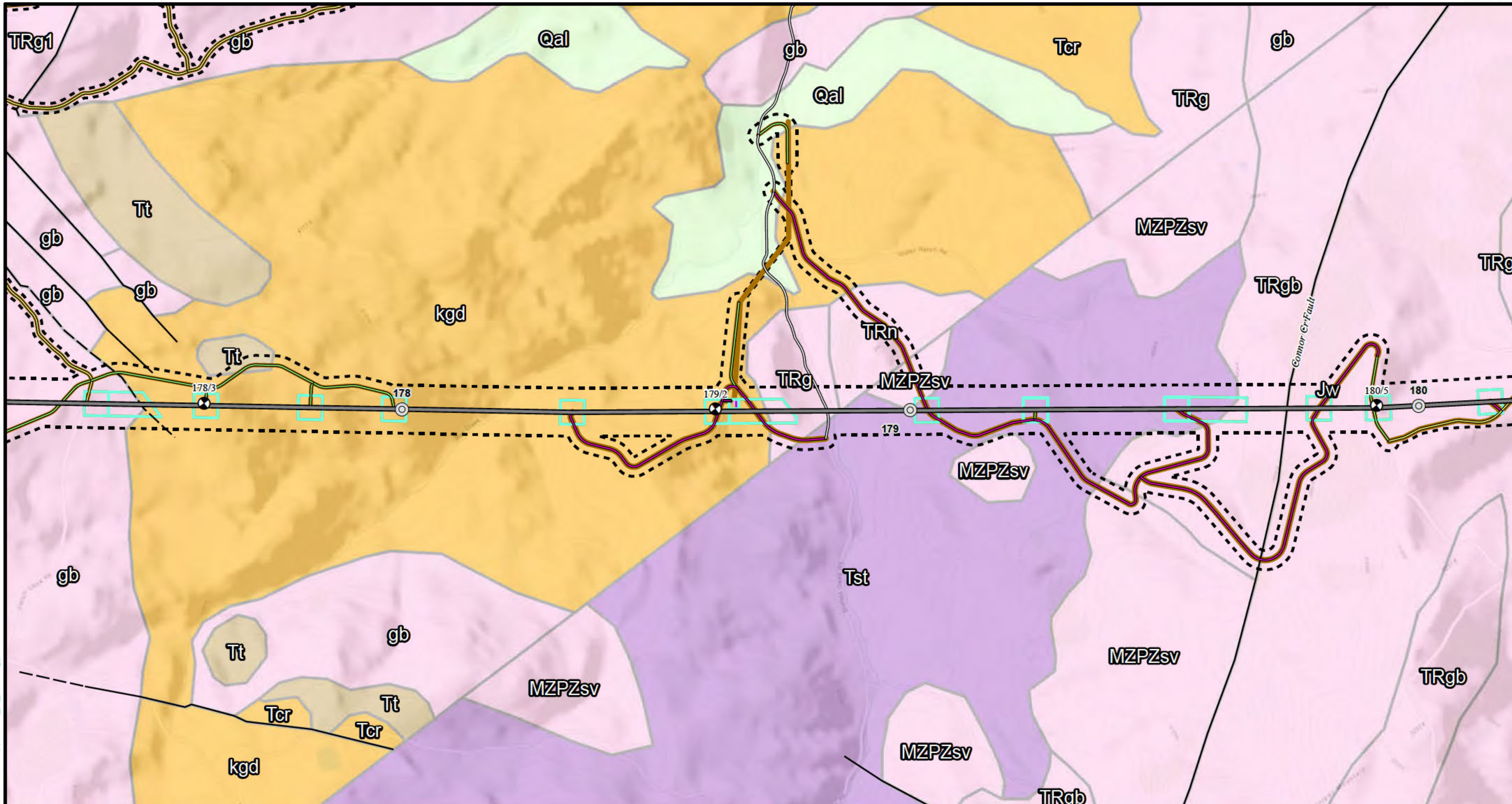

LEGEND

TRANSMISSION FEATURES
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Boardman - Hemingway
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Oregon - Idaho

GEOLOGY

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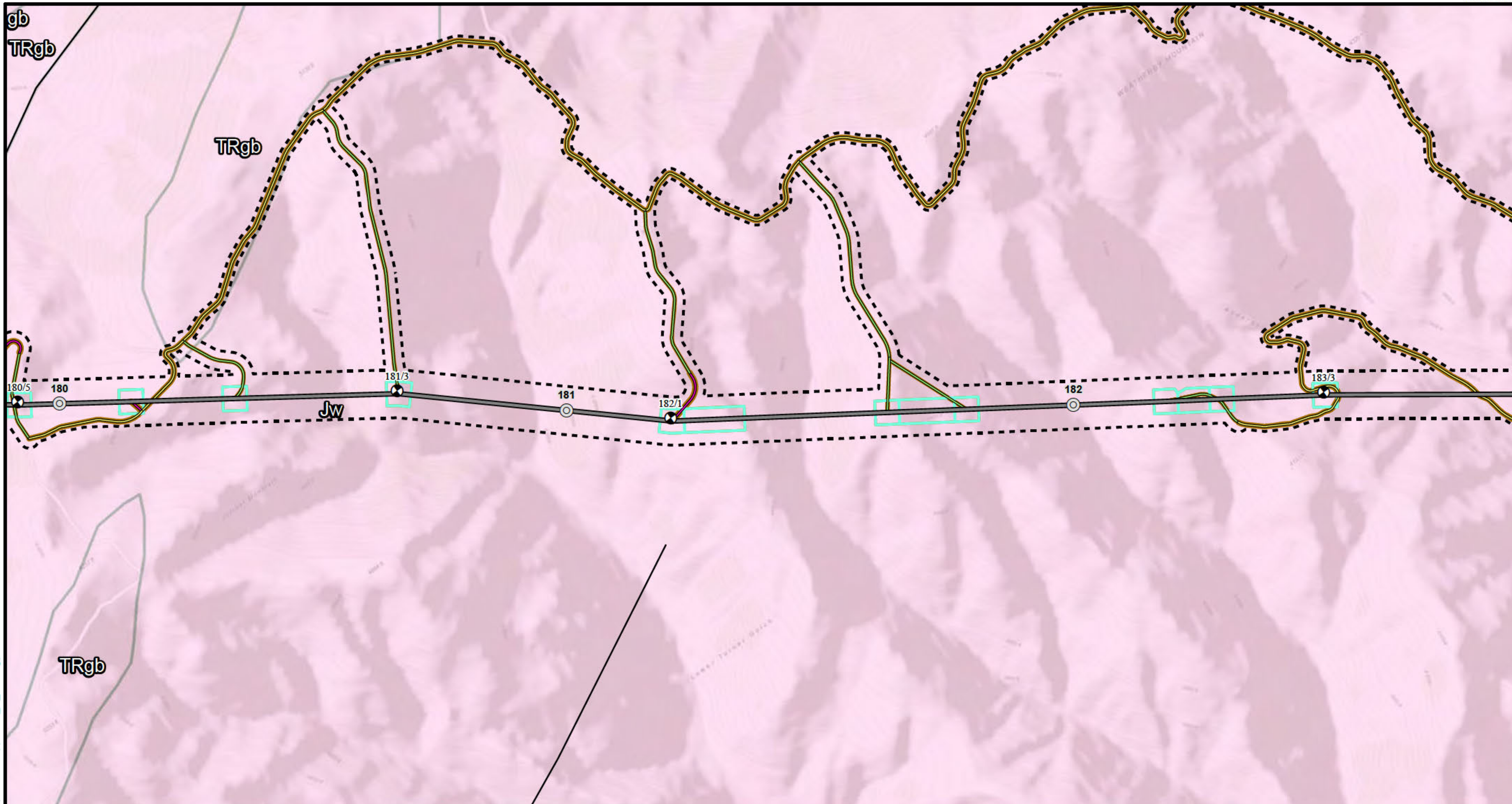

LEGEND

TRANSMISSION FEATURES
- IPC Proposed Route
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Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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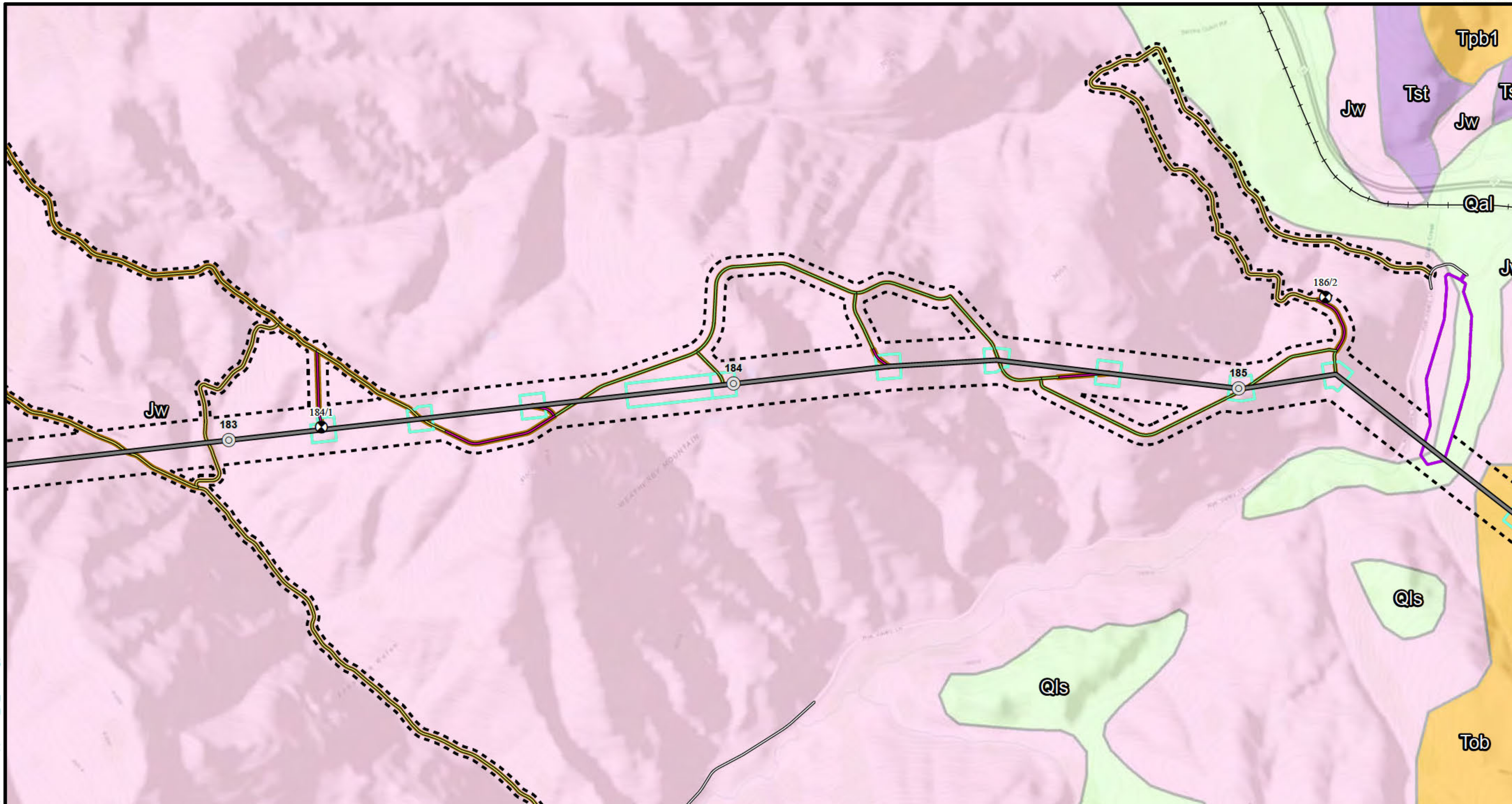

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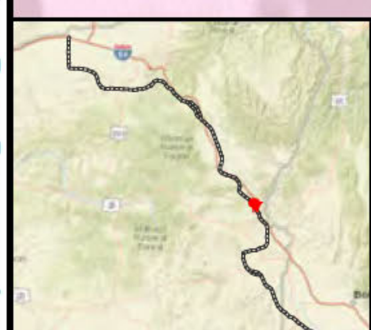

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GEOLOGY

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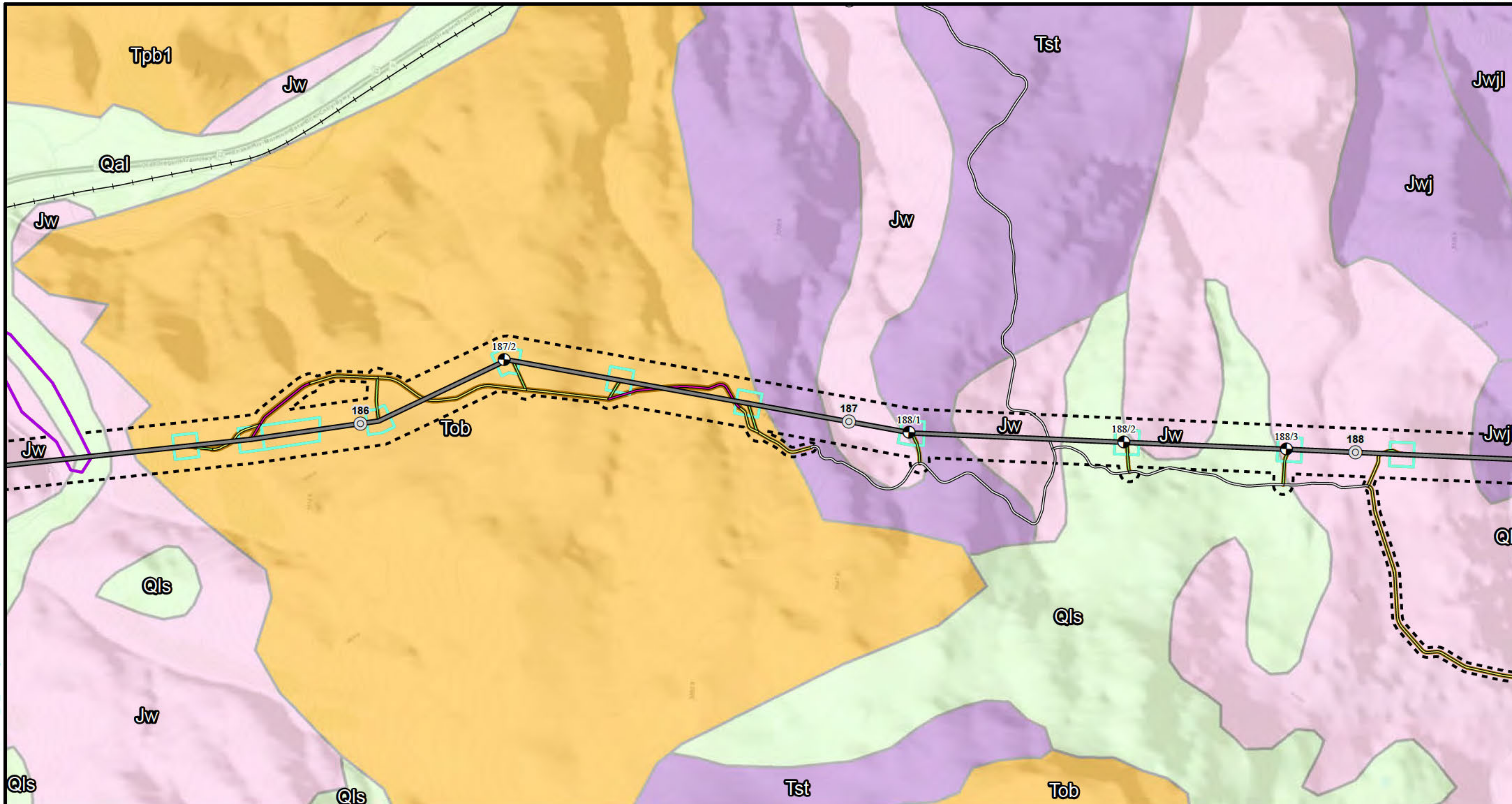

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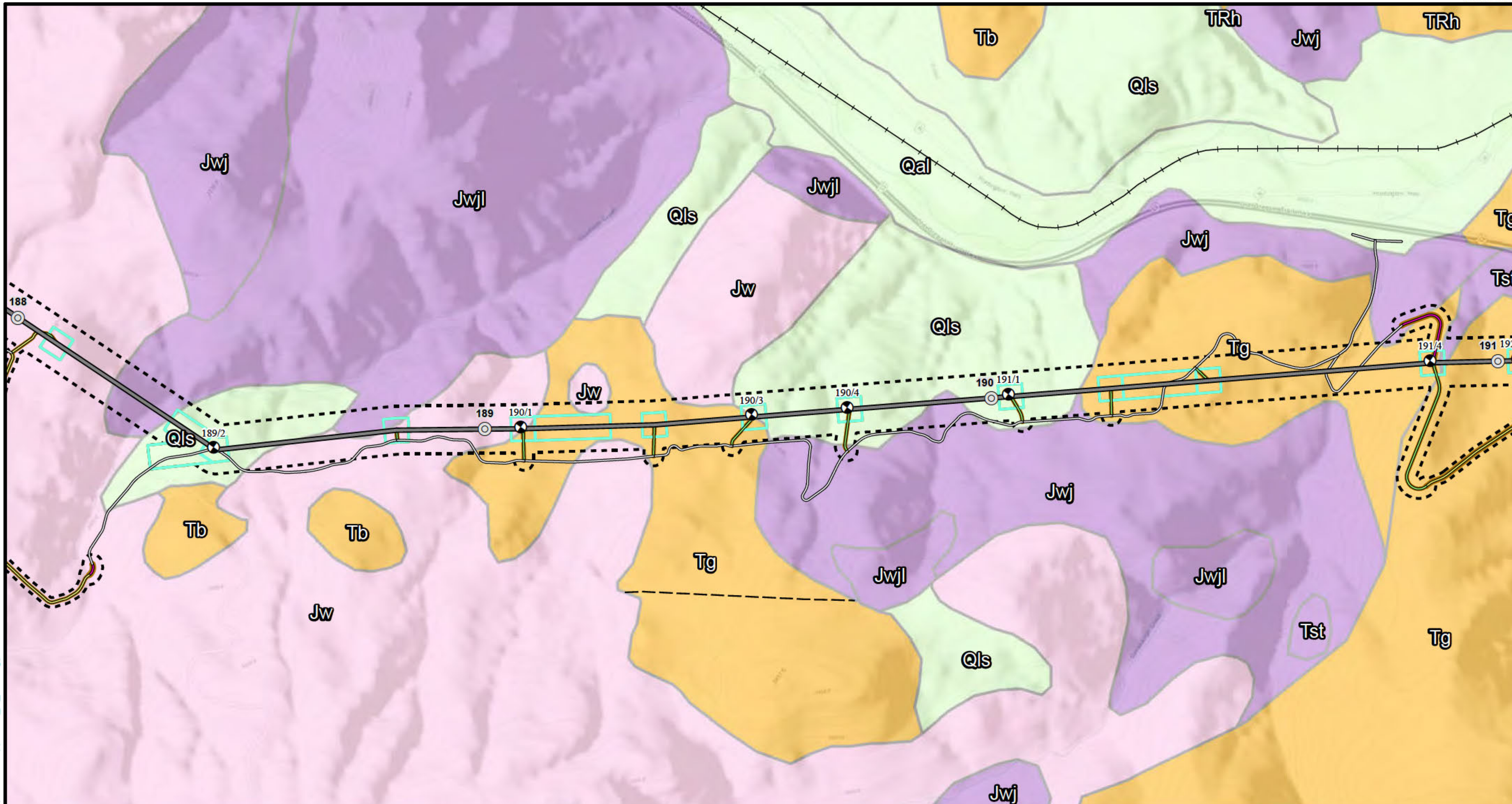

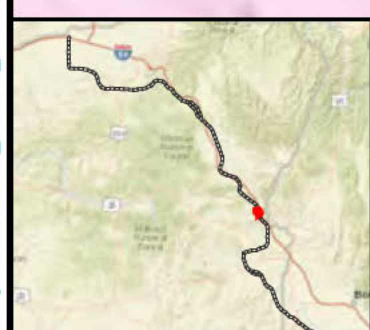

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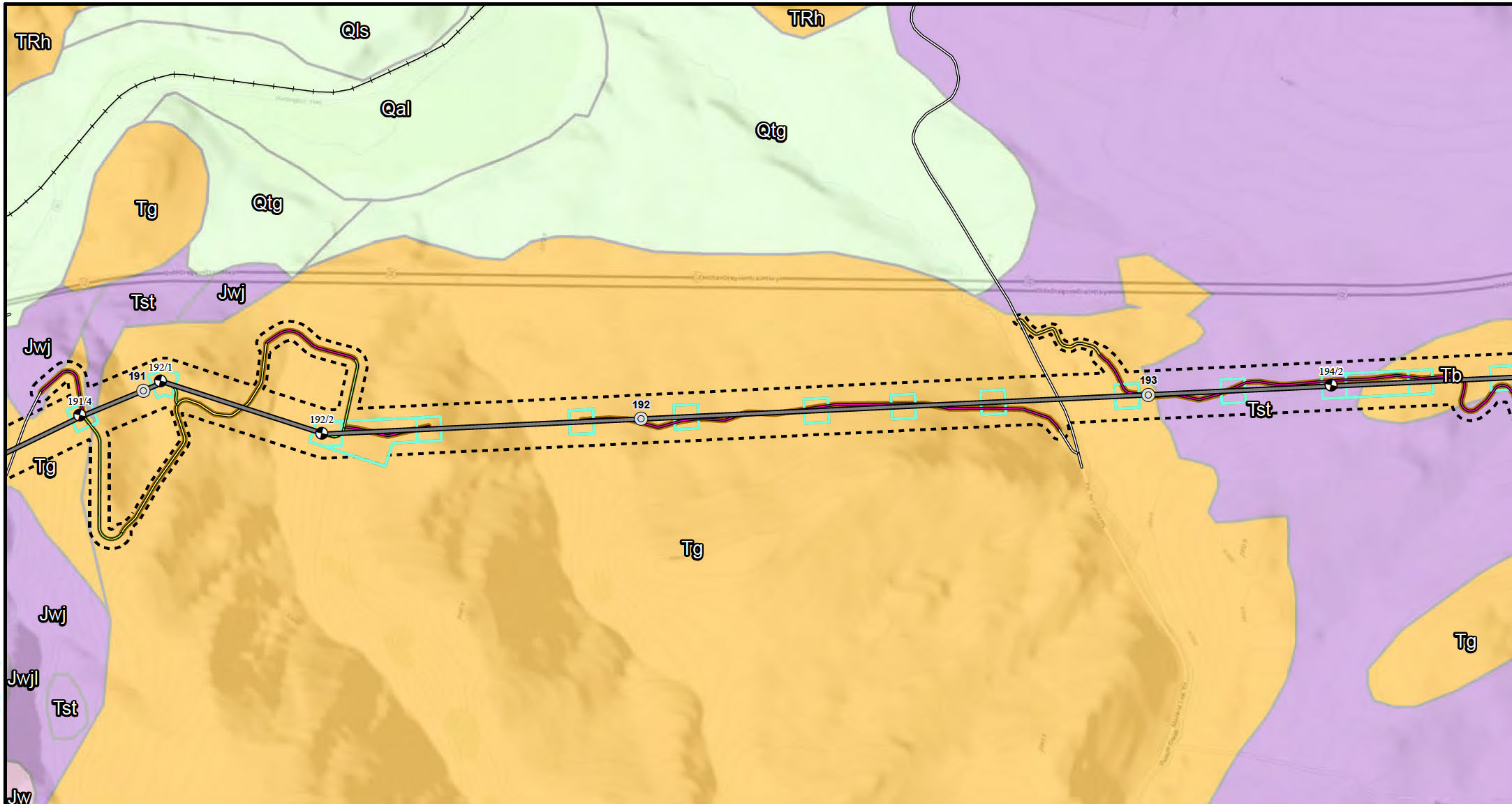

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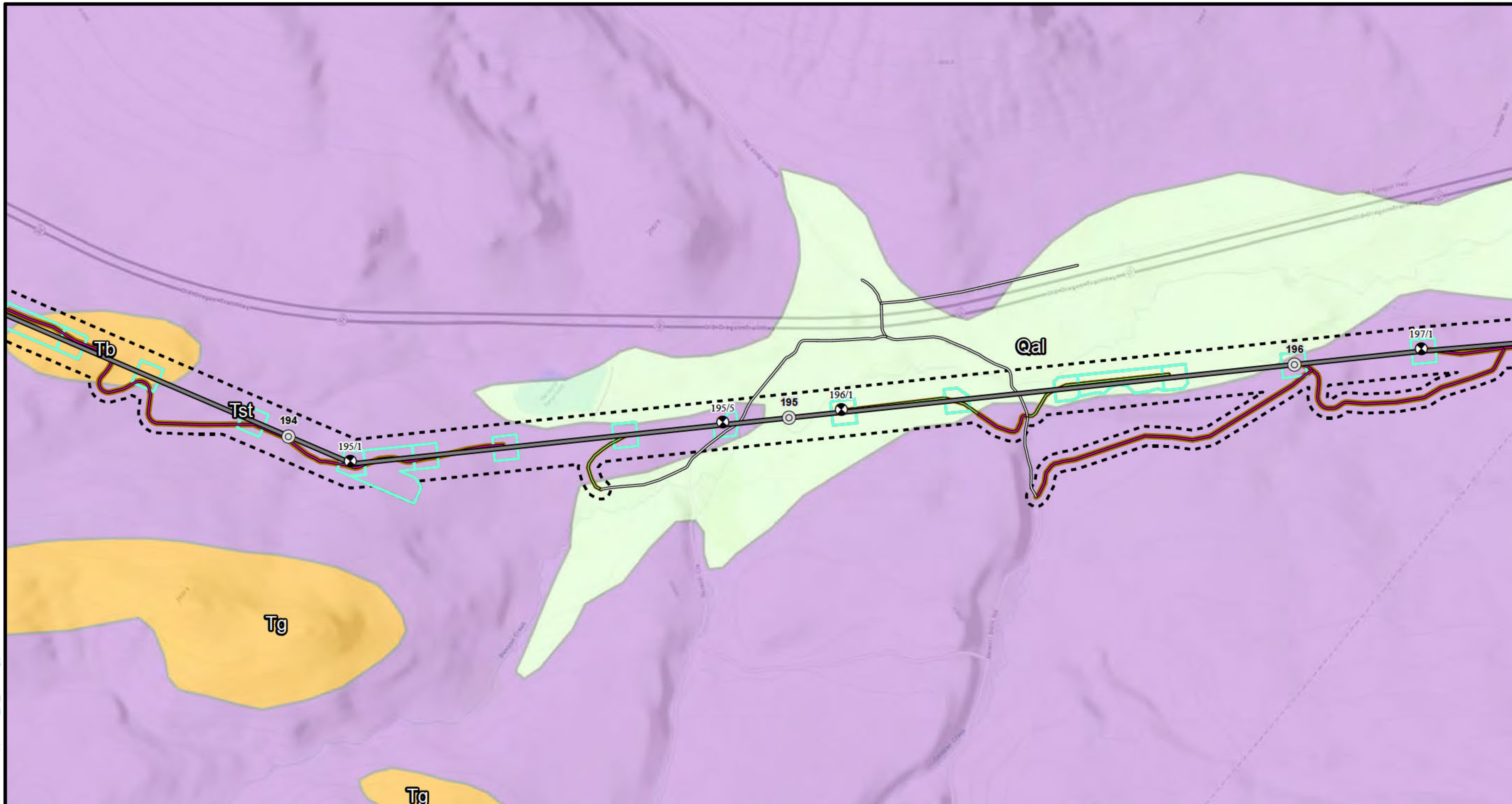

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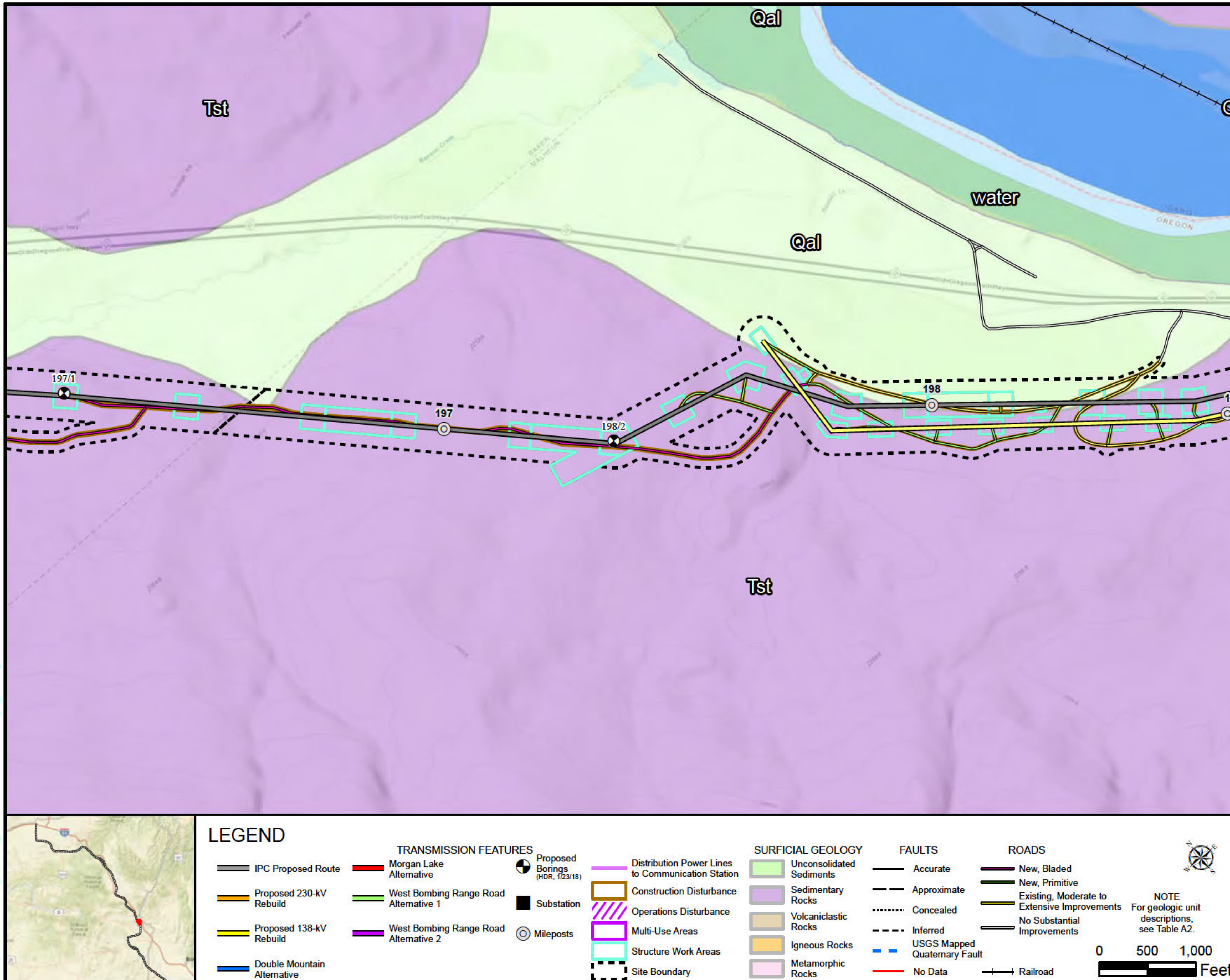

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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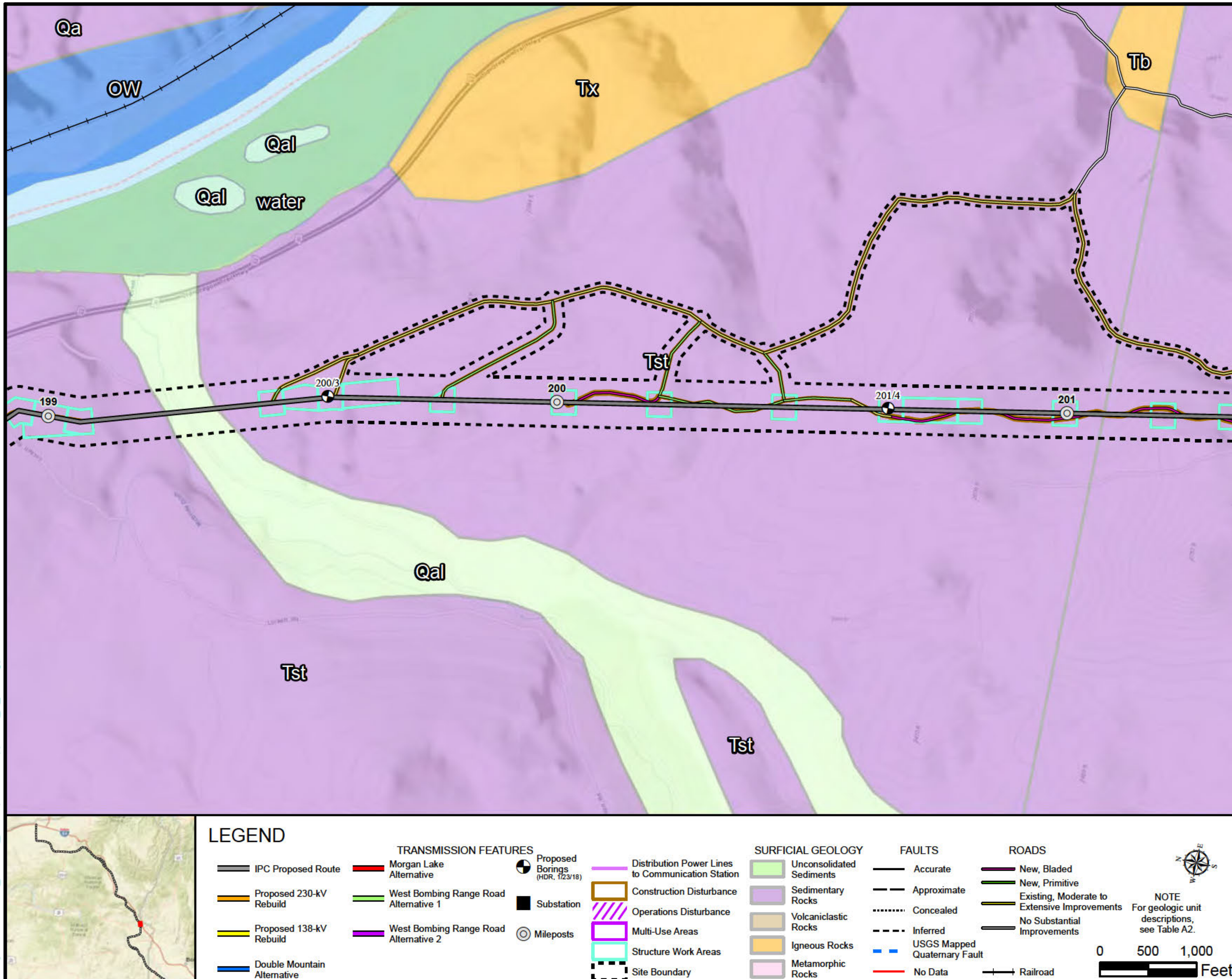

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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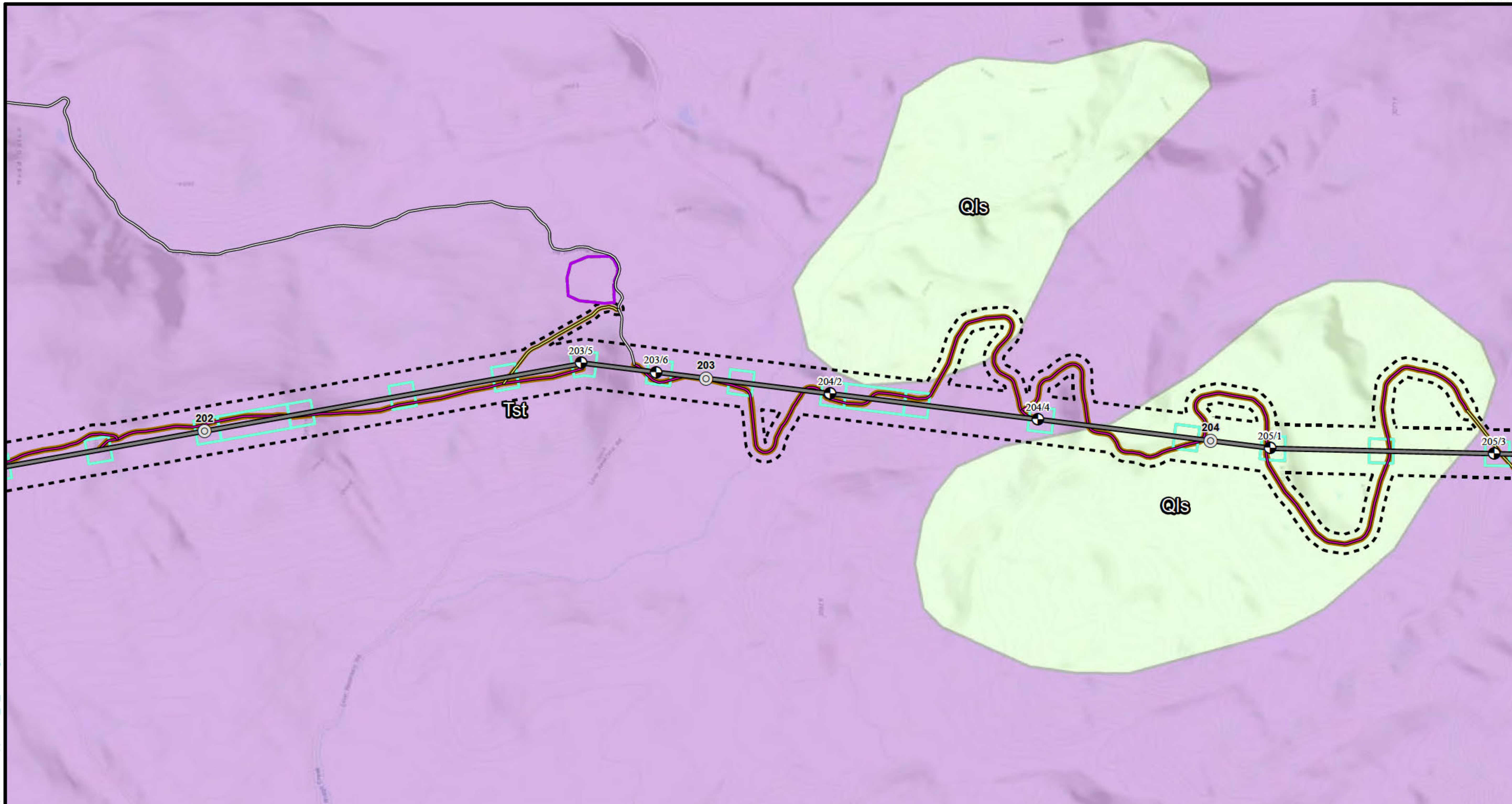

LEGEND

TRANSMISSION FEATURES
IPC Proposed Route
Proposed 230-kV Rebuild
Proposed 138-kV Rebuild
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Inferred
USGS Mapped Quaternary Fault
No Data

ROADS
New, Bladed
New, Primitive
Existing, Moderate to Extensive Improvements
No Substantial Improvements
Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000
Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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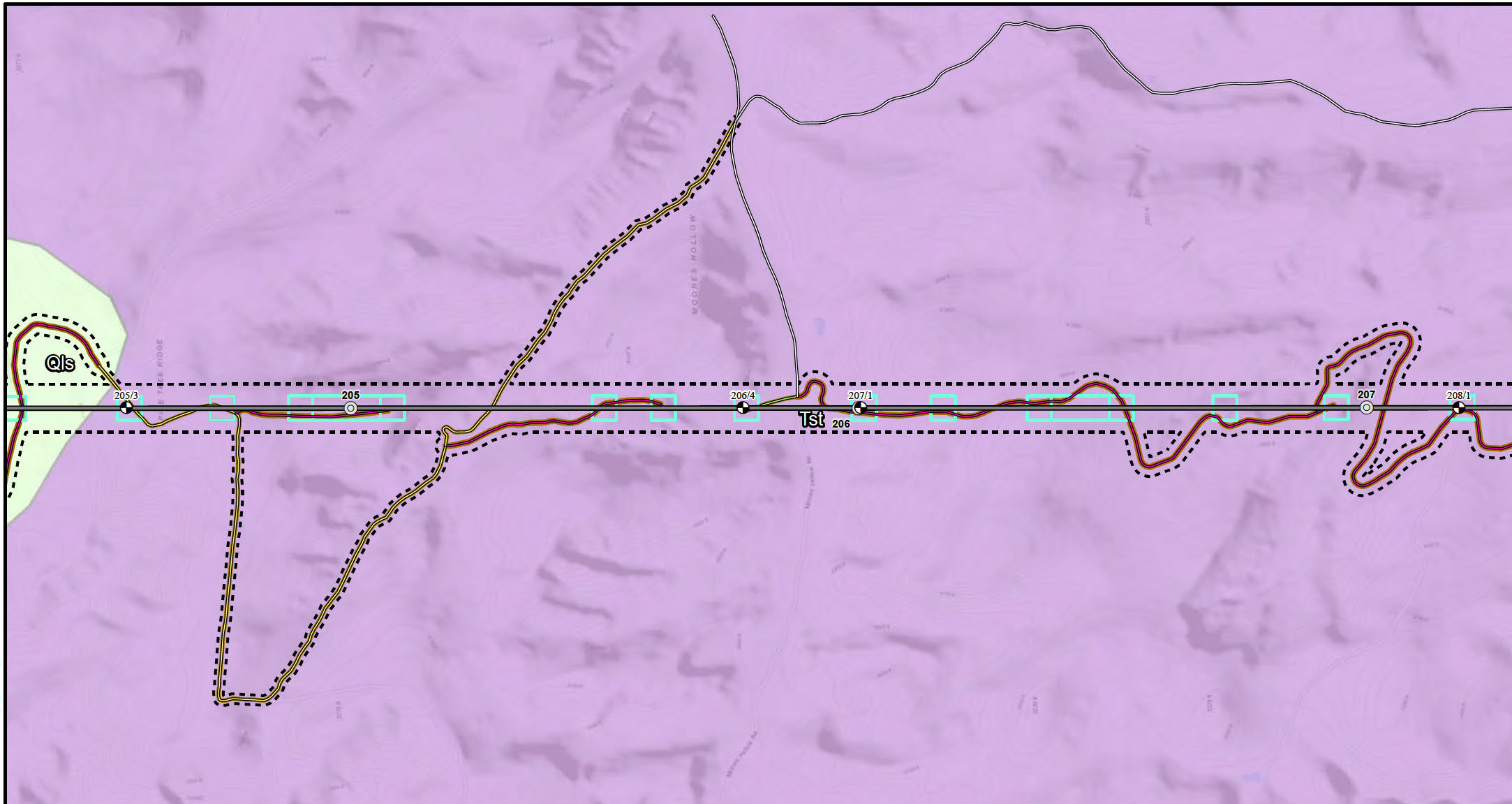

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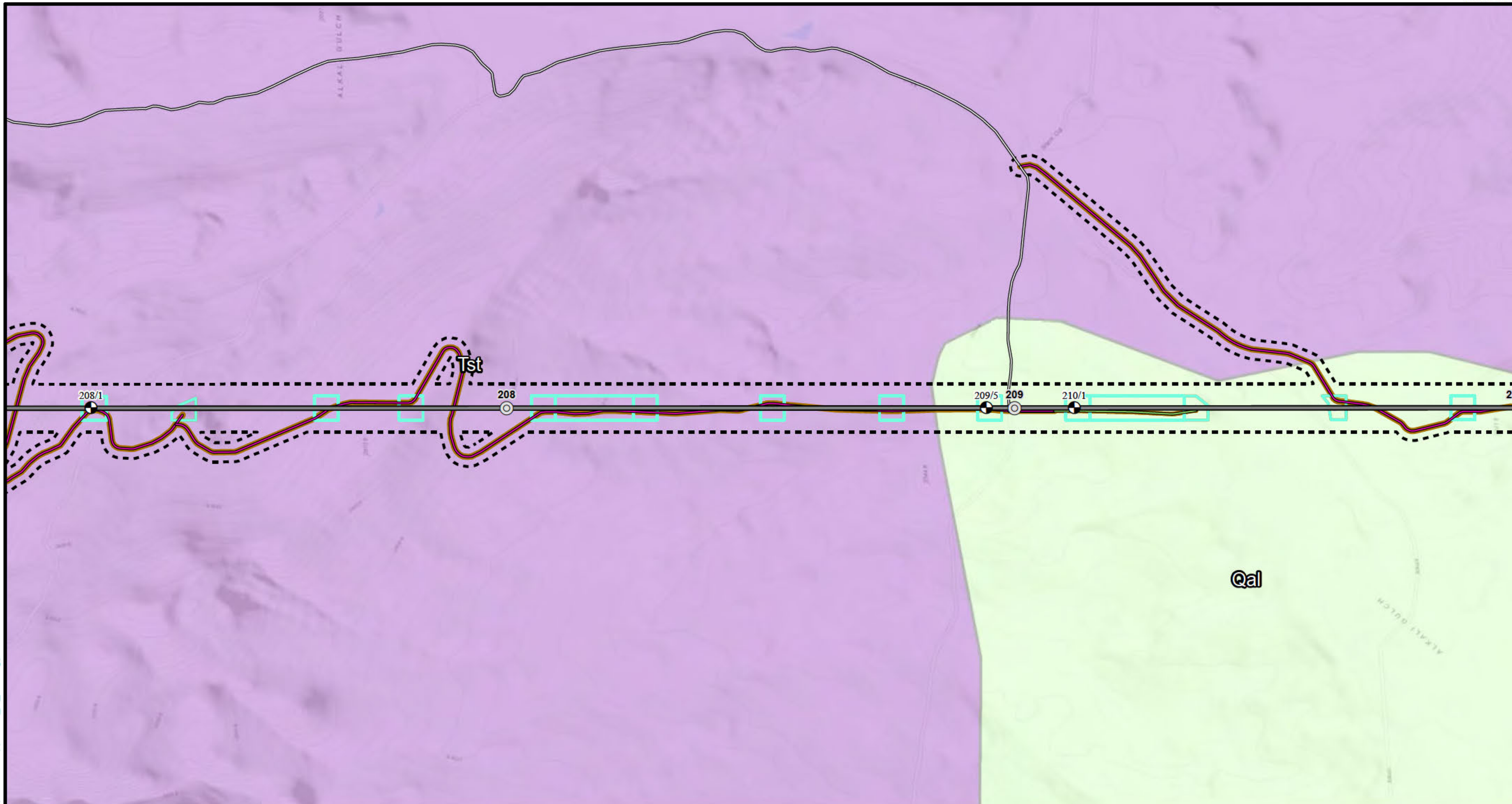

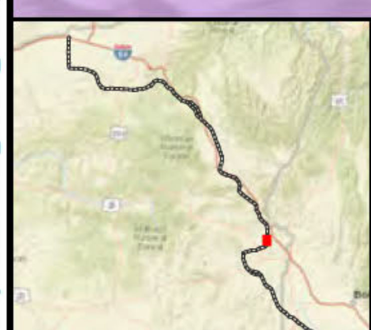

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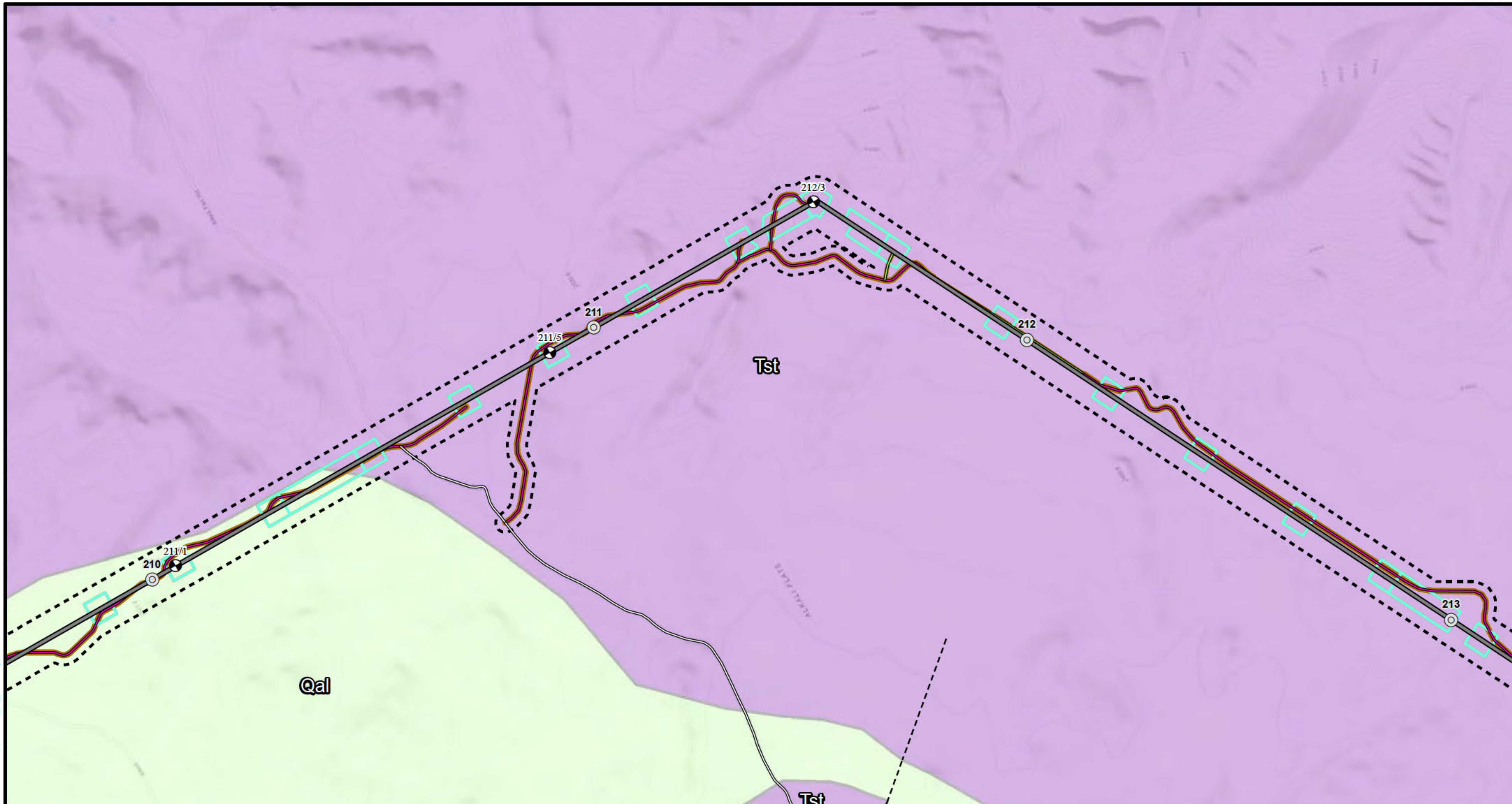

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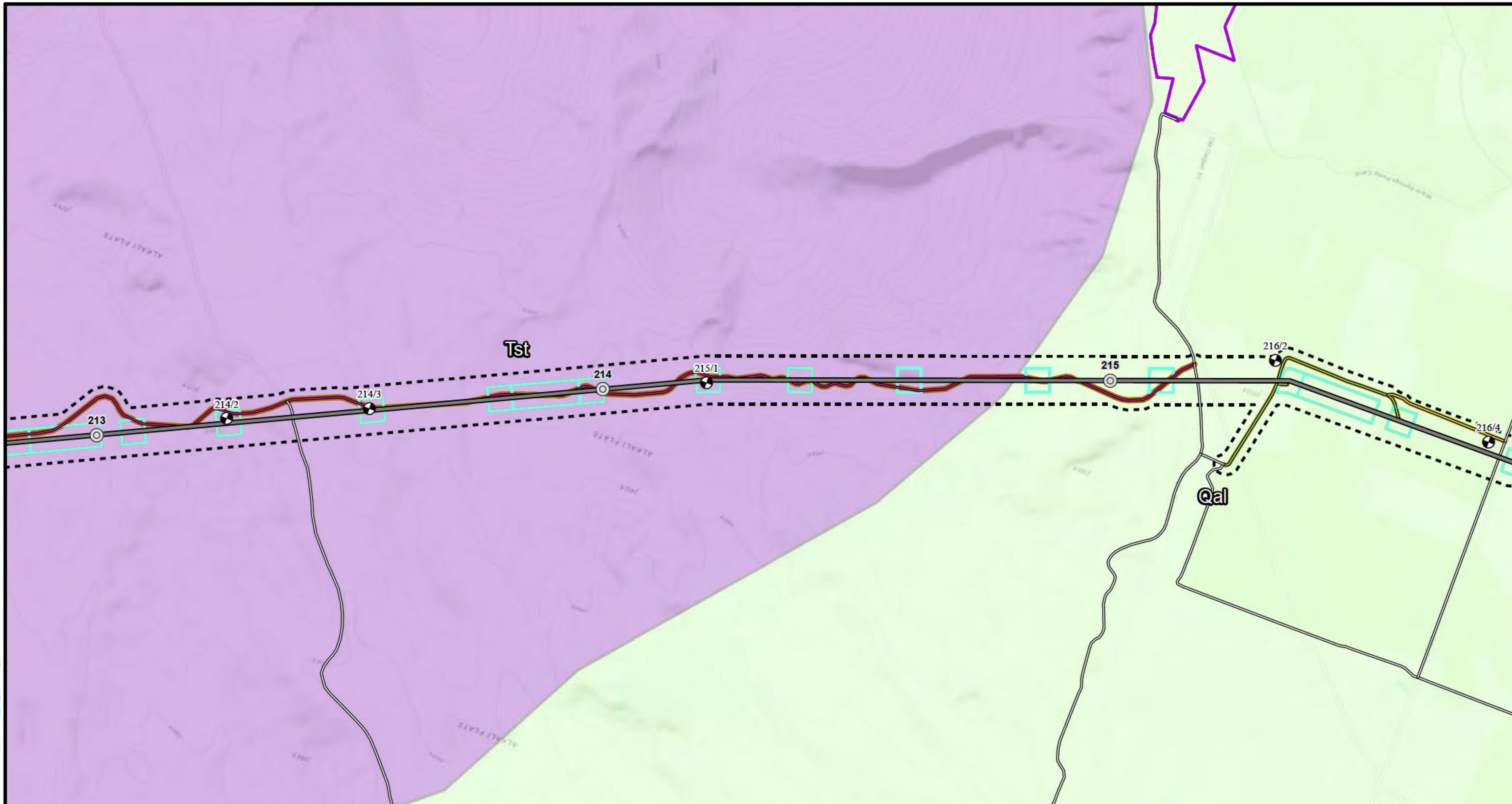

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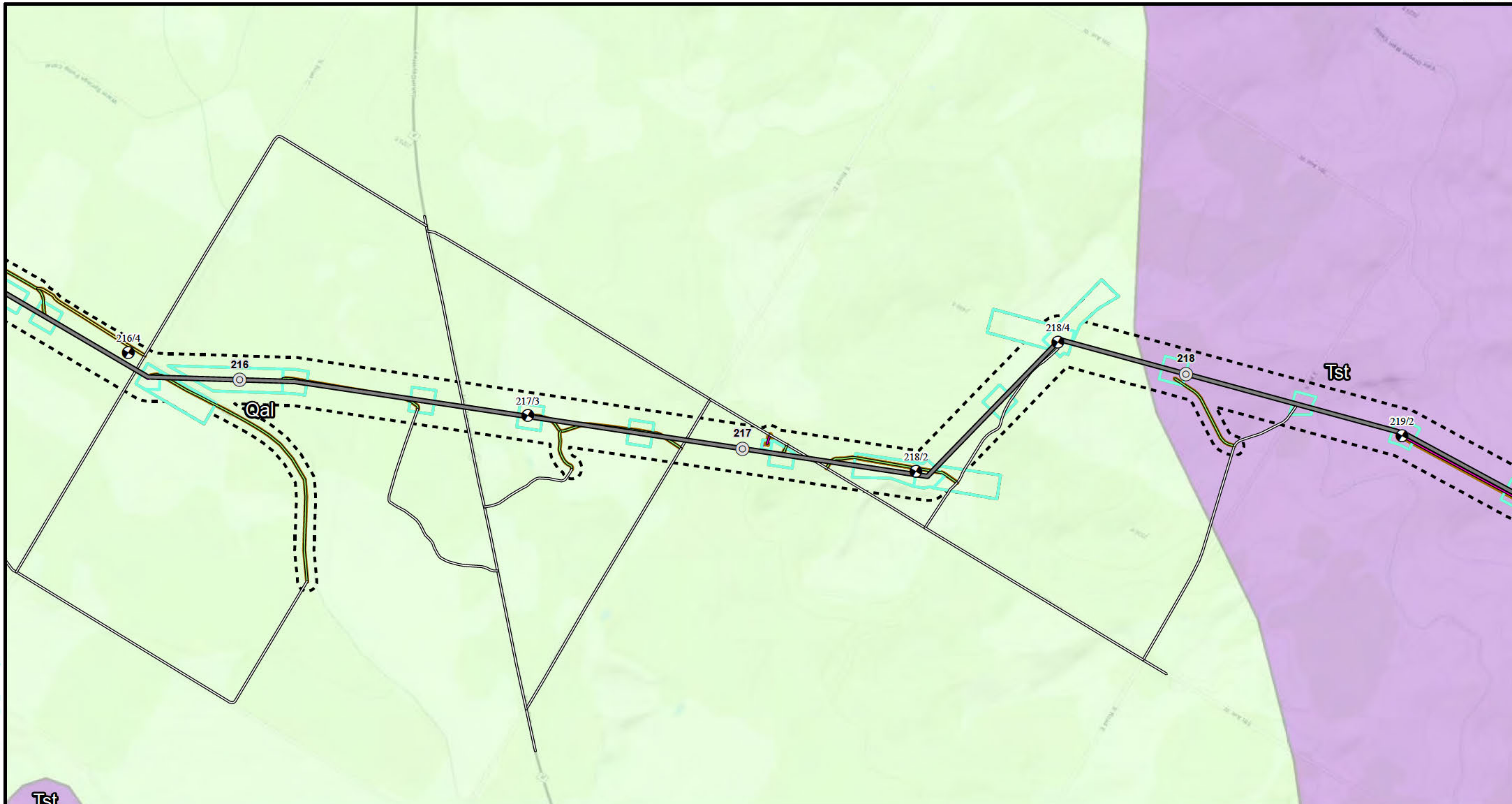

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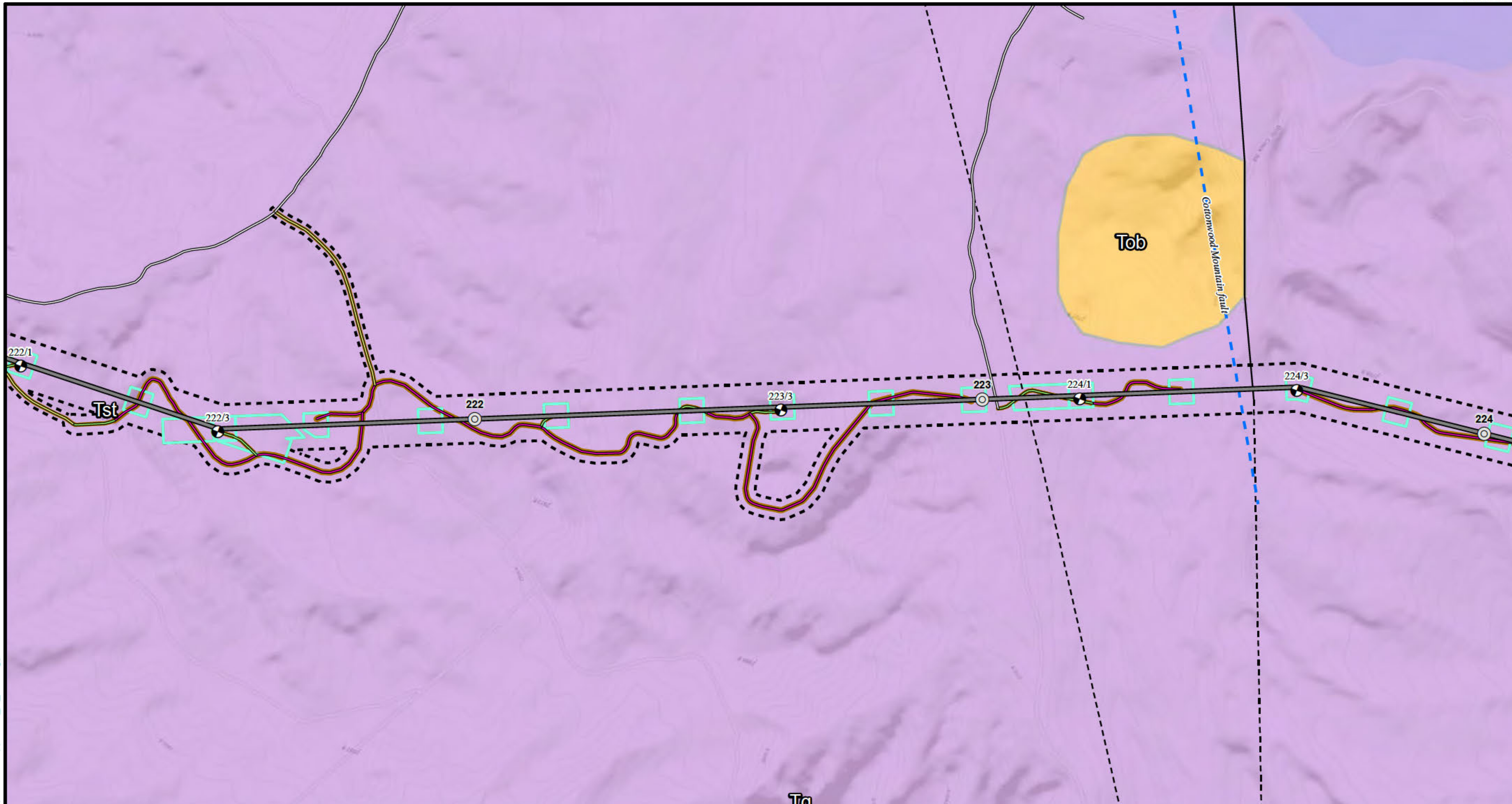

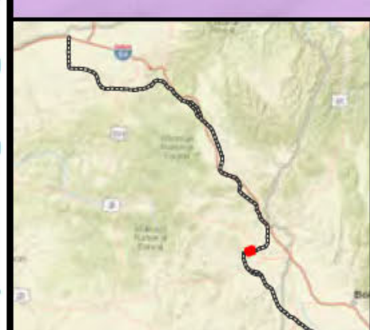

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Oregon - Idaho

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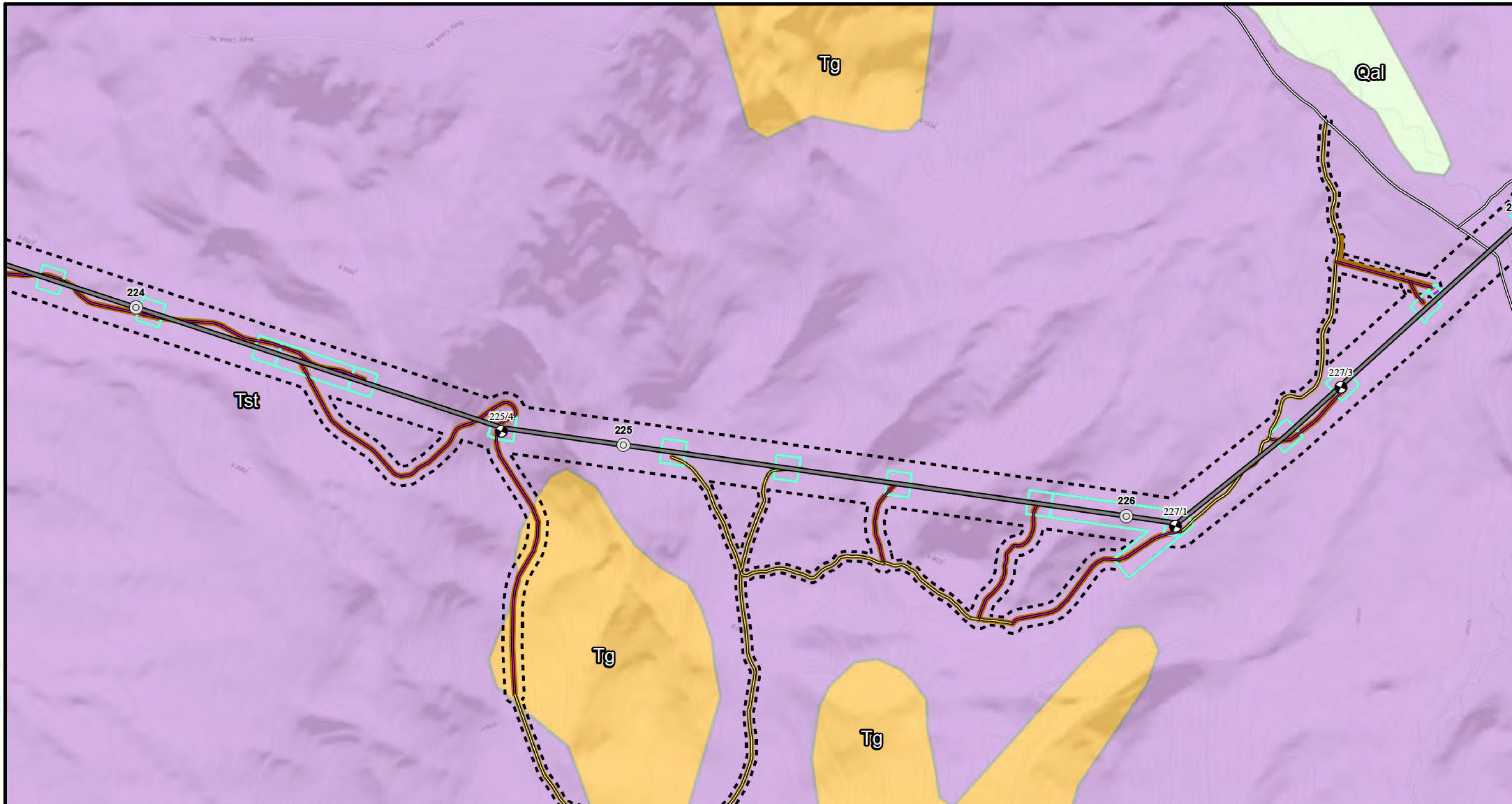

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500kV Transmission Line
Oregon - Idaho

GEOLOGY

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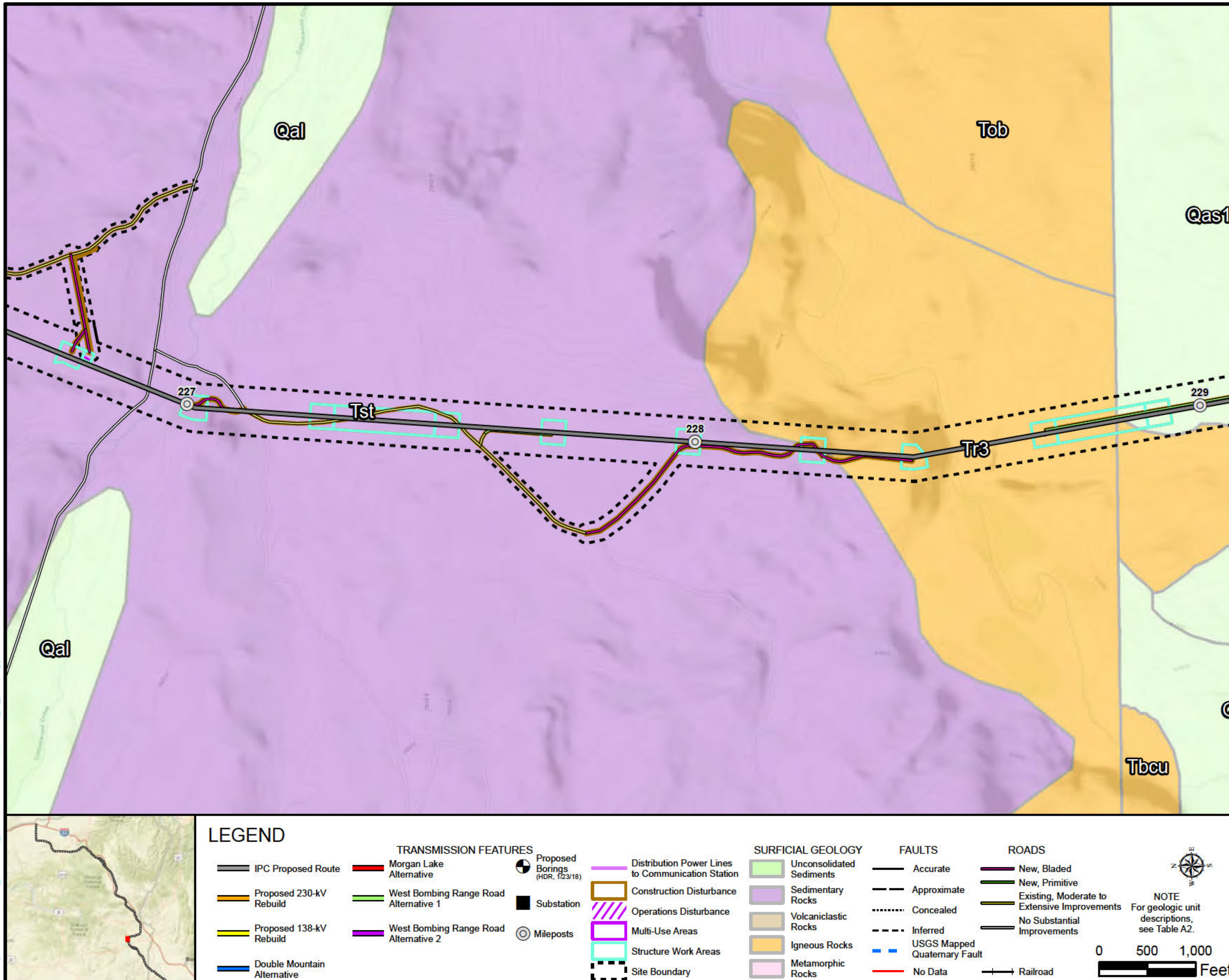

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

GEOLOGY

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Oregon - Idaho

GEOLOGY

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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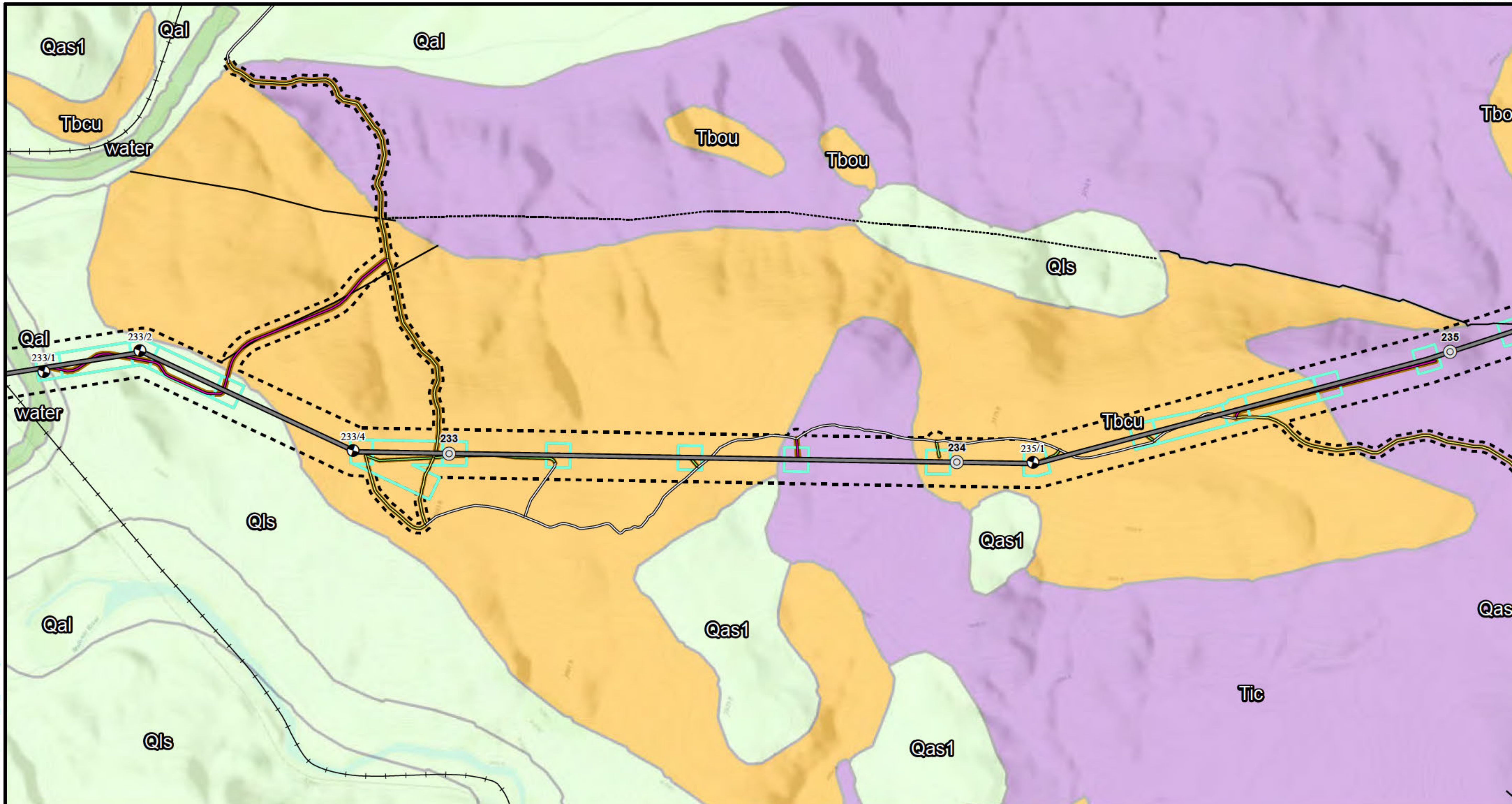

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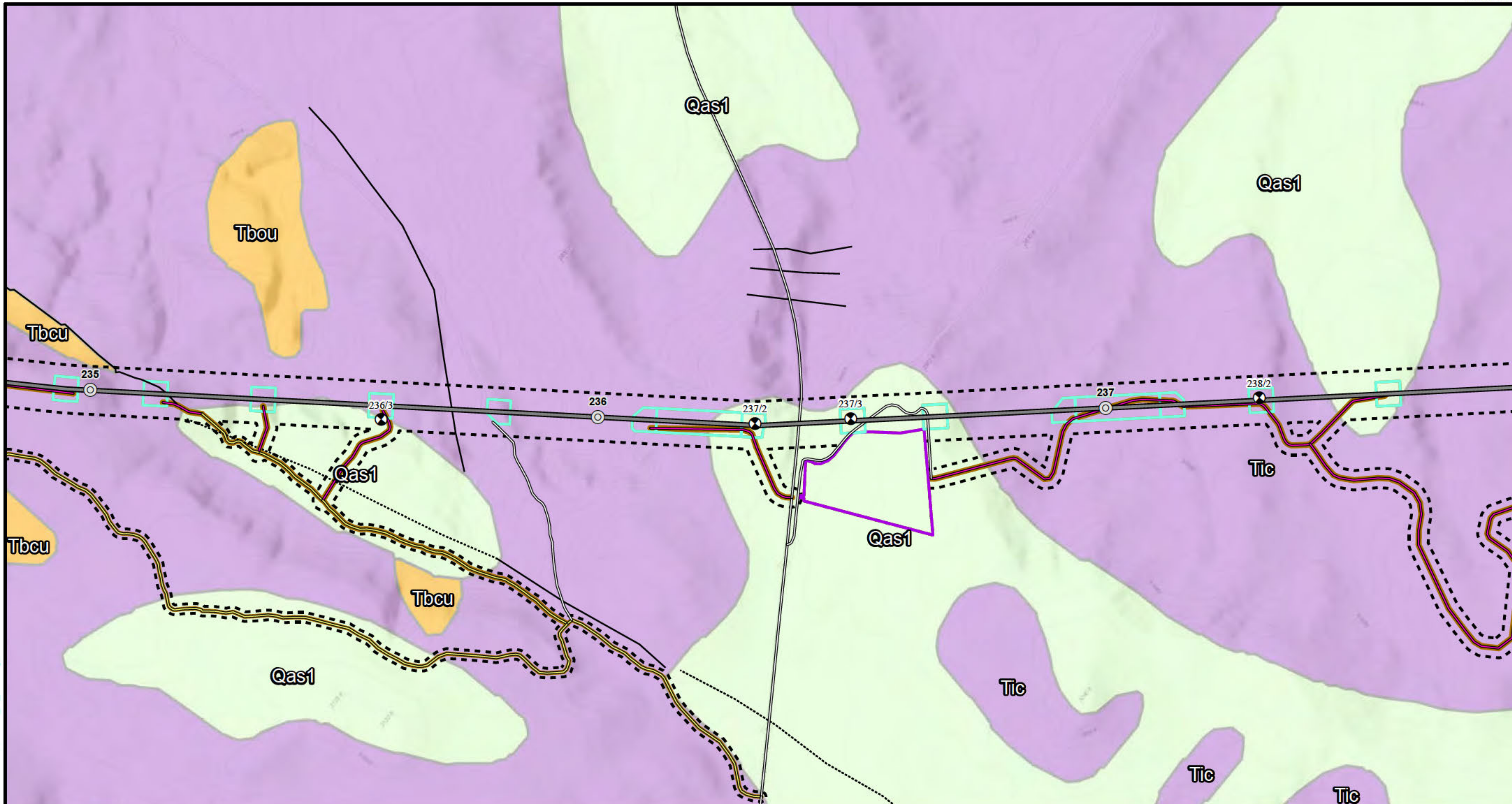

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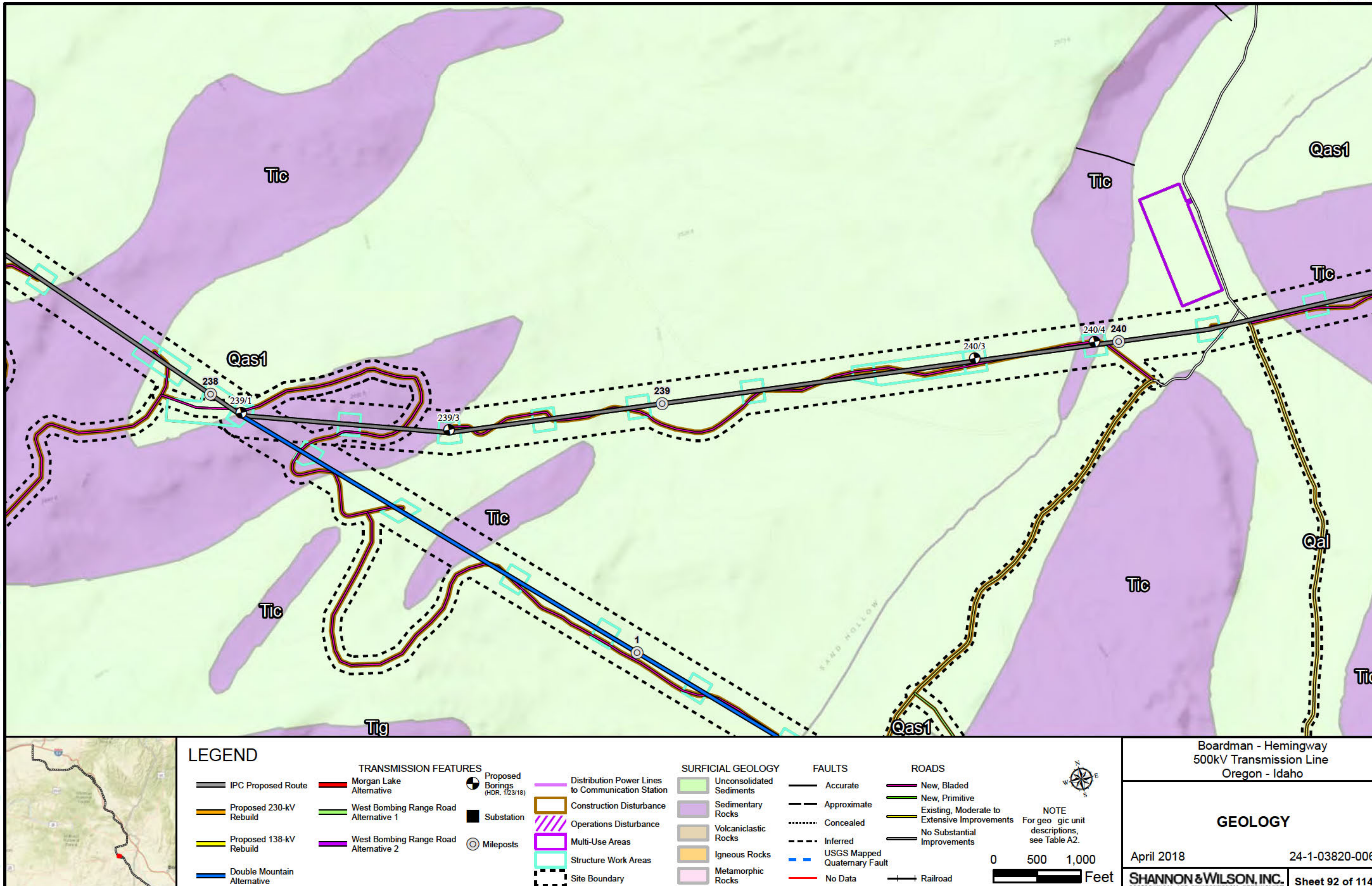

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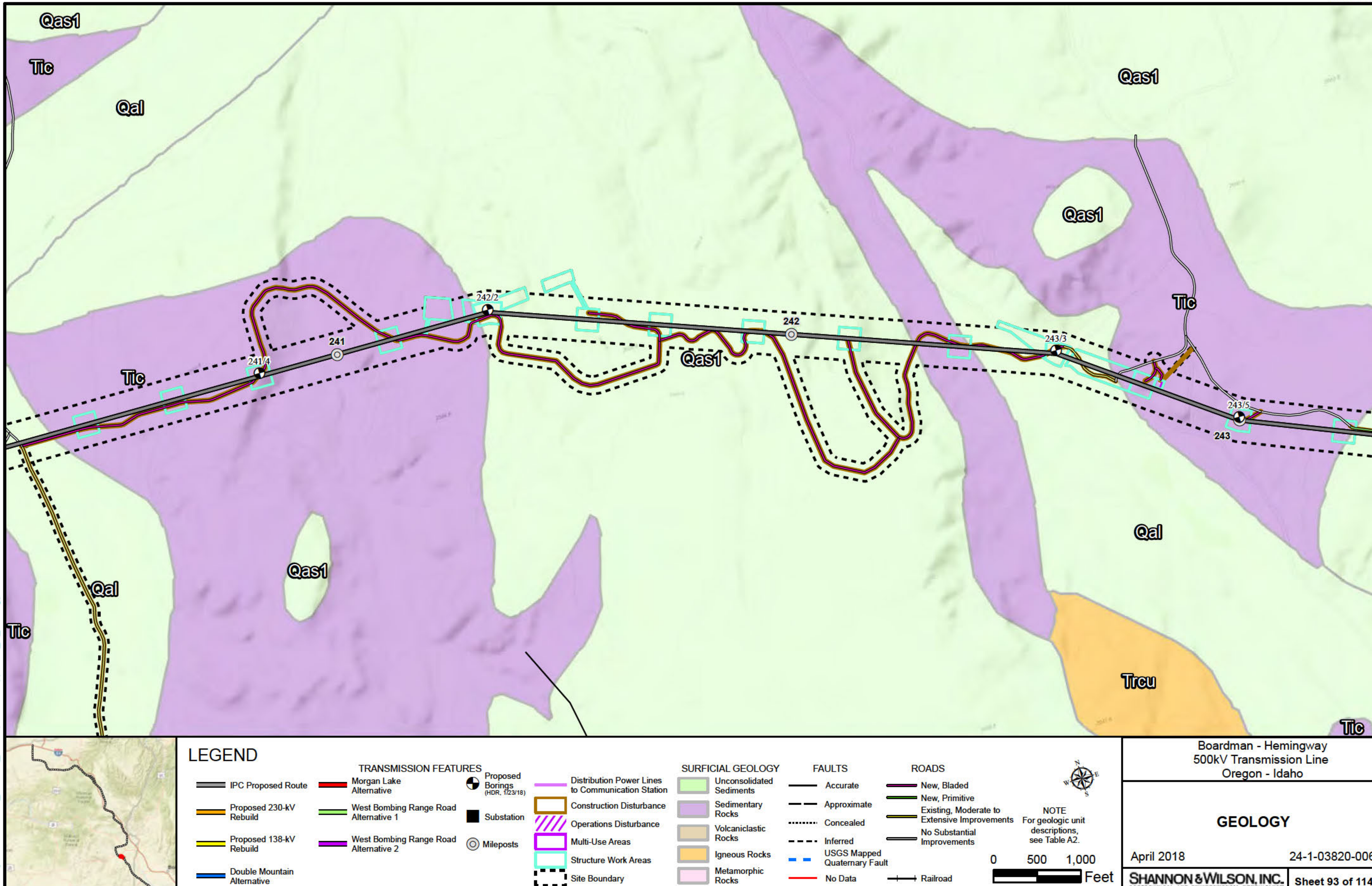

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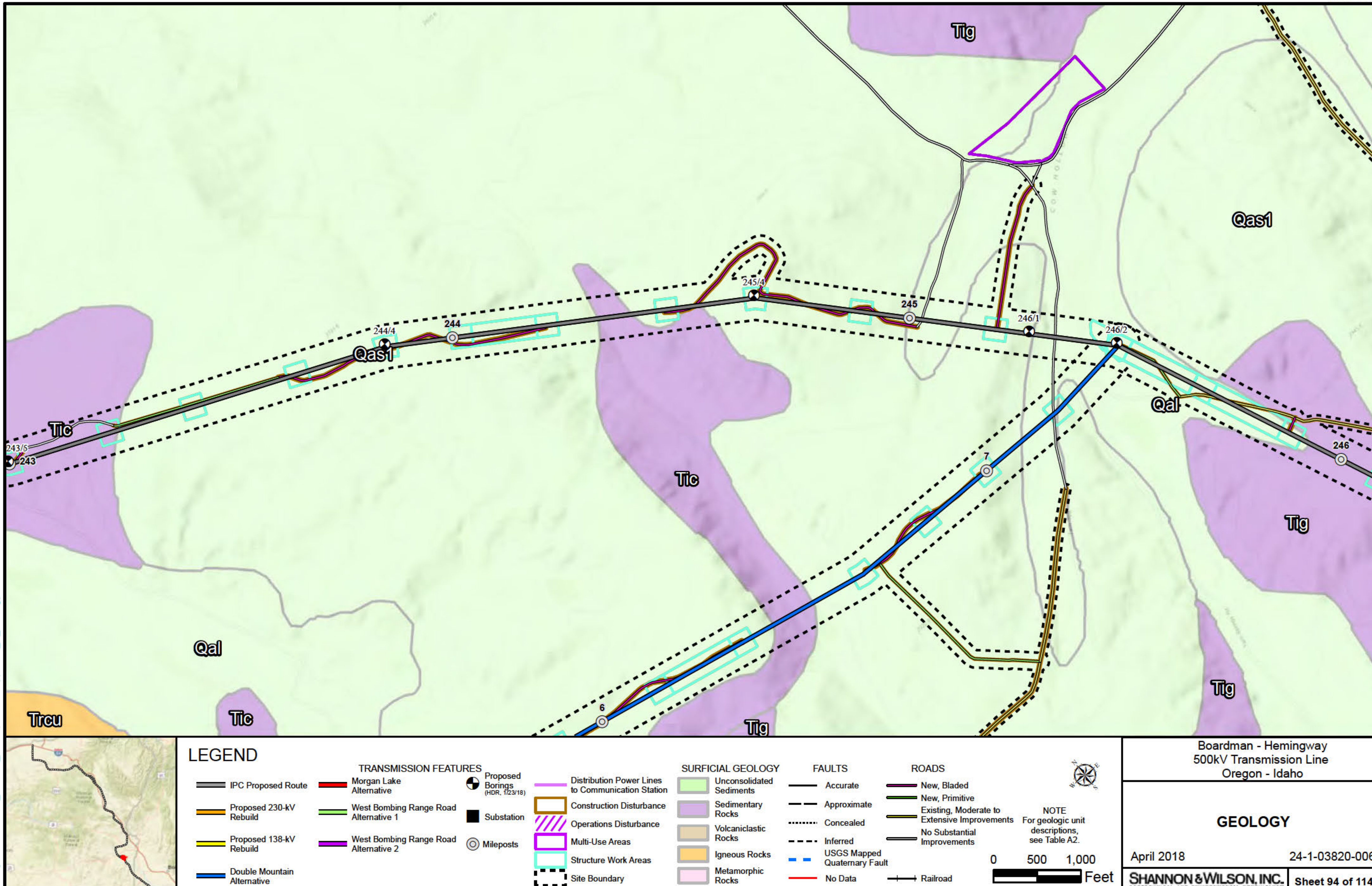

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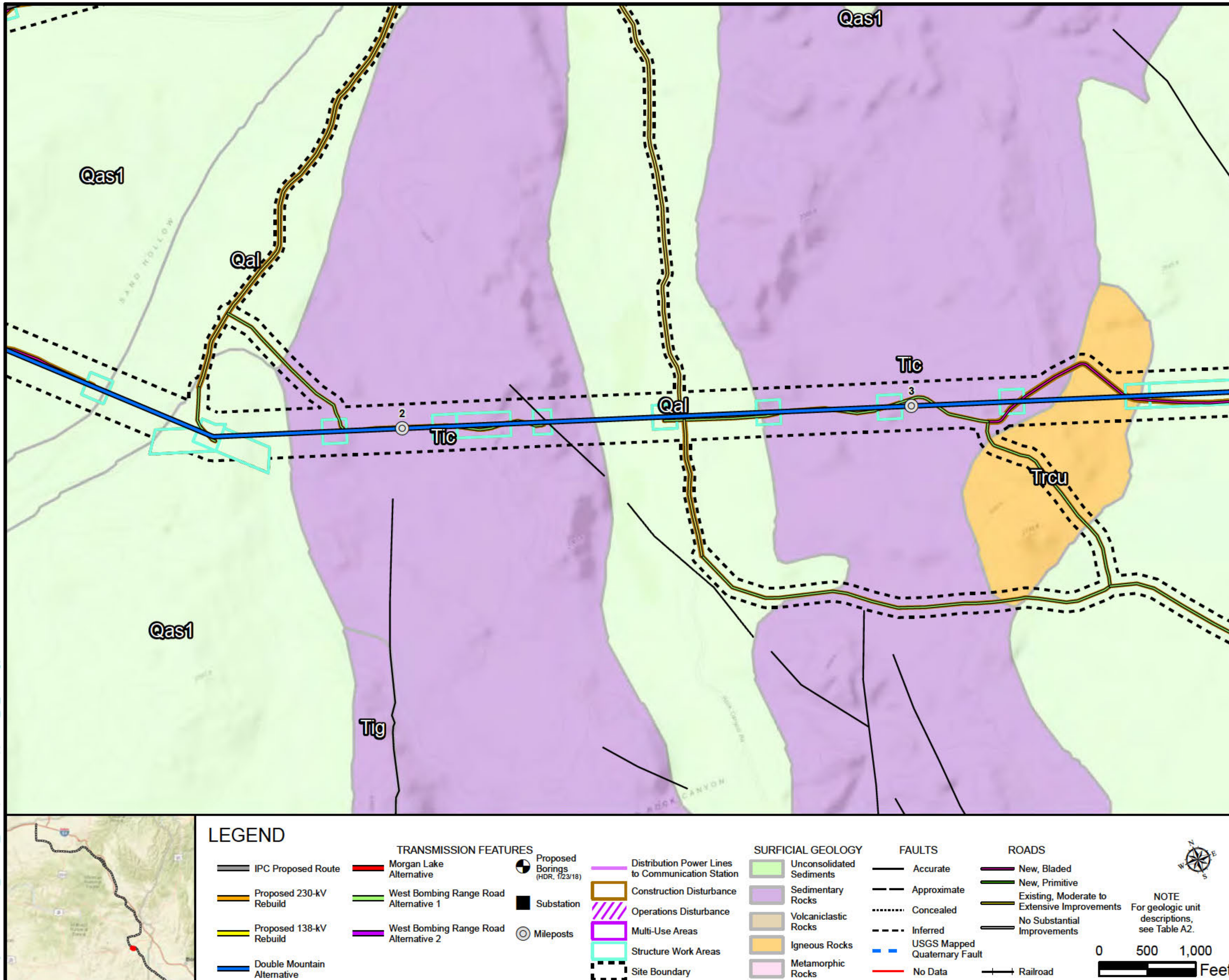

Boardman - Hemingway
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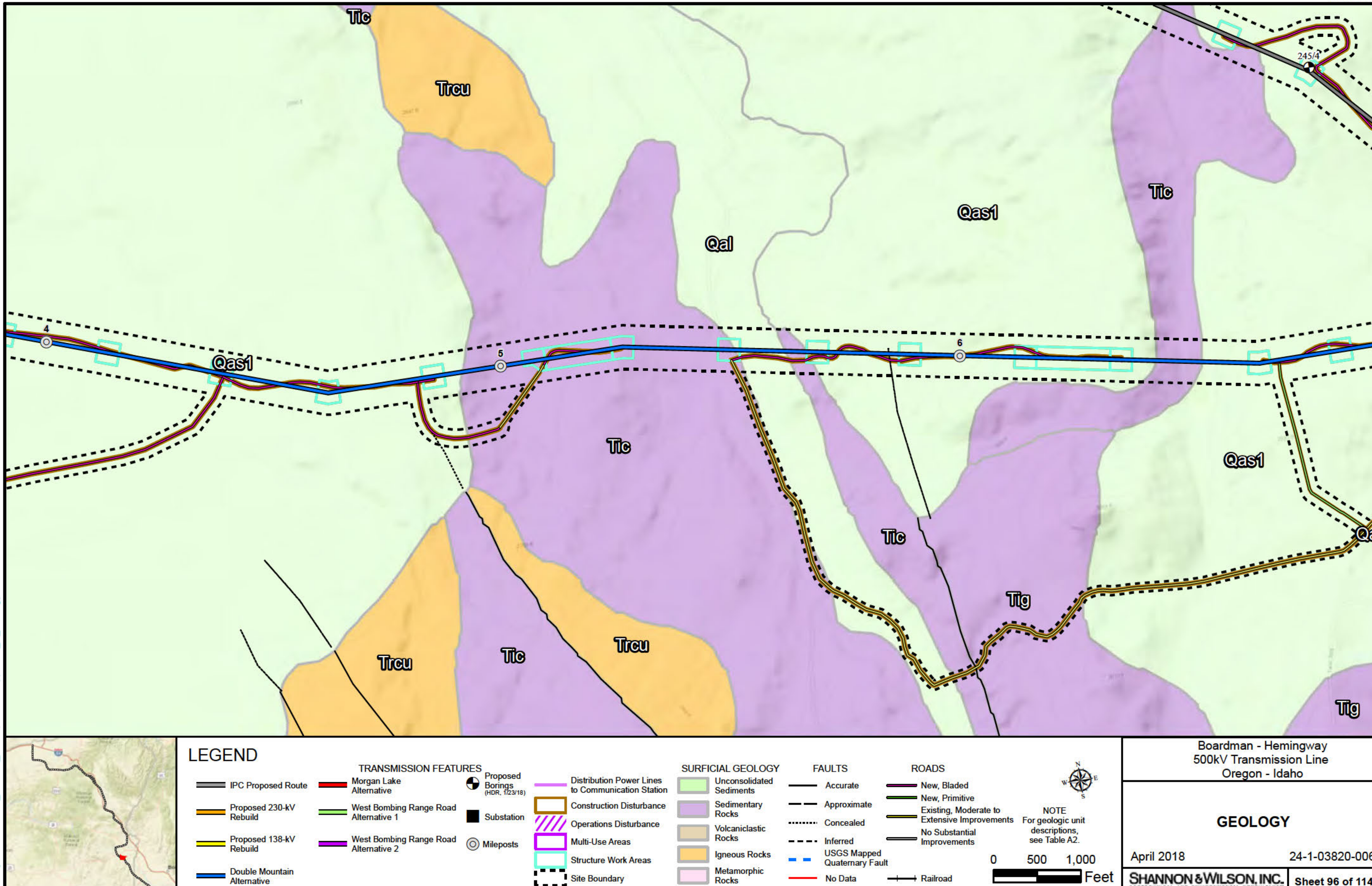

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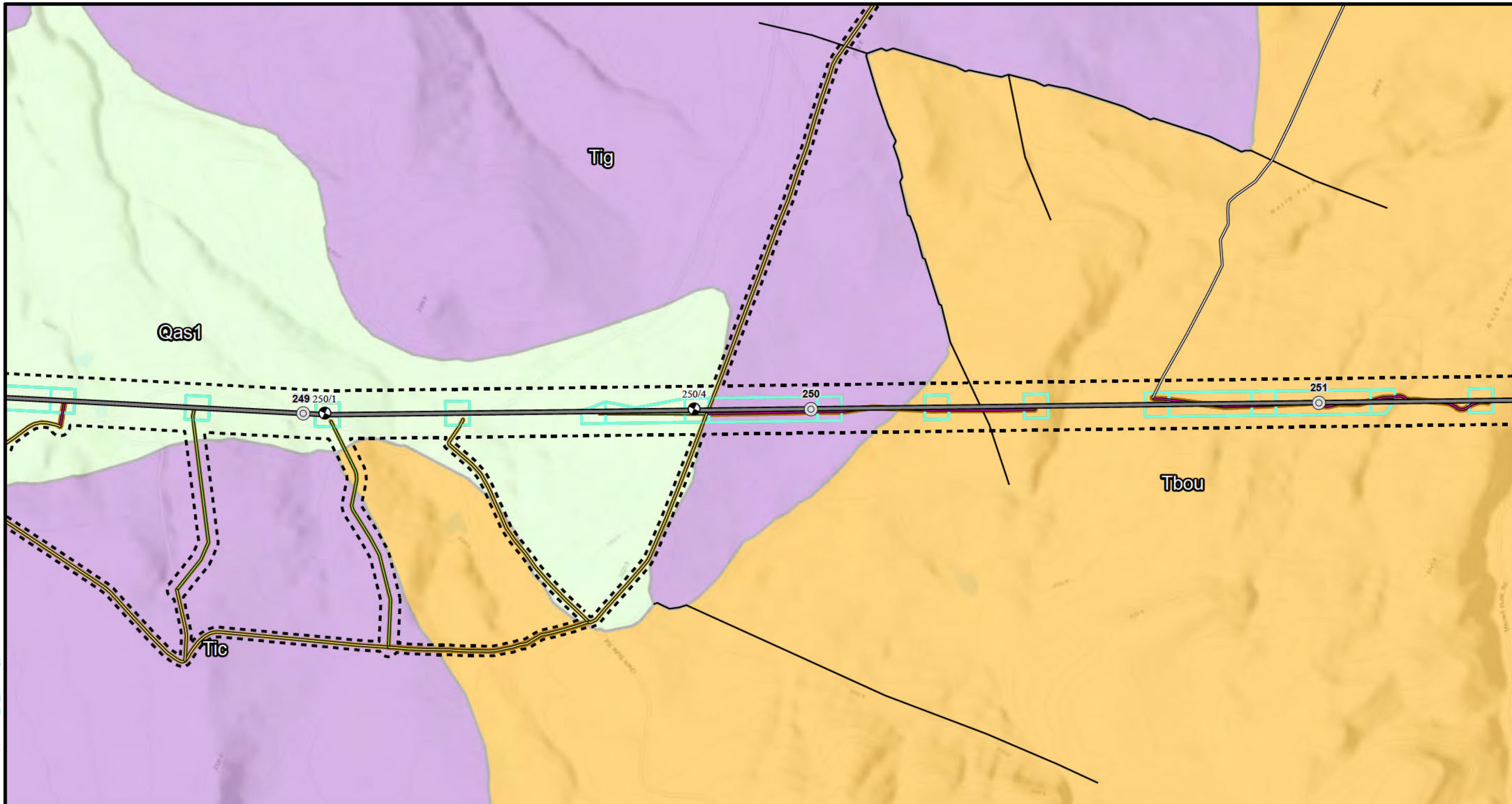

LEGEND

TRANSMISSION FEATURES
- IPC Proposed Route
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- Proposed 138-kV Rebuild
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- Morgan Lake Alternative
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FAULTS
- Accurate
- Approximate
- Concealed
- Inferred
- USGS Mapped Quaternary Fault
- No Data

ROADS
- New, Bladed
- New, Primitive
- Existing, Moderate to Extensive Improvements
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- Railroad

NOTE
For geologic unit descriptions, see Table A2.

0 500 1,000 Feet

Boardman - Hemingway
500kV Transmission Line
Oregon - Idaho

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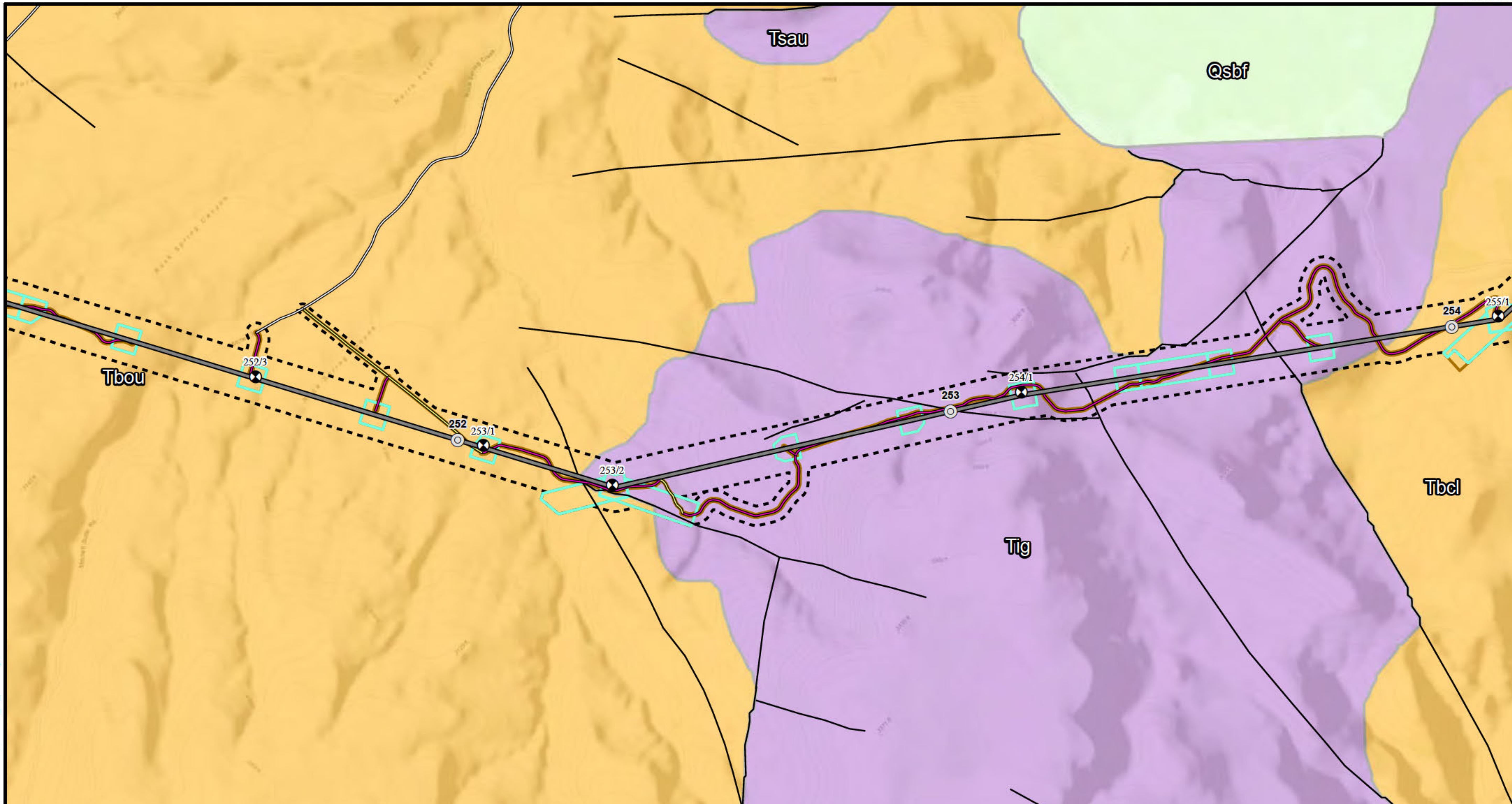

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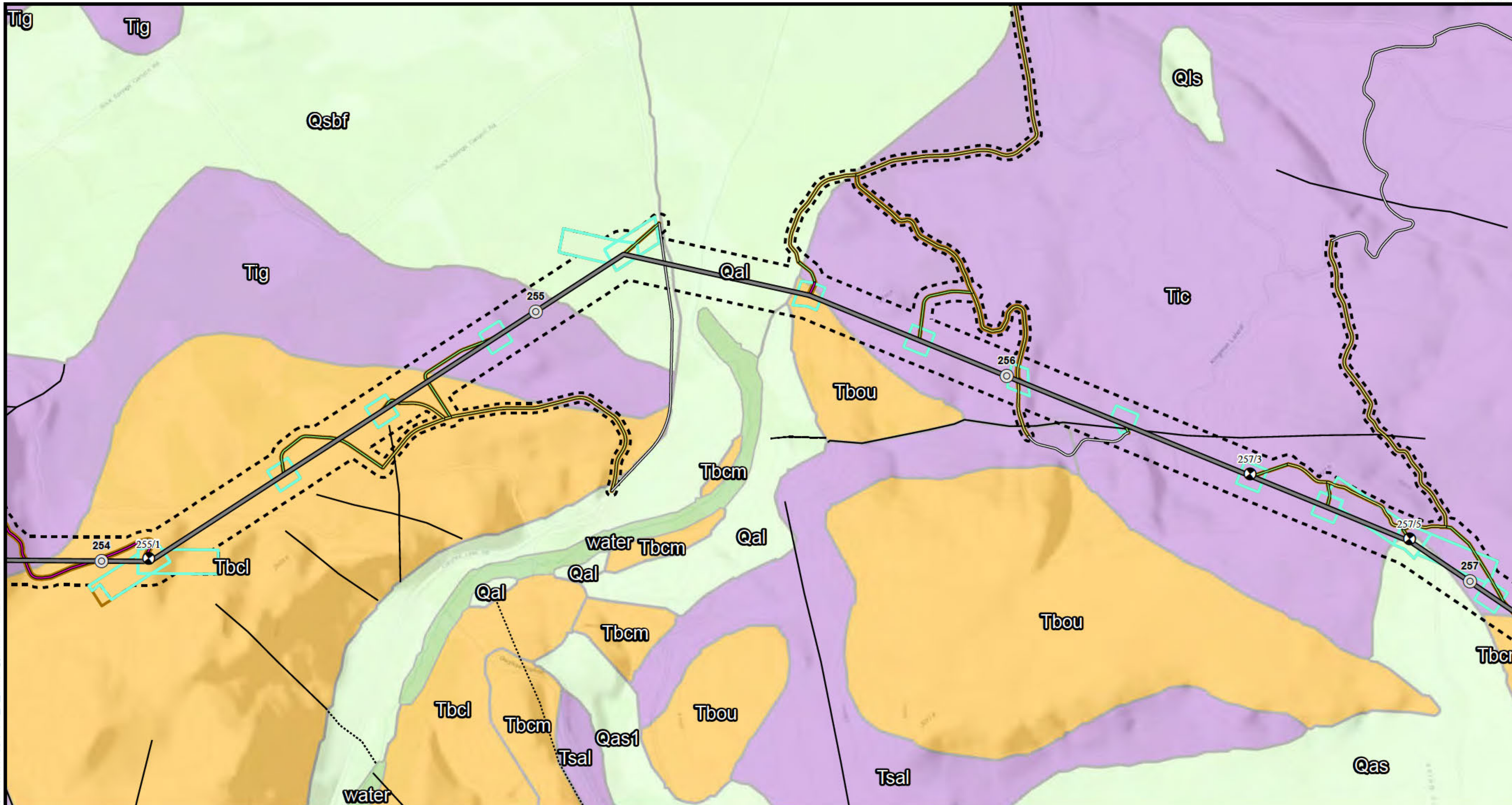

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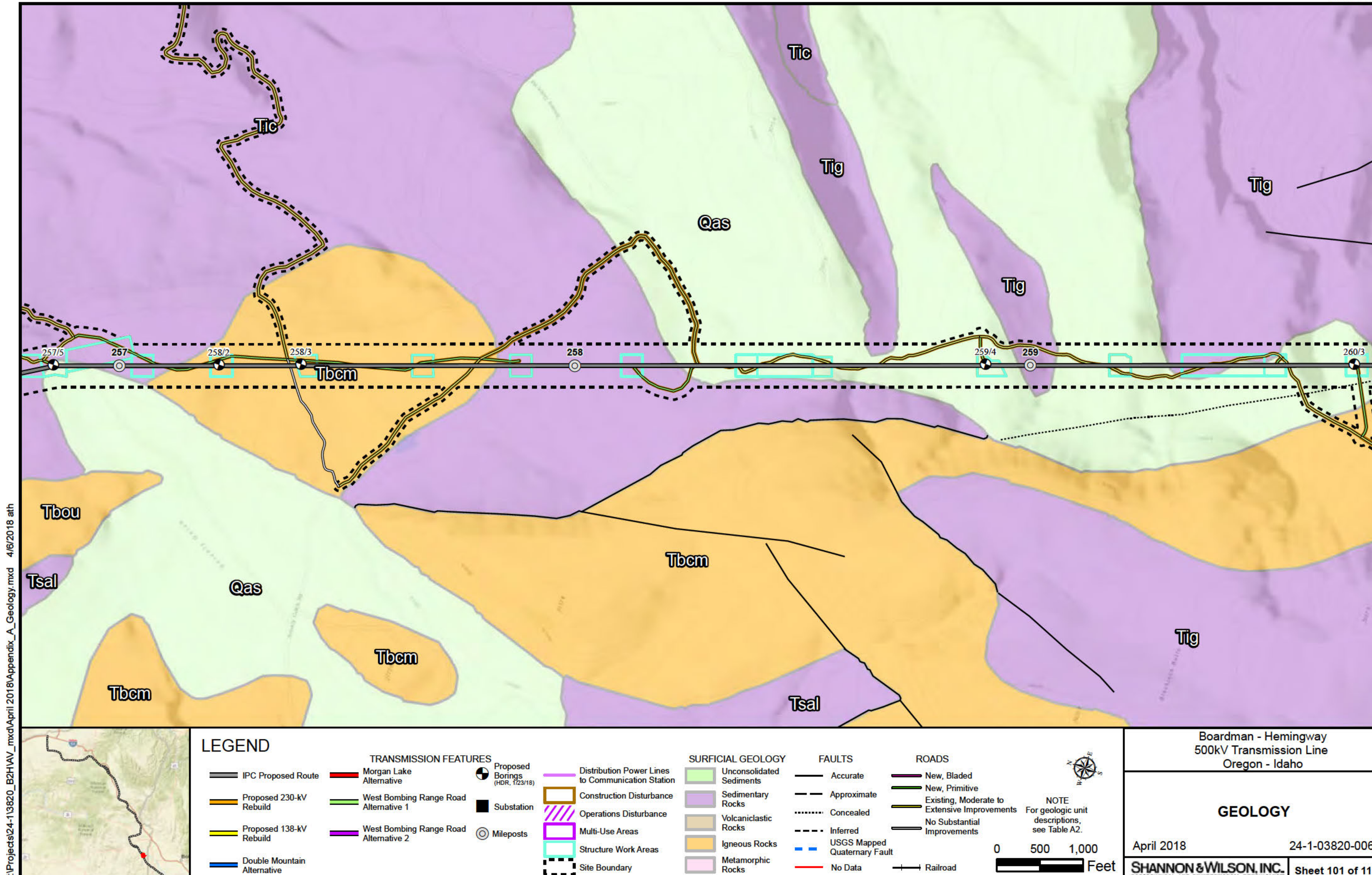
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Qas
Tbcm
Tbou
Tsal
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260/3
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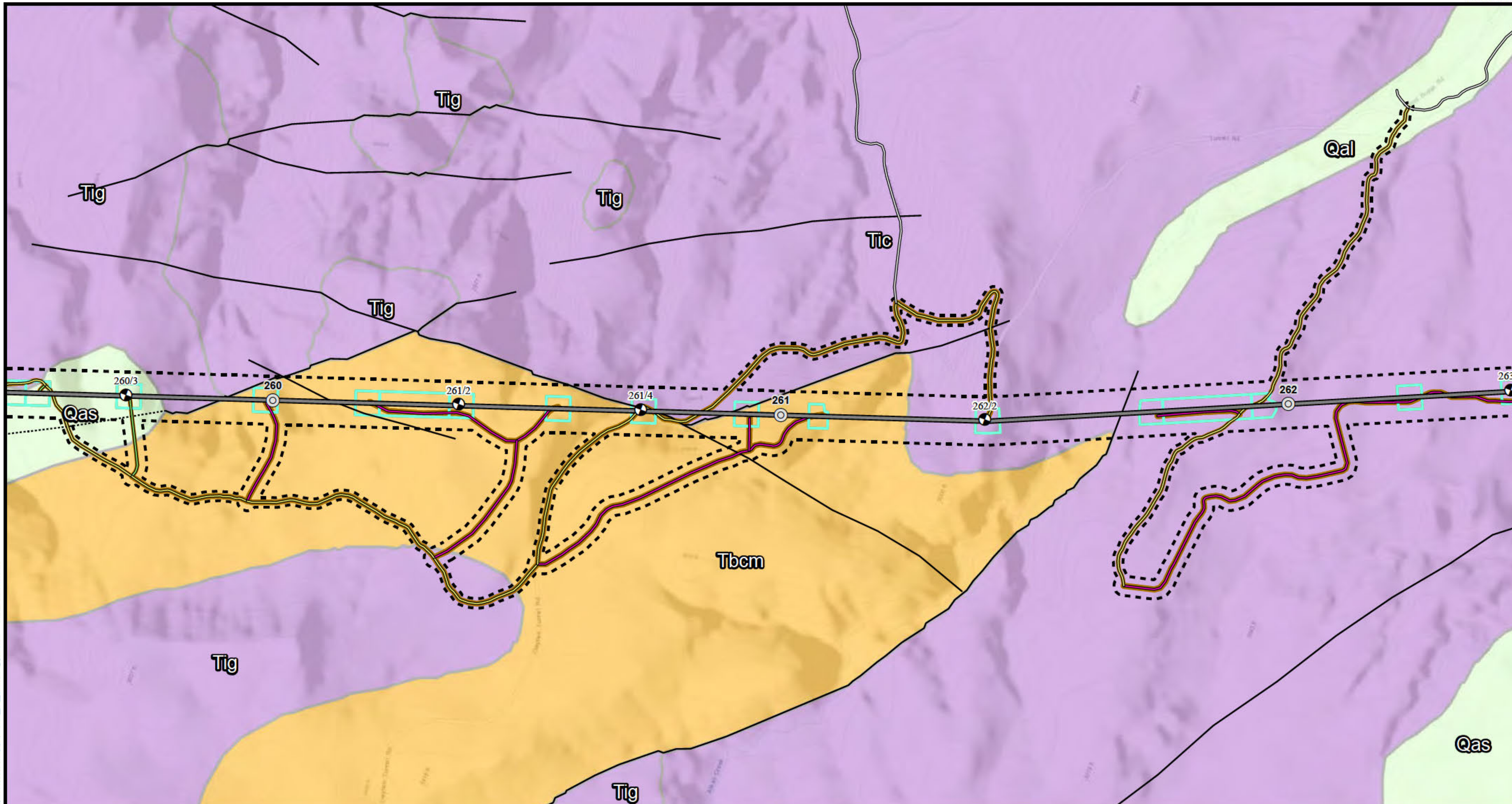

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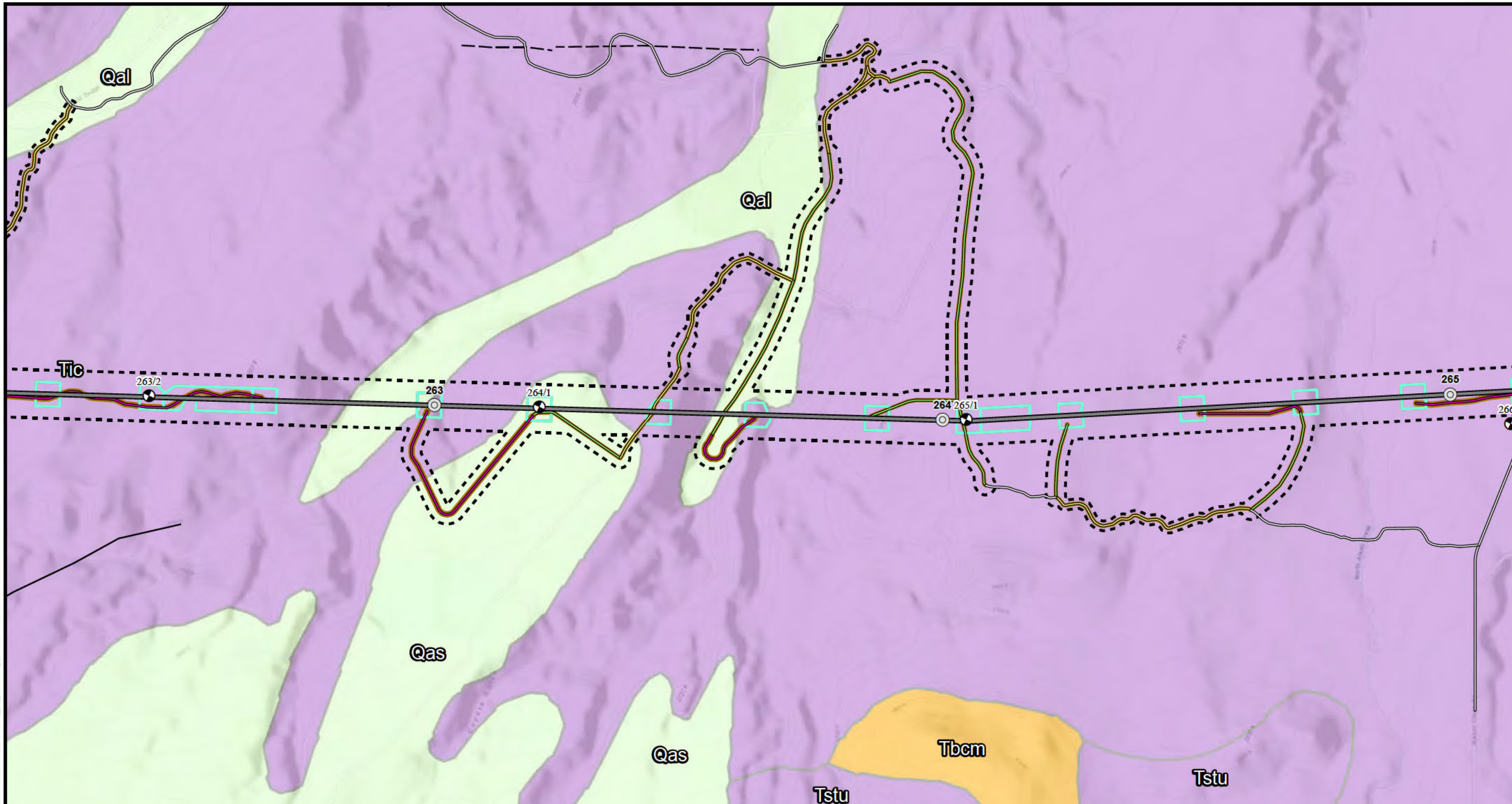

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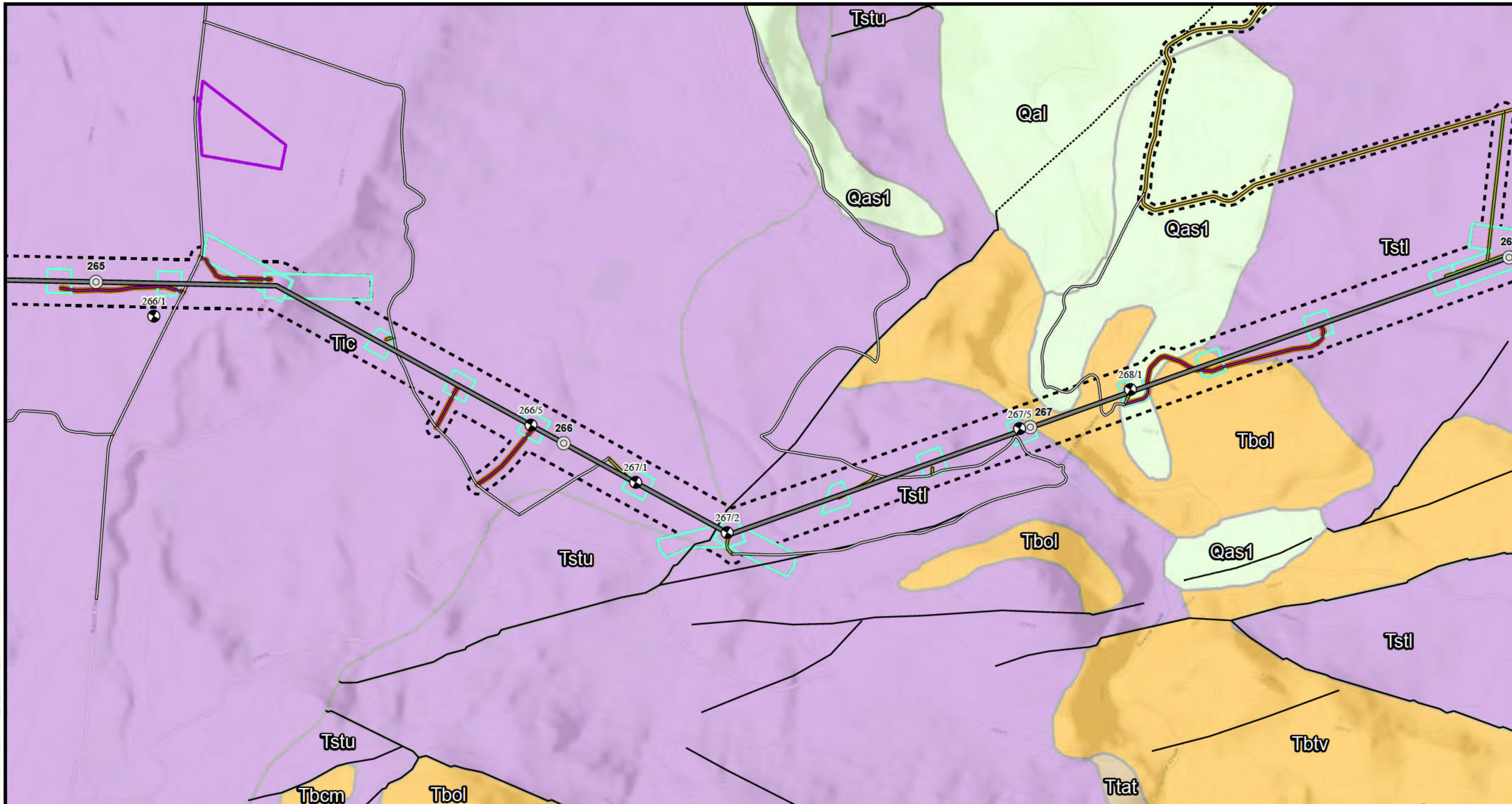

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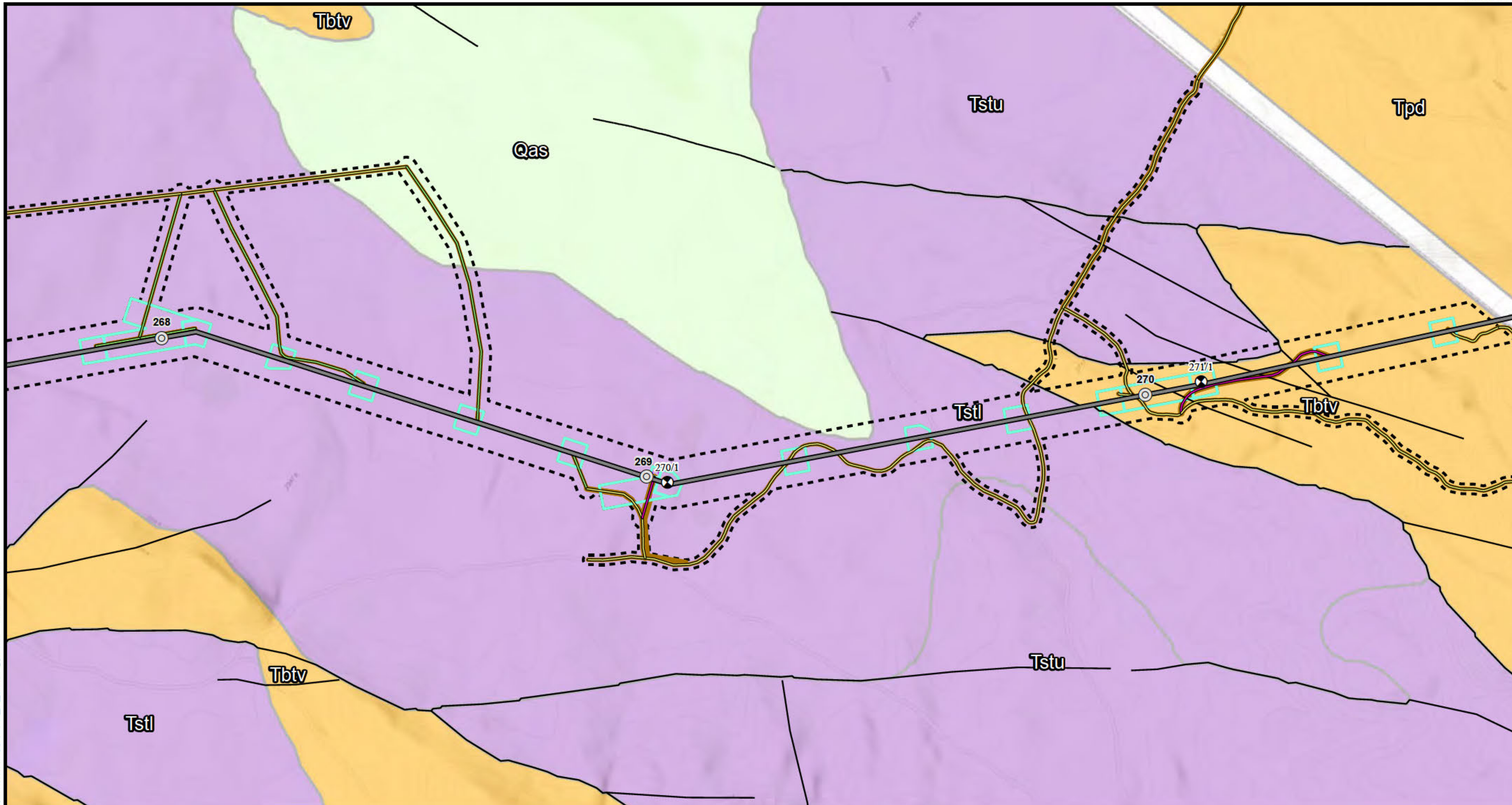

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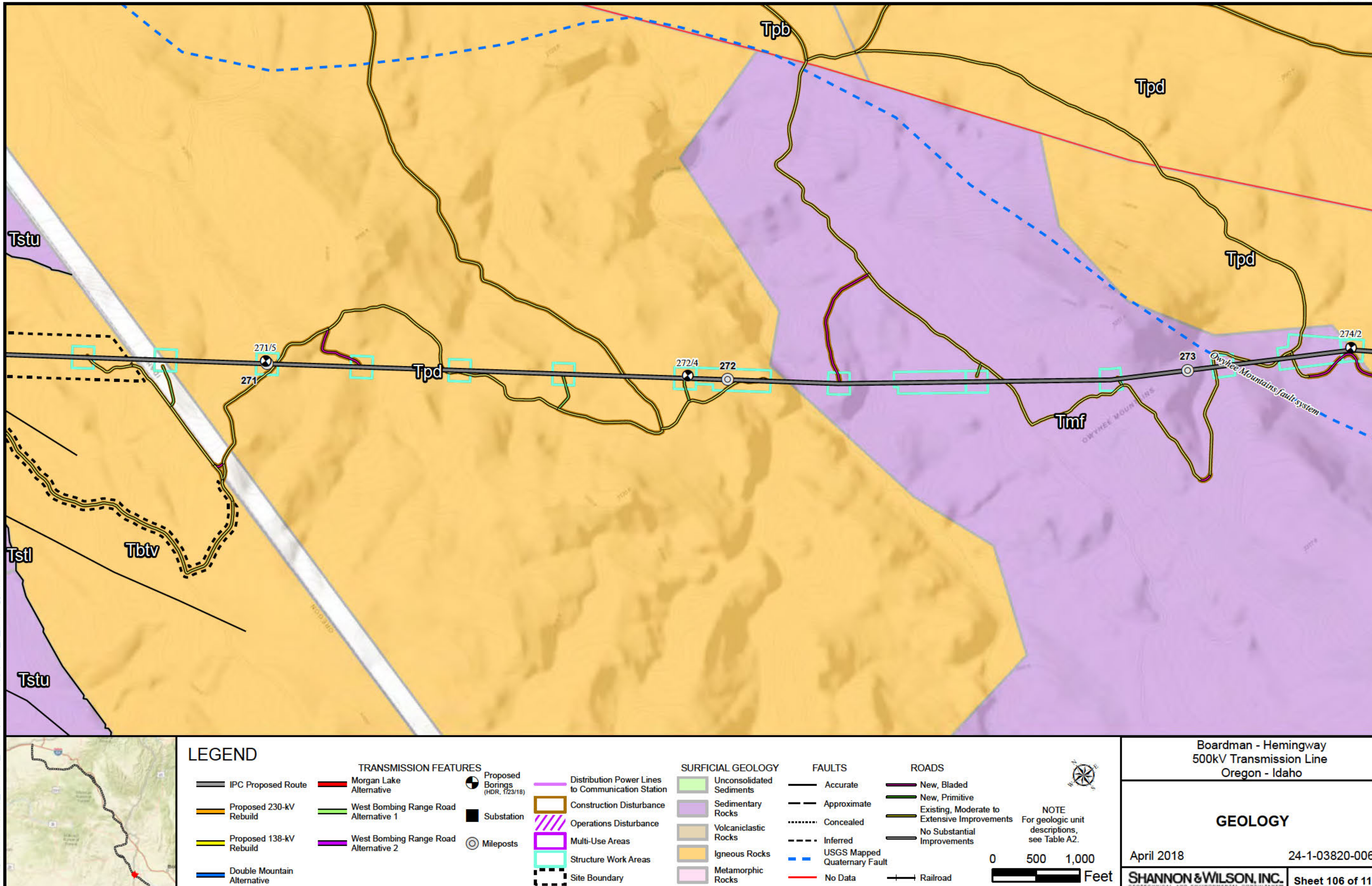

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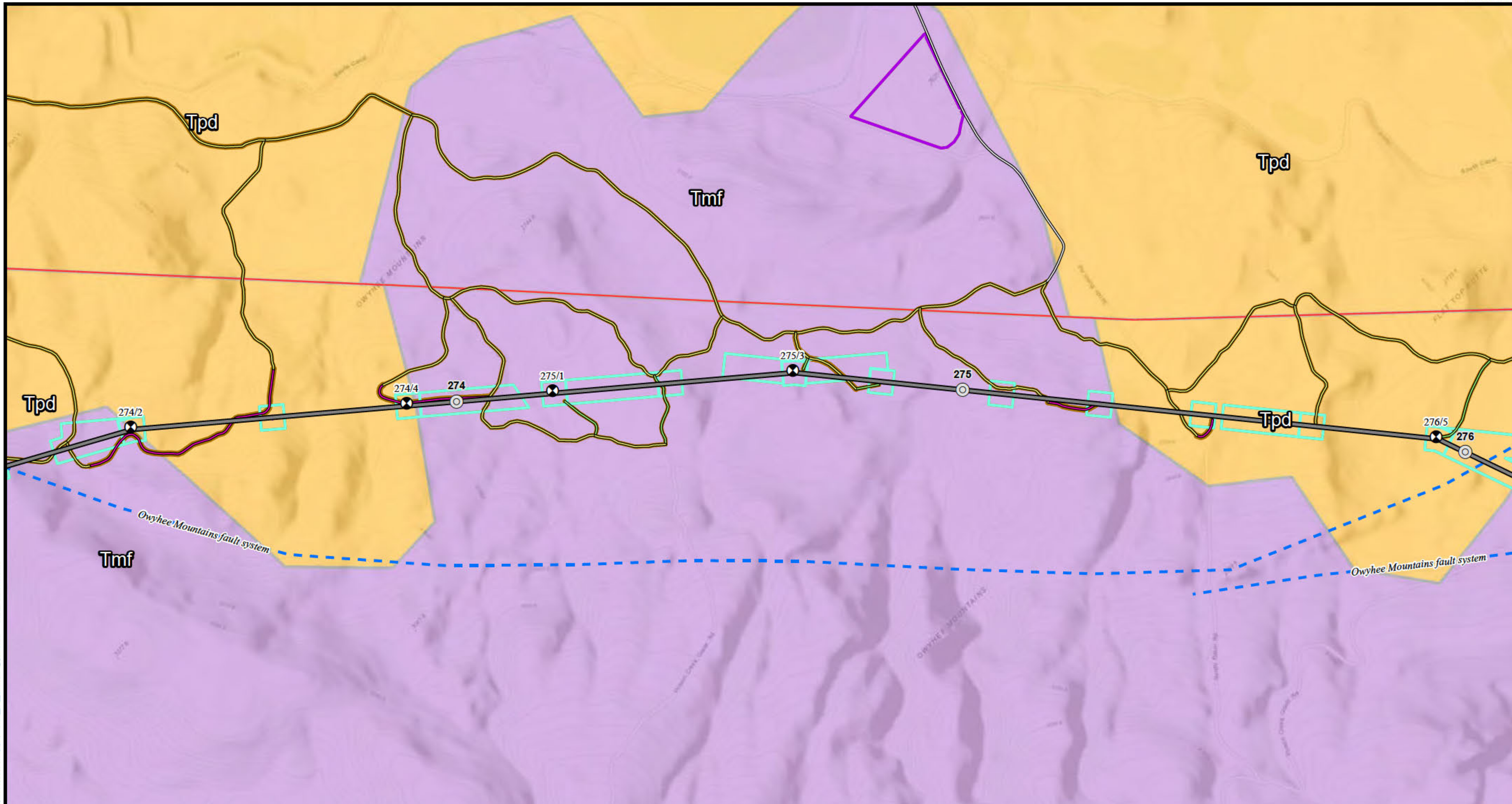

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GEOLOGY

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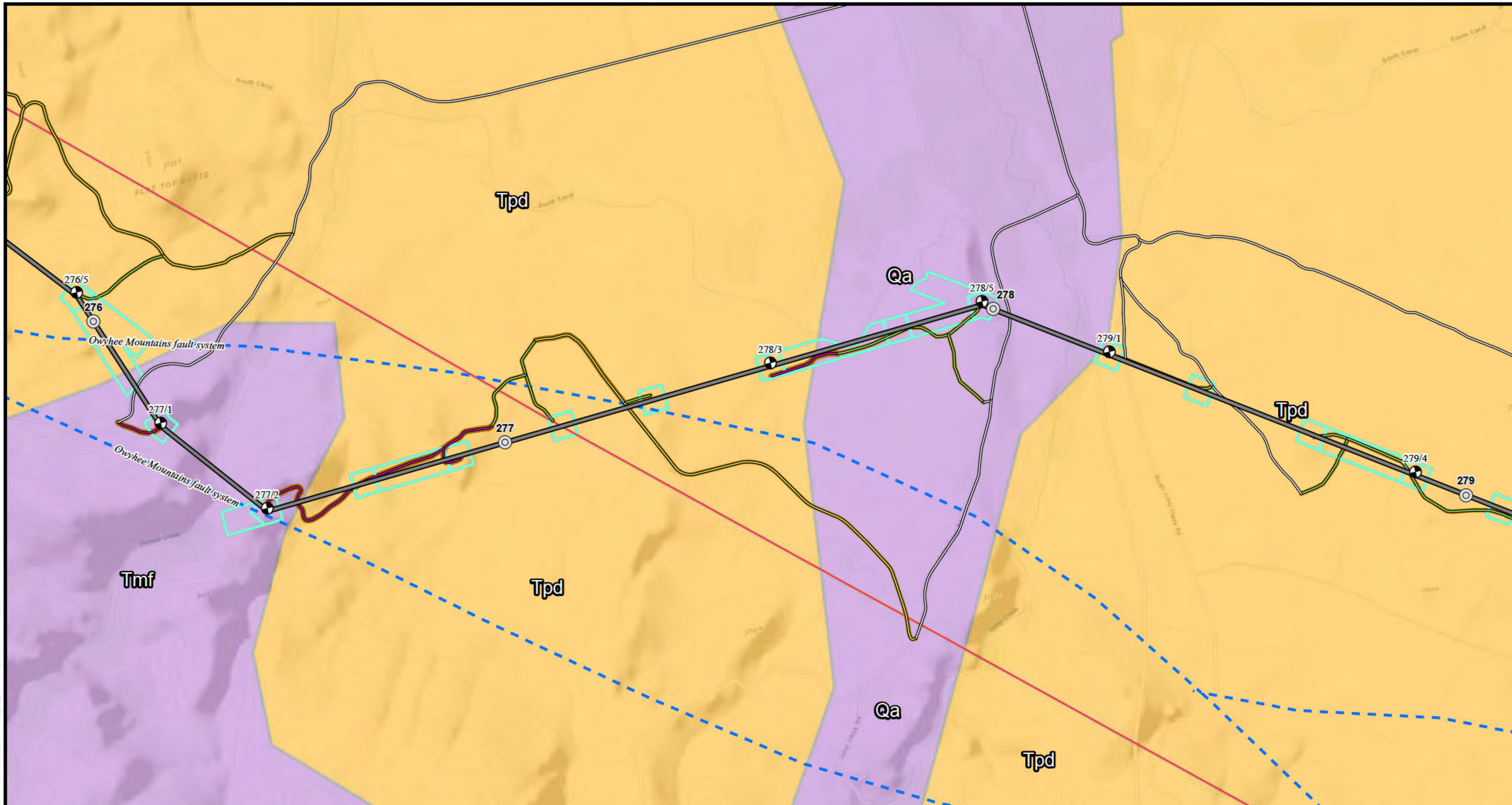

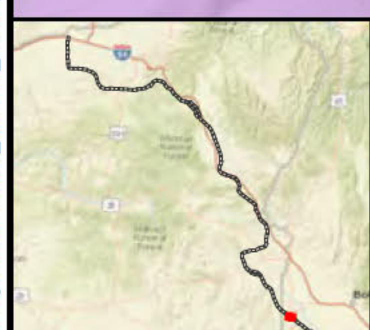

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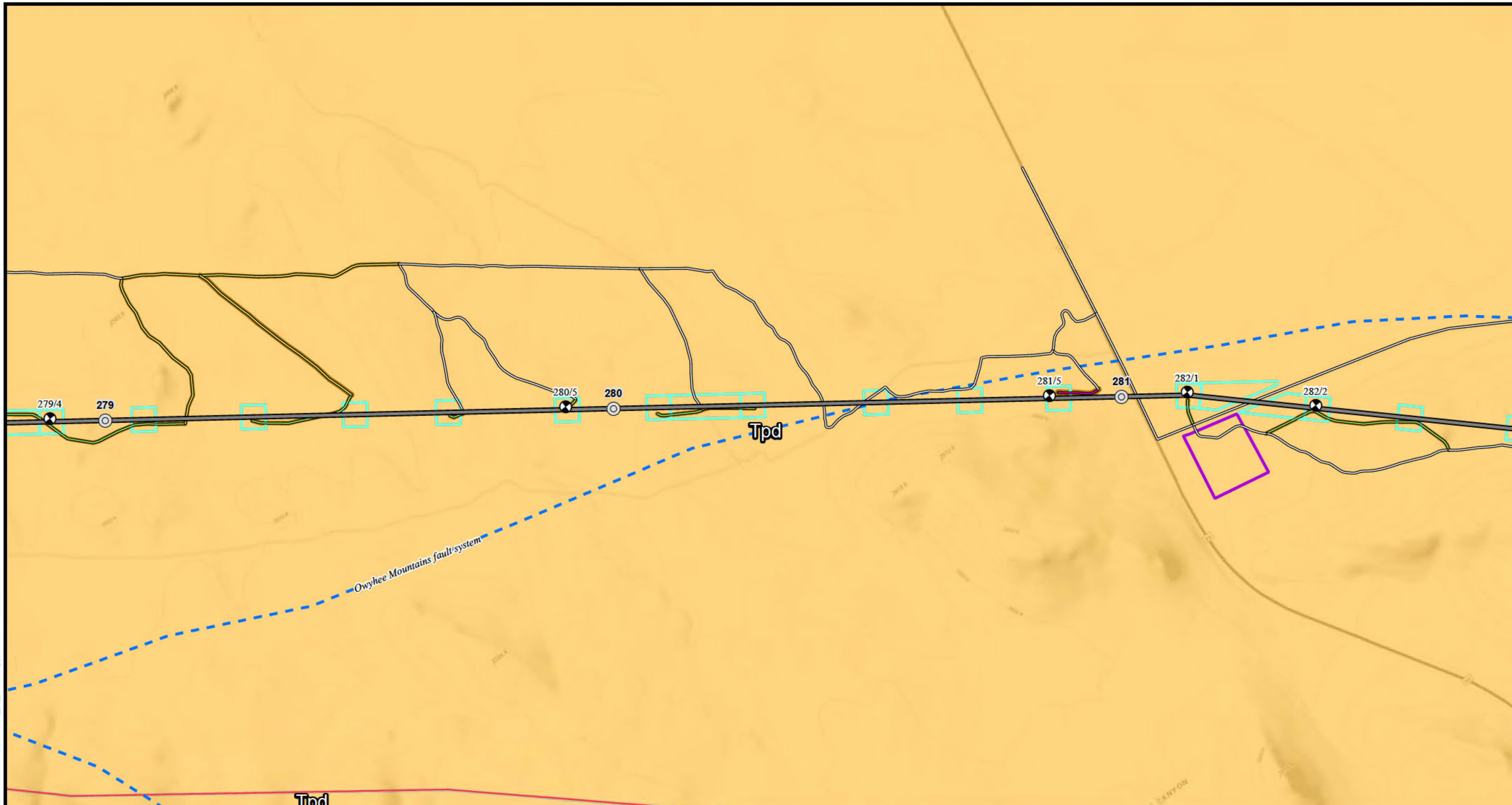

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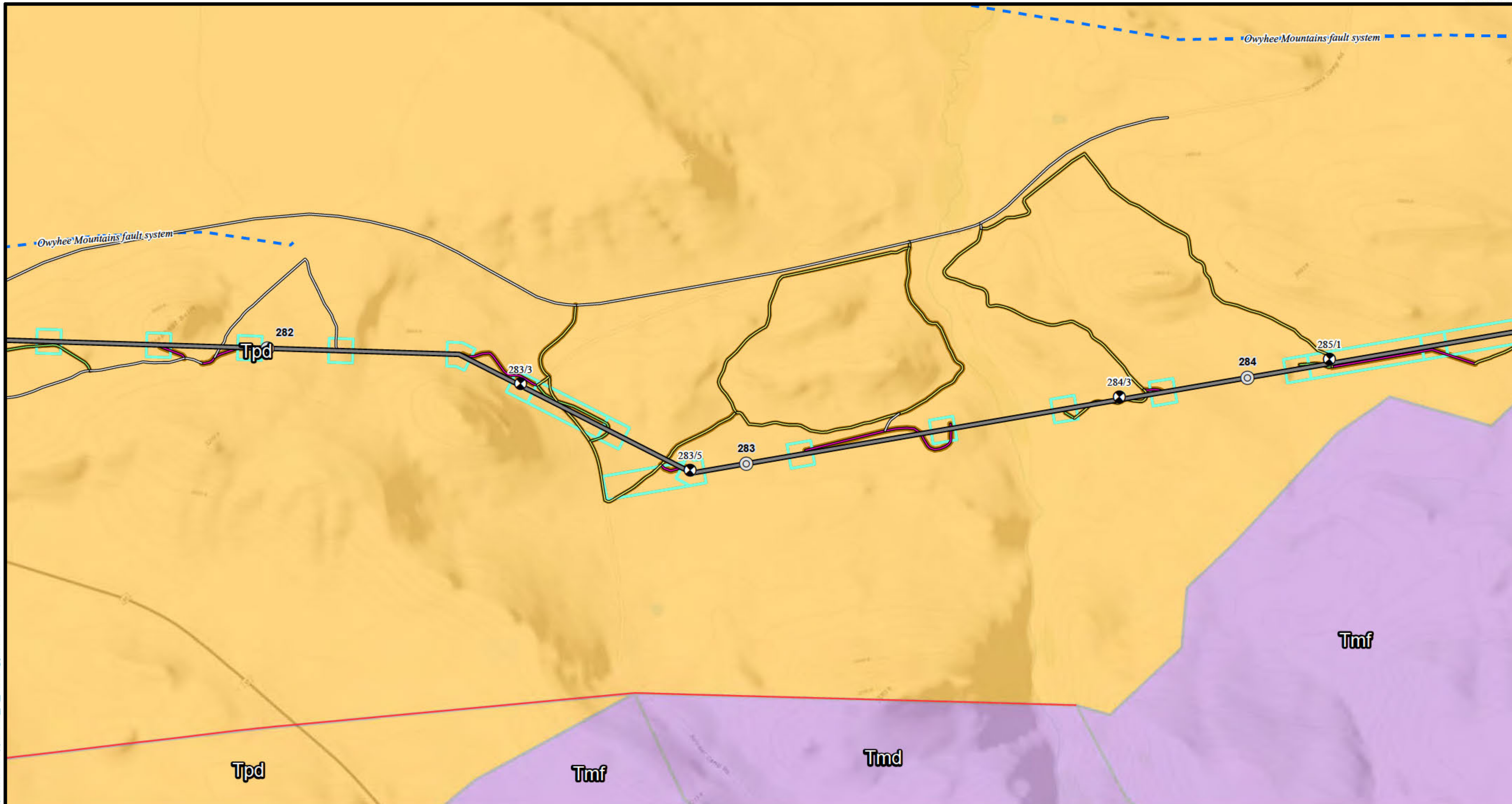

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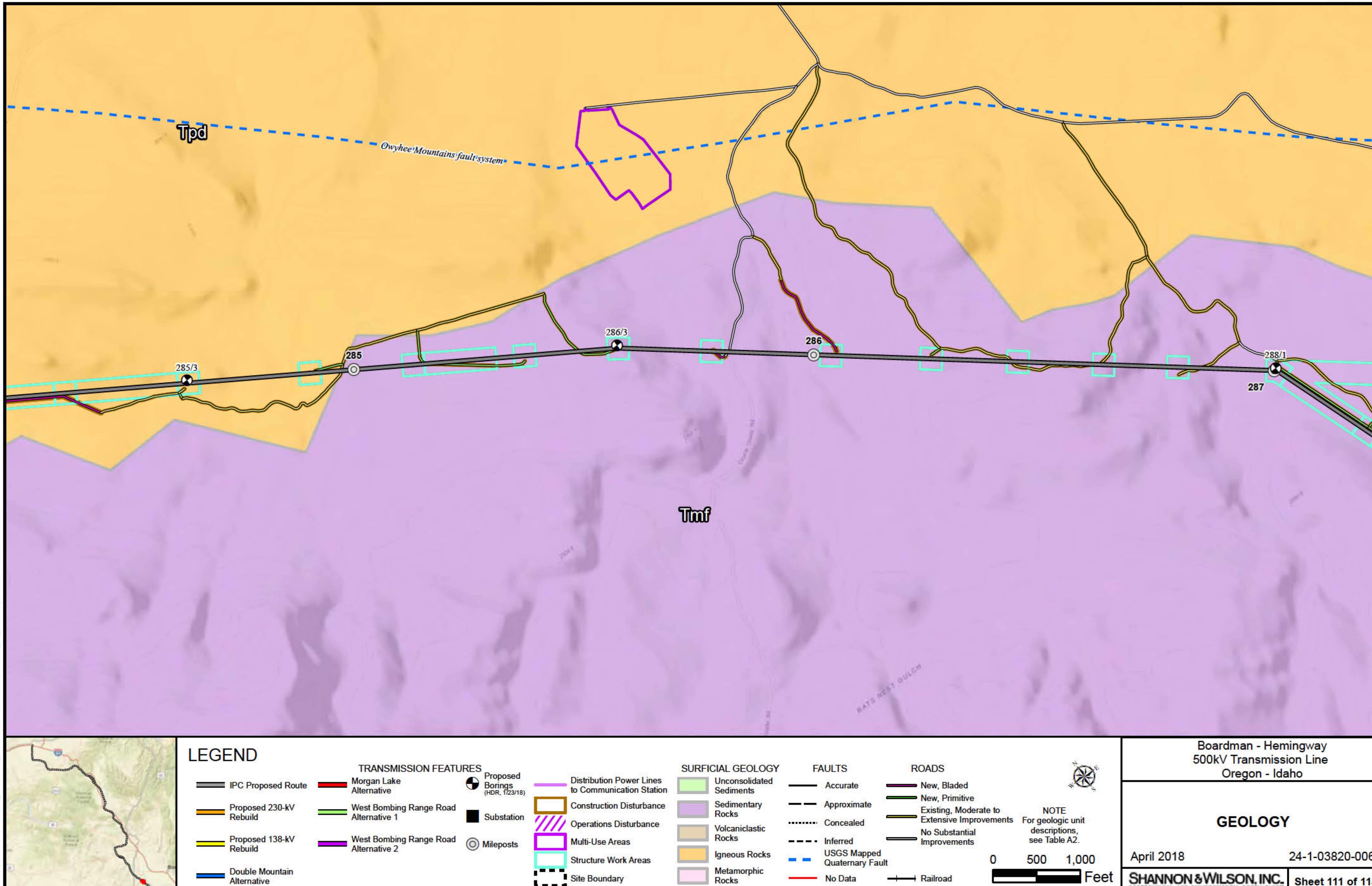

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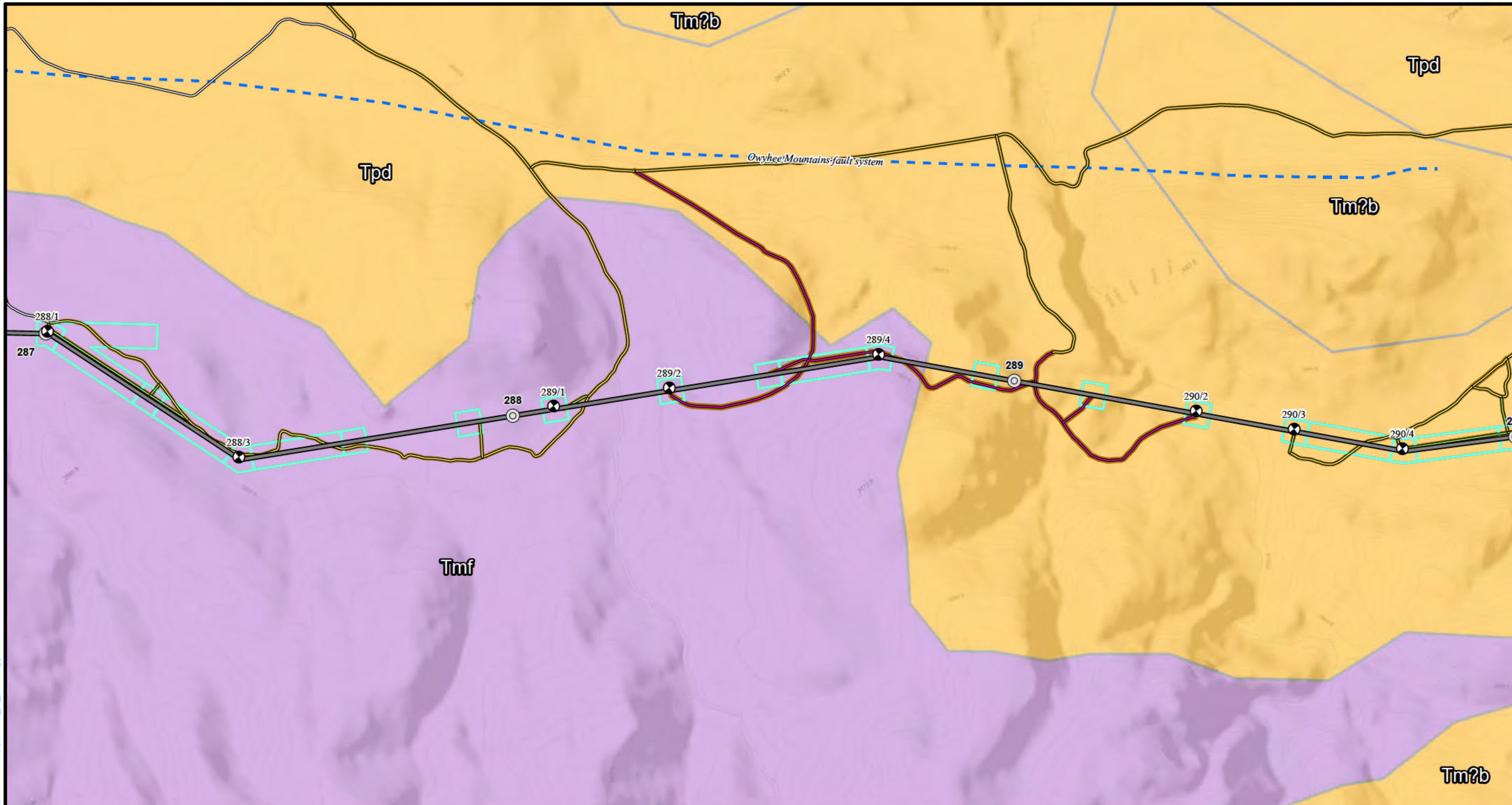

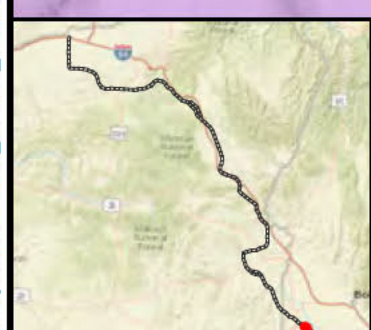

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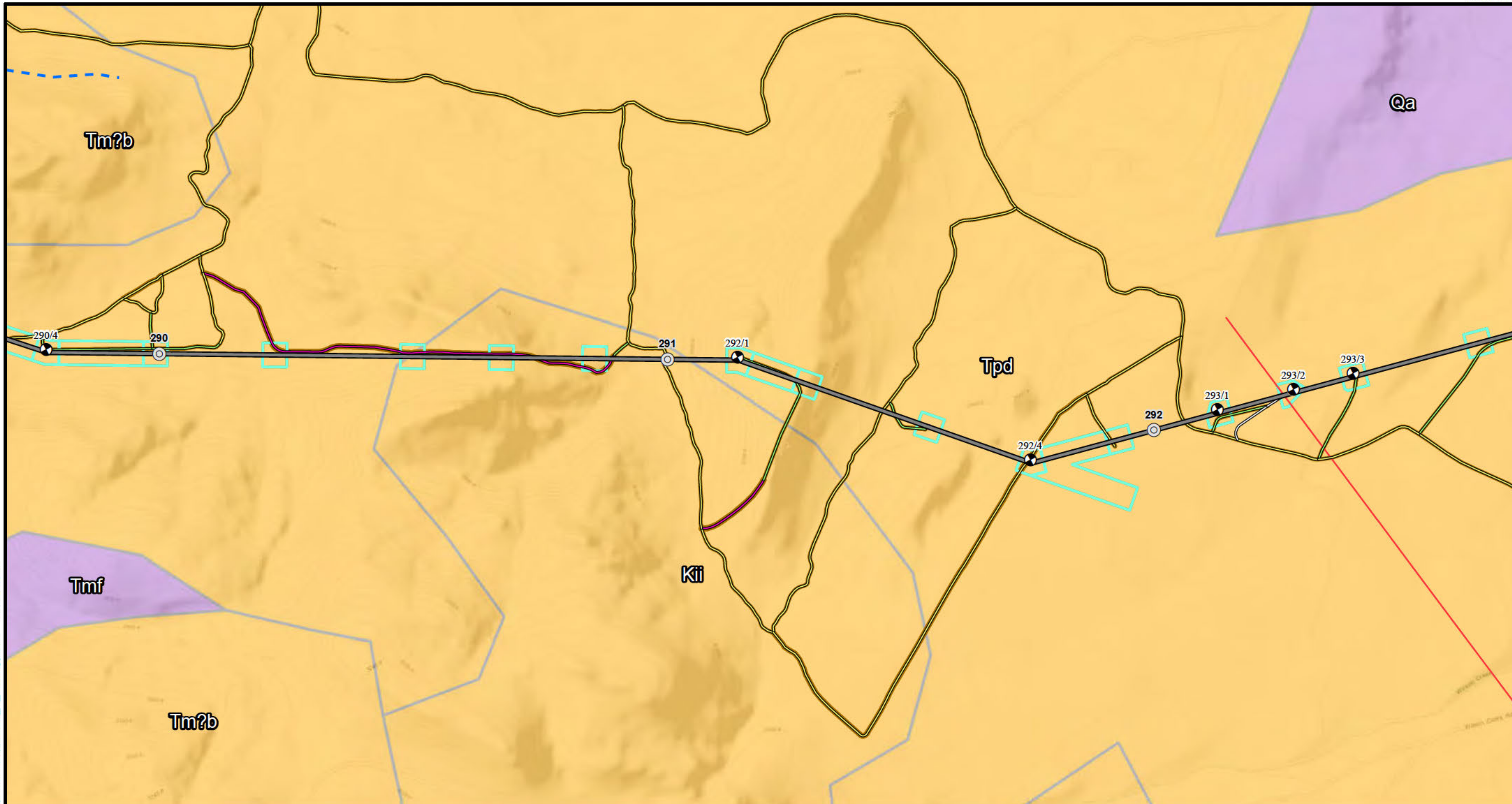

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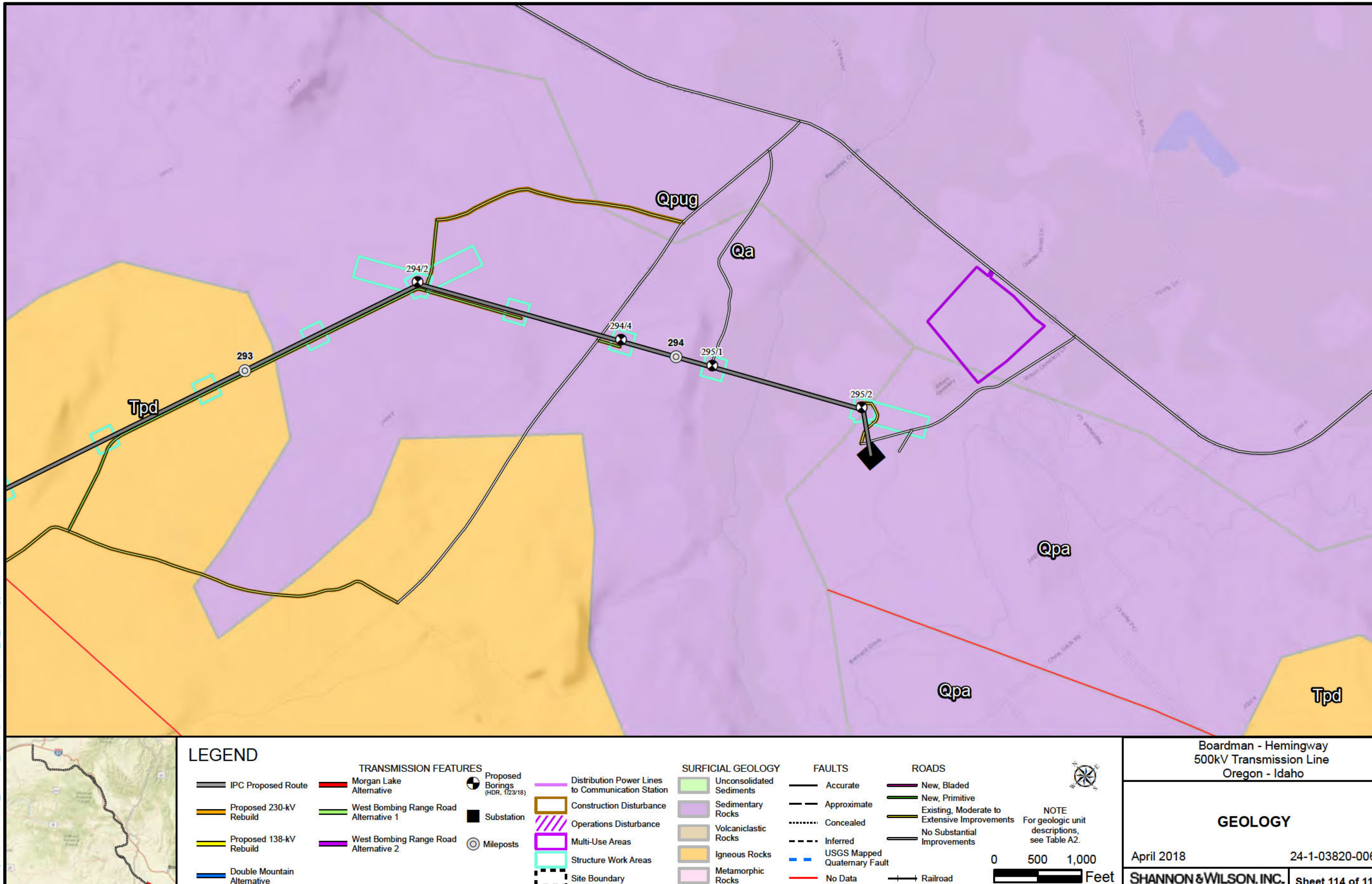

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IDAHO POWER COMPANY'S STANDARD DATA REQUEST NO. 2:

Has the petitioner acquired or filed for any of the following:

a. Third-party funding approvals. If so, please provide documentation of these approvals.

b. Applications for project funding including, but not limited to, federal grants, loan guarantees or other infrastructure stimulus. If so, please provide applications, and documentation of each such approval.

c. ROE adders to Federal Energy Regulatory Commission ("FERC") transmission or wheeling rates.

RESPONSE TO IDAHO POWER COMPANY'S STANDARD DATA REQUEST NO. 2:

a. Under the current Permit Funding Agreement, Idaho Power has an approximate 21 percent interest while Bonneville Power Administration ("BPA") has an approximate 24 percent interest and PacifiCorp has an approximate 55 percent interest in permitting of the project. However, as detailed in the non-binding Term Sheet executed by the Company, BPA and PacifiCorp related to the Construction, Ownership, Operation, Asset Exchanges, and Service Agreements Regarding the Boardman to Hemingway Transmission Line Project and Other Transmission Facilities ("Term Sheet"), included as Attachment 1, BPA intends to transfer their permitting interest to Idaho Power requiring an amendment to the permit funding agreement to recognize the re-allocation of permitting interests among the parties and related funding obligations.

   Also detailed in the Term Sheet, Idaho Power and PacifiCorp intend to enter into a Construction Funding Agreement that will define the roles and responsibilities of each party in construction of the B2H project, including an agreement that funding of the B2H project will be consistent with the parties' respective ownership shares.

b. Idaho Power has not applied for project funding through any type of federal grant, loan guarantee, other infrastructure stimulus, or any comparable funding option.

c. With respect to the B2H project, the Company has not applied for a Return on Equity ("ROE") adder or requested inclusion in wheeling rates with FERC.

Contract No. 22TX-17207

TERM SHEET

THIS TERM SHEET IS INTENDED SOLELY TO FACILITATE DISCUSSIONS AMONG IDAHO POWER COMPANY ("***IDAHO POWER***" or "***IPC***"), PACIFICORP ("***PACIFICORP***" or "***PAC***"), AND THE BONNEVILLE POWER ADMINISTRATION ("***BPA***") (EACH REFERRED TO HEREIN AS A "***PARTY***" AND COLLECTIVELY REFERRED TO HEREIN AS THE "***PARTIES***") RELATED TO THE CONSTRUCTION, OWNERSHIP, OPERATION, ASSET EXCHANGES, AND SERVICE AGREEMENTS REGARDING THE BOARDMAN TO HEMINGWAY TRANSMISSION LINE PROJECT ("***B2H PROJECT***" OR "***PROJECT***") AND OTHER TRANSMISSION FACILITIES. EXCEPT FOR SECTION 5 OF THIS TERM SHEET WHICH SHALL BE LEGALLY BINDING UPON THE PARTIES UPON THE EXECUTION AND DELIVERY OF THIS TERM SHEET BY ALL OF THE PARTIES (THE "***EFFECTIVE DATE***"), (I) THIS TERM SHEET IS NOT INTENDED TO CREATE, NOR SHALL IT BE DEEMED TO CREATE, A LEGALLY BINDING OR ENFORCEABLE AGREEMENT OR OFFER, AND (II) NO PARTY SHALL HAVE ANY LEGAL OBLIGATION WHATSOEVER PURSUANT TO THIS TERM SHEET.

1. **BPA Requirements.** The Parties acknowledge and agree that in order to negotiate the Agreements (as defined below) and before BPA can make a definitive final decision regarding whether to enter into the Agreements, BPA must (1) engage in customer and stakeholder outreach, share information about this Term Sheet during the outreach, and solicit feedback; (2) fulfill all requirements under the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA) and other applicable environmental laws, and (3) make a definitive decision in an Administrator's final record of decision. Nothing in this Term Sheet shall be construed as indicating that BPA has engaged in customer and stakeholder outreach; completed its NEPA and other environmental review processes or made a decision regarding how to proceed.

2. **Term.** This Term Sheet shall terminate the earlier of (a) energization of the B2H Project, or (b) execution of all agreements identified in the Term Sheet, or (c) mutual written agreement of all Parties. This Term Sheet may be extended by mutual written agreement of all Parties.

3. **Agreements.** Upon execution of this Term Sheet, the Parties intend to negotiate in good faith toward the execution of the definitive, binding agreements and amendments between or among the Parties described below consistent with the terms and conditions described below ("***Agreements***"). Each of the Parties intends to prepare and deliver to the other Parties initial drafts of the Agreements it is designated as responsible for below by no later than the date identified for each agreement. The Parties further intend, subject

to the BPA requirements in Section 1, that they will endeavor to complete negotiation of and execute the Agreements by no later than the date identified for each agreement; provided, however, that the effectiveness of any such Agreement may be subject to one or more conditions precedent, including state or federal regulatory approvals.

a) <u>Asset Exchanges, Transmission Service Agreements, and Amended and Restated Existing and Future Agreements</u>: The table below defines the transactions contingent on completion of the B2H Project including, without limitation, regulatory approval associated with IPC's acquisition of BPA's interest in the Amended and Restated Boardman to Hemingway Transmission Project Joint Permit Funding Agreement ("Joint Permitting Agreement"), asset exchanges, transmission service agreements, and amended and restated existing and future agreements. Each of the Parties will prepare an initial draft of the Agreements and Amendments below for which it is designated as the Primary Drafter, consistent with the following terms:

	Parties / Agreement / Action / Primary Drafter	***General Terms / Details***
1.	***PAC, BPA*** ***Agreement on Principles and Timelines*** ***Prepare First Draft – BPA: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 3 of Calendar Year 2022***	PAC and BPA are parties to the Amended and Restated Midpoint-Meridian Agreement, originally executed June 1, 1994 (the "Midpoint-Meridian Agreement"), which provides PAC with 340 MW of bidirectional scheduling rights over the Buckley-Summer Lake 500kV line (the "Buckley-Summer Lake Line"). In connection with the Goshen Area Asset Exchange (as referenced in Section 3(a)(7) of this table) and the B2H Midline Series Capacitor Project (as referenced in Section 3(a)(12) of this table), PAC and BPA are discussing options to allow PAC the ability to schedule 340 MW from the Buckley substation to the 500kV side of the Ponderosa Transformer Bank 500/230 kV #1 ("Ponderosa 500") and to concurrently schedule 340 MW from the Summer Lake substation to Ponderosa 500 upon energization of the B2H line and the B2H Midline Series Capacitor Project. I. Contingent upon the conditions set forth below, PAC and BPA desire for the concurrent bidirectional scheduling rights over the Buckley-Summer Lake line to be provided as firm point-to-point transmission service ("PTP service") pursuant to the terms and conditions in BPA's Tariff and rate schedules upon energization of the B2H line

			and the B2H Midline Series Capacitor Project. As of the Effective Date, the PAC and BPA understand that such PTP service remains subject to further BPA evaluation. a. BPA's offer of PTP service may include conditions if such conditions are identified during BPA's evaluation. Conditions for PTP service are at BPA's sole discretion and, if required, will be developed consistent with the principles set forth in Section 3(a)(1)(II)(b) so that flows associated with the PTP service over the Buckley-Summer Lake line do not exceed 340 MW in the north-to-south direction and concurrently does not exceed 340 MW in the south-to-north direction during all lines in service. b. As part of the PTP service evaluation, PAC and BPA will also explore options to combine an offer of PTP service with the modification to points of receipt and points of delivery in PAC's existing PTP service tables ("redirect") within the Long Term Firm Point-to-Point Service Agreement (No. 04TX-11722) between PAC and BPA, subject to BPA's Tariff and related business practices including available transfer capability ("ATC"), with a goal to optimize PAC's transmission service over the Federal transmission system to serve its central Oregon loads (*e.g.*, using a single wheel from a network point of receipt to PAC's load at Ponderosa 230 or Pilot Butte 230). BPA will apply its long-standing practice to evaluate the ATC impacts of the new PTP service against the ATC impacts of existing service, to include the bidirectional scheduling rights and redirected service. c. BPA may request additional information from PAC. PAC will make good faith efforts to provide such information within 30 days of BPA's request. d. PAC will submit applicable transmission service request(s) ("TSR") within 30 days

		of BPA's notice to PAC that such requests should be submitted. e. If BPA determines, in its sole discretion, that BPA can convert the bidirectional scheduling rights to PTP service, BPA agrees to offer PTP service pursuant to BPA's Tariff and rate schedules. i. The PTP service will be contingent upon and will not be effective before (A) the energization of the B2H line and the installation of the B2H Midline Series Capacitor Project; (B) approval by the Federal Energy Regulatory Commission ("FERC") of the proposed amendments to the Midpoint-Meridian Agreement discussed in this Section 3(a)(1), per subpart (iii below; and (C) the Goshen Area Asset Exchange set forth in Section 3(a)(7) of this table is completed and all associated agreements are in effect. ii. PAC and BPA will adhere to the applicable requirements set forth in BPA's Tariff and related business practices, including timelines for execution or amendment of a service agreement. iii. Concurrent with the execution of the PTP service agreements contemplated in this Section 3(a)(1)(I), PAC and BPA will amend Section 4(a) of the Midpoint-Meridian Agreement to remove and otherwise terminate PAC's bidirectional scheduling rights over the Buckley-Summer Lake Line. f. If BPA offers PTP service that satisfies PAC's objectives as expressed in this Term Sheet, PAC intends to accept such service subject to the condition regarding FERC approval described below. If following FERC acceptance without material conditions of the arrangements negotiated between BPA and PAC in this Section 3(a)(1)(I), PAC nonetheless fails to submit applicable TSRs or otherwise

		declines to accept the PTP service or execute a PTP service agreement, then BPA will have no further obligations to provide PAC with the PTP service described in this Section 3(a)(1)(I) or the scheduling rights described in Section 3(a)(1)(II) below. g. PAC and BPA will negotiate in good faith to complete and enter into agreements needed to complete the other conditions set forth in Sections 3(a)(2) through (14) and 3(c) of this Term Sheet, as such conditions are applicable to either Party. h. PAC will seek FERC guidance as necessary and file the proposed amendment to the Midpoint-Meridian Agreement with FERC for acceptance. BPA will reasonably coordinate with PAC to prepare for FERC meetings and submissions. FERC's unconditioned acceptance shall be a condition to PAC's obligations as contemplated under this Term Sheet. II. Following either (1) BPA's determination that it is unable to provide the PTP service to PAC consistent with Section 3(a)(1)(I) above, or (2) FERC's failure to accept without material conditions the arrangements negotiated between PAC and BPA under Section 3(a)(1)(I) above, BPA will, effective upon energization of the B2H line and the B2H Midline Series Capacitor Project provided that all conditions described below are met, provide PAC with bidirectional scheduling rights over the Buckley-Summer Lake line which give PAC the ability to (A) schedule 340 MW from the Buckley substation to Ponderosa 500 ("North to South schedules") and (B) concurrently schedule 340 MW from the Summer Lake substation to Ponderosa 500 ("South to North schedules") (collectively referred to as "scheduling limits"). The concurrent, bidirectional scheduling rights described in the immediately preceding sentence will be

		provided pursuant to an amendment to the Midpoint-Meridian Agreement and one or more separately negotiated agreements, that will be effective upon acceptance by FERC and after all conditions set forth in this Section 3(a)(1)(II) are met and will remain in effect until BPA offers PTP service as set forth in Section 3(a)(1)(I). PAC and BPA will work in good faith to satisfy all such conditions consistent with the principles articulated in Section 3(a)(1)(II)(b) below by energization of the B2H line. a. <u>Transmission service to move from the Ponderosa 500 substation</u>. The utilization of the concurrent bidirectional scheduling rights at the Ponderosa substation described in this Section 3(a)(1)(II) is limited to Ponderosa 500. PAC must reserve PTP service from BPA pursuant to BPA's Open Access Transmission Tariff ("OATT"), business practices, and rate schedules in effect at the time of such reservation to move from Ponderosa 500 to the 230 kV side of Ponderosa transformer bank #1 for delivery to PAC load in central Oregon. b. <u>Principles to guide satisfaction of conditions</u>. i. North to South schedules, South to North schedules, and the associated directional power flows may not exceed the scheduling limits (*e.g.*, 340 MW North to South and, concurrently, 340 MW South to North, under all lines in service). A Power Transfer Distribution Factor ("PTDF") based methodology ("PTDF algorithm") and calculator will be used to determine directional power flow. The PTDF algorithm will sum positive flows in the North to South and South to North directions (*i.e.*, schedules and flows are not netted). ii. If, at any time, North to South schedules, South to North schedules, or the associated directional power

			flows exceed the scheduling limits, PAC shall reduce the schedules so that the schedules and directional power flows are within the scheduling limits. BPA can, at BPA's sole discretion, curtail the schedules in whole or in part to maintain the scheduling limits and to mitigate congestion, such as during outages. iii. Schedules (E-Tags) must contain a single granular source and sink. Sources and sinks (1) cannot be consolidated on a single E-Tag; and (2) must be granular enough to determine the PTDF impact. Sources and sinks that are scheduling points, hubs, or nodes are not sufficiently granular to determine the PTDF impact. iv. PAC may not schedule from sources and sinks for which the PTDF impact has not been determined. PAC will provide BPA with advance notice of sources and sinks with sufficient time for BPA to determine the PTDF impact and, if necessary, to accommodate modifications to tools, systems, and contracts. v. The terms, tools, and protocols associated with the concurrent bidirectional scheduling rights will be structured to minimize to the maximum extent possible any impacts exceeding the scheduling limits (*e.g.*, 340 MW North to South and, concurrently, 340 MW South to North, under all lines in service) that the physical flows associated with the concurrent bidirectional scheduling rights have on the Pacific Northwest AC Intertie (as such transmission facilities are defined in the various PNW AC Intertie-related agreements among PAC, BPA and the other PNW AC Intertie owners, the "NW AC Intertie") or the Federal transmission

		system, as reasonably determined by BPA. c. Conditions to Effectiveness of 3(a)(1)(II) Scheduling Rights i. PTDF calculator. BPA will develop a PTDF algorithm to calculate the directional power flow associated with each source and sink that PAC intends to schedule. PAC and BPA will coordinate to develop, at PAC's expense, a PTDF calculator that uses the PTDF algorithm and related communication equipment. ii. Agreement on operational terms. After the PTDF calculator is developed, PAC and BPA will work in good faith to develop operational terms, to include the protocols and requirements for monitoring, dispatch, curtailment, reduction of scheduling limits due to outages, and future modifications to stay current with reliability standards, automation, and technological abilities. The operational terms will remain in effect for the duration of the concurrent bidirectional scheduling rights described in this Section 3(a)(1)(II) and will be incorporated into the proposed amendments to the Midpoint-Meridian Agreement or such other agreement as mutually agreed by PAC and BPA. iii. Energization of the B2H Project, including the B2H Midline Series Capacitor Project. iv. The agreements set forth in Section 3(a)(1)(III) below are, to the extent required, accepted for filing at FERC without material conditions. v. The Goshen Area Asset Exchange set forth in Section 3(a)(7) of this table is completed and all associated agreements are in effect. III. Agreements.

		a. Agreement on Principles and Timelines. Following execution of the Term Sheet, PAC and BPA will negotiate and execute an agreement to reflect the objectives, commitments, principles, conditions, and timelines, including negotiation of applicable follow-on agreements for the PTP service described in Section 3(a)(1)(I), and the concurrent, bidirectional scheduling rights described in Section 3(a)(1)(II). With regard to the concurrent, bidirectional scheduling rights described in Section 3(a)(1)(II), the Agreement on Principles and Timelines would include the principles and conditions set forth in Section 3(a)(1)(II) above, and the timelines for development of the PTDF calculator and negotiation of operational terms and protocols. b. Follow-on Agreements. Before energization of B2H and subject to the conditions described above in this Section 3(a)(1) being met, PAC and BPA will negotiate and execute (1) the agreements and amendments referenced in Section 3(a)(1)(I) above, or (2) if BPA is not yet providing PTP service upon B2H energization consistent with Section 3(a)(1)(I) above, then an amendment to the Midpoint-Meridian Agreement to reflect the addition of the concurrent bidirectional scheduling rights, including term, scheduling and directional power flow requirements, usage of the PTDF calculator, and operational terms, all as consistent with Section 3(a)(1)(II) above. PAC and BPA understand that PAC may be required to file amendments to the Midpoint-Meridian Agreement with FERC for acceptance and that the effective date for the agreements referenced above will be upon FERC acceptance without material conditions. IV. Consistent with the "Phase II Joint Study Report (2020-2021), Boardman to

		Hemingway (B2H) and Incremental Central Oregon Load" completed on March 23, 2021, upon notice from BPA, PAC will upgrade the existing Meridian Series Capacitor on the 500 kilovolt bus or install an electrically equivalent series capacitor on the PAC section of the Dixonville-Meridian-Klamath Falls-Captain Jack lines in southern Oregon within a reasonable time after receiving the notice. PAC shall be responsible for all costs associated with the upgrade. V. PAC and BPA agree that the proposed modifications to the Midpoint-Meridian Agreement described above are limited in scope to PAC's bidirectional scheduling rights over the Buckley-Summer Lake line under Section 4 of the Midpoint-Meridian Agreement and do not include BPA's bidirectional scheduling rights over the Summer-Lake Malin line under Section 4 of the Midpoint-Meridian Agreement. PAC and BPA do not intend to modify, change, alter, or terminate BPA's bidirectional scheduling rights over the Summer Lake-Malin line set forth in Section 4 of the Midpoint-Meridian Agreement or the General Transfer Agreement between PAC and BPA, originally executed May 4, 1982, as amended.
2.	***IPC & PAC & BPA*** ***New operational agreement between IPC, PAC & BPA*** ***Prepare First Draft – BPA: Quarter 3 of Calendar Year 2022*** ***Target Execution Date: Quarter 4 of Calendar Year 2022***	IPC, PAC and BPA agree to negotiate in good faith and draft a tri-party operational agreement that will: a. Consider Midpoint-Meridian Agreement Section 5(f); and b. Define the curtailment procedures between NW AC Intertie, Western Electricity Coordinating Council (WECC) Path 14 (Idaho to Northwest), and WECC Path 75 (Hemingway – Summer Lake); and c. Identify conditions for revising the tri-party operational agreement including, but not limited to: i. Engagement with NW AC Intertie partners;

		ii. In the event the B2H Project and the B2H Midline Series Capacitor Project are not complete and energized by 2027. The Parties will make best efforts to negotiate and target execution of the tri-party operational agreement within one year of the Effective Date of this Term Sheet, with an effective date for the tri-party operational agreement a reasonable time thereafter.
3.	***PAC & BPA*** ***Termination of Existing NITSAs:*** ***PAC Trans – BPA Merchant NITSAs (SA Nos. 746, 747)*** ***Incorporate into Agreement on Principles and Timelines under 3(a)(1)***	BPA Network Integration Transmission Service Agreements ("NITSAs") (PacifiCorp Service Agreement No. 746 and No. 747): BPA and PAC agree to terminate the aforementioned NITSAs upon (1) the completion of the asset purchase and sale between IPC and PAC as detailed in Section 3(a)(5) through Section 3(a)(7) of this table – the Goshen Area Asset Exchange, and (2) the commencement of network service as described in Section 3(b)(1).
4.	***IPC & BPA & PAC*** ***New Agreement:*** ***Longhorn Substation Agreements*** ***Prepare First Draft – BPA: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 3 of Calendar Year 2022***	IPC and PAC will fund a portion of the proposed Longhorn substation near Boardman, Oregon, if B2H interconnects at Longhorn. This funding will occur as specified in one or more negotiated Longhorn Substation Agreements between the Parties that is consistent with BPA's Line and Load Interconnection Business practices and allows for recovery of the network portion of these funds through incremental transmission wheeling revenue. The agreement will: a. include provisions for IPC and PAC to pay a use of facilities charge or other charge pursuant to BPA's OATT and applicable rate schedules to transact across the Longhorn bus in the future; b. include provisions for IPC and PAC to potentially own, operate and maintain B2H equipment, which shall include: the

		B2H series capacitor at Longhorn, the B2H shunt line reactors at Longhorn, any ancillary equipment required to support those devices, such as switches, bypass breakers (series cap), and insertion breakers (shunt reactor); and c. be contingent upon BPA completing its obligations and responsibilities under NEPA, NHPA, and other requisite environmental compliance laws and making a decision regarding how to proceed (including provisions for IPC and PAC funding upfront at a prorated amount based on cost allocation of Longhorn, BPA's NEPA, NHPA, and environmental compliance costs). Non-binding cost estimates identified for the potential Longhorn aspects of the B2H Project as of the Effective Date of this Term Sheet are as follows, which all Parties acknowledge and agree are preliminary and may be modified and revised prior to and upon B2H energization: *These are estimated costs, charges to be trued up with actual costs.* a. Longhorn (base substation) network costs ~$59M. Costs subject to transmission credit. i. IPC 21% ~ $12M (BPA to cover up to $14M of IPC cost) ii. PAC 55% ~ $33M iii. BPA 24% ~ $14M (plus IPC ~ $12M, for total ~ $26M) b. B2H connection to Longhorn Network Bay~$11M. Constructed/Owned/Maintained by BPA. Develop bay 3 with (2) 500kV circuit breakers & (5) 500kV disconnects. Costs subject to transmission credits. i. IPC & PAC 100% c. Customer built (not subject to transmission credits). Including civil work with the reactor and cap costs.

5.	***IPC & PAC*** ***New Agreement:*** ***Purchase and Sale Agreement for Asset Exchange -potentially utilize the previously developed Joint Purchase and Sale Agreement*** ***Prepare First Draft – IPC: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 4 of Calendar Year 2022***	PAC and IPC would purchase and sell to each other various assets to achieve the objectives identified in Section 3(a)(6) and Section 3(a)(7) of this table. PAC and IPC will seek to first balance the purchase and sale of the transferred assets through the depreciated net book value of such assets and allocation of upgrade costs and, finally, if necessary, will be balanced between IPC and PAC through cash considerations. <u>Details related to Populus – Four Corners assets</u>: These assets will provide IPC ownership on the existing PAC transmission system from Four Corners substation in New Mexico to Populus substation in Idaho. This will include 345 kV transmission lines between the following substations and assets to create a path through each substation: Four Corners, Pinto, Huntington, Camp Williams, Mona, Terminal, 90th South, Ben Lomond and Populus. Consistent with federal processes, IPC and PAC will complete required studies to determine if recent system upgrades result in a possible increase in existing transmission capacity between Borah and Populus to facilitate IPC's incremental transfer needs associated with this exchange. If determined necessary, IPC and PAC will identify revisions to the JOOA (as defined in Section 3(a)(6) of this table), upgrades, modifications, or other options to meet each party's commercial needs between Borah and Populus. <u>Details related to Borah/Kinport to Hemingway and Midpoint to Borah/Kinport assets</u>: These assets will provide PAC ownership on the existing IPC transmission system from Borah/Kinport to Hemingway and from Midpoint 500 to Borah/Kinport. This will include 500 kV and 345 kV transmission lines between the following substations and assets to create a path through each substation: Borah, Kinport, Adelaide, Midpoint and Hemingway. Upgrades are required across the Borah West and Midpoint West paths to facilitate this portion of the

		proposed asset exchange transaction. The cost of these upgrades will be determined in the course of negotiating the proposed asset exchange transaction described in this Section 3(a)(5). <u>Details related to Goshen Area assets</u>: As described in more detail in Section 3(a)(7) of this table, PAC will transfer to IPC certain to-be-determined Goshen areas transmission assets that would allow IPC to provide transmission service to all BPA customers in southeast Idaho currently served by PAC. These assets are being transferred to IPC, from PAC, as part of the negotiations between PAC and BPA as described in Section 3(a)(1) of this table, with the consideration for these assets being the transmission service provided by BPA to PAC as detailed in Section 3(a)(1) of this table. IPC and PAC intend for these Goshen assets to be incorporated into the broader purchase and sale agreement described in this Section 3(a)(5) with a goal of minimizing changes to each company's transmission rate base. This goal is intended to be facilitated through the allocation of the costs associated with the Borah West and Midpoint West upgrades.
6.	***IPC & PAC*** ***Amendment to Existing Agreement:*** ***IPC – PAC Joint Ownership and Operating Agreement ("JOOA")*** ***Prepare First Draft – IPC: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 4 of Calendar Year 2022***	As part of a transaction transferring assets described in Section 3(a)(5) of this table, IPC and PAC may expand their existing Joint Ownership and Operating Agreement, as amended and restated August 22, 2019 ("JOOA"), to include the following: I. PAC owning 300 MW of west-to-east transmission assets between Midpoint 500 and Borah (transferred from IPC); and II. PAC owning an additional 600 MW of east-to-west transmission assets between Borah and Hemingway (transferred from IPC) - total increases from the current 1,090 MW to 1,690 MW; and III. IPC owning 200 MW of bi-directional transmission assets between Populus, Mona and Four Corners (transferred from PAC); and IV. Other revisions as necessary to facilitate other asset exchanges (*e.g.*, for Goshen area, as

		described in Section 3(a)(5) and Section 3(a)(7) of this table).
7.	***IPC & PAC*** ***Goshen Area Asset Exchange*** ***Part of 3(a)(5)***	As referenced in Section 3(a)(5) and Section 3(a)(6) of this table, IPC and PAC would negotiate an asset exchange to be effective no later than (i) energization of the B2H line and (ii) commencement of the NITSA between BPA and IPC, as referenced in Section 3(b)(1), that enables BPA to to serve its loads currently in PAC's East transmission system (Lower Valley Elec., Idaho Falls, Fall River Rural Elec., Lost River Electric, Salmon River Electric, Soda Springs,) ("Southeast Idaho Load Service (SILS) Customers") with one leg of firm IPC network transmission service. As referenced in Section 3(a)(6) of this table, the Goshen area asset exchange may be wrapped into the existing JOOA framework. IPC, PAC, and BPA agree to make best efforts to plan for service to Idaho Falls that requires only one leg of network transmission from the BPA transmission system, provided such best efforts among the Parties must (1) respect and retain the existing services arranged for Idaho Falls load service between BPA and Utah Associated Municipal Power Systems (UAMPS); and (2) be in line with FERC orders in similar circumstances and accepted by FERC.
8.	***IPC & BPA*** ***New Agreement:*** ***Point to Point TSA*** ***Prepare First Draft – BPA: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 3 of Calendar Year 2022***	IPC will acquire up to 500 MW of PTP transmission service from Mid-C to Longhorn subject to the terms of BPA's OATT, business practices and applicable rate schedules. The duration of the new service must be for an initial service duration of at least 5 years, and sufficient to compensate BPA for BPA's revenue requirement associated with BPA capital investments to facilitate the transmission service, with the right to rollover service in accordance with the BPA's OATT and business practices in effect at the conclusion of the initial term.

9.	***IPC & PAC***	Upon energization of the B2H Project, PAC would not renew its current 510 MW of east-to-west rights on the IPC system (which rights are found in IPC 1st Revised Service Agreement (SA) Nos. SAs 344-346 and 383-384). Consistent with and pursuant to IPC's OATT, PAC and IPC will coordinate to extend any remaining IPC SAs, enter into new SAs, or take other action as necessary to bridge any SA expiration dates until such time as the B2H project is in-service.
10.	***IPC & PAC*** ***B2H Construction Funding Agreement-related Commitments***	The B2H Construction Funding Agreement, between IPC and PAC as referenced in Section 3(d) below, and any additional agreements as the Parties determine necessary, will include terms necessary to implement the Agreement to Reimburse BPA's Removal and Replacement Related Transaction Costs, among IPC, PAC and BPA, dated March 18, 2020 (BPA Contract No. 20TX-16835). IPC, on behalf of the B2H Project, will assure that it coordinates construction of the B2H Project with BPA in a manner consistent with the terms of BPA's Use Agreement, as amended by Amendment Two (2) to NF(R)-9617, including Exhibits A, B and C, between the United States of America, Dept. of the Navy and the United States of America, Bonneville Power Administration Ptn Secs 13, 23 and 24-T2N-R25E, W.M. IPC and PAC acknowledge that the Removal and Replacement Related Transactions described in Contract No. 20TX-16835 are contingent upon (1) BPA obtaining acceptable service from Umatilla Electric so that BPA may continue to serve Columbia Basin Electric's load; (2) BPA completing its obligations and responsibilities under NEPA, NHPA, or other requisite environmental compliance laws and making a decision regarding how to proceed; and (3) IPC and PAC moving forward with construction of the B2H Project.
11.	***IPC & PAC & BPA***	In conjunction with the termination of the NITSAs identified in Section 3(a)(3) of this table (*i.e.*, PAC

	BPA Redirect and Assignment of existing PTP transmission service ***Incorporate into Agreement on Principles and Timelines under 3(a)(1)***	SAs 746 & 747), following the energization of B2H, BPA will redirect its two 100 MW PTP transmission service agreements (91629850 and 91629500, or any applicable AREFs that supersede or replace them) that it takes from IPC (*i.e.*, IPC 1st Revised SAs 324 & 342) such that the new POR of each SA will be Walla Walla and the new POD for each SA will be Borah. Consistent with and pursuant to IPC OATT, following approval of such redirects by IPC as described above, BPA will assign those redirected reservations to PAC. This redirect and assignment will be delayed by BPA if B2H energization is delayed past 07/01/2026. PAC shall be responsible to pay for all costs associated with 91629850 and 91629500, or any applicable AREFs that supersede or replace them, upon approval of such redirect by IPC and assignment by BPA.
12.	***IPC & PAC & BPA, with respect to B2H Plus Facilities Expectations*** ***IPC & PAC, with respect to B2H Construction Funding Agreement***	The B2H Project will include the installation of the B2H Midline Series Capacitor Project and development of a remedial action scheme ("RAS"). When considering BPA's study methodology, the B2H midline series capacitor reduces simultaneous interactions between the NW AC Intertie, central and southern Oregon load service, and WECC Path 14 (Idaho to Northwest). The Parties agree to funding of the B2H Midline Series Capacitor Project as follows: a. IPC: funding 45% of the cost. b. PAC: funding 55% of the cost c. BPA: funding 0% of the cost The Parties will work in good faith to have the B2H Midline Series Capacitor Project in-service when the B2H Project is energized and to document expectations of operation, maintenance, and future reinforcements and upgrades.
13.	***IPC & PAC*** ***B2H Grant or Additional Funding***	Under IPC and PAC's existing OATT rate procedures, IPC and PAC will include any United States Department of Energy ("DOE") grant or additional funding received for the B2H project in the appropriate FERC account provided such account is allocated 100% to Transmission. Nothing in this Term Sheet limits or waives any party's right to participate, review, comment, or challenge the other

		party's rate case or formula rate inputs through their respective update processes.
14.	***IPC & PAC & BPA*** ***Permit Funding Agreement Amendment***	Upon transfer of BPA's Permitting Interest to IPC identified in 3(b)(3) below, the Permit Funding Agreement will be amended to recognize the re-allocation of the Parties' Permiting Interests and related funding obligations.

b) <u>NITSA Terms and Conditions, NITSA Security Agreement, NITSA Backstop</u>

1.	***IPC & BPA*** ***New Agreements:*** ***Network Integration Transmission Service Agreement to serve BPA customers at Goshen*** ***Network Integration Transmission Service Agreement to service BPA's customer at Burley*** ***Amendment to currently effective Network Integration Transmission Service Agreements*** ***Prepare First Draft – IPC: Quarter 2 of Calendar Year 2022***	IPC and BPA will enter into two NITSAs for IPC to provide firm network transmission service to BPA. One NITSA will serve BPA customers at Goshen (replacing what is, as of the Effective Date of this Term Sheet, provided under PAC Service Agreement 746) and one NITSA will serve Idaho Falls (replacing what is, as of the Effective Date of this Term Sheet, provided under PAC Service Agreement 747) ("New NITSAs"). The New NITSAs will be in addition to the existing NITSAs BPA currently holds with IPC for service to BPA's customers located on IPC's system ("Existing NITSAs"). The term of BPA's New NITSAs will be 20-years from energization of the B2H Project, with a renewal or rollover option at BPA's discretion as required and permitted by FERC a. The NITSA Security Agreement (as referenced in Section 3(b)(2) of this table), and any related other agreements necessary, between BPA and IPC will be updated once the energization of B2H has occurred to document the term and the repayment periods with the actual energization date. b. The New NITSAs, NITSA Security Agreement, and any related other agreements necessary, are conditioned on the Goshen Area Asset Exchange set forth in Section 3(a)(7) being completed and all associated agreements being in effect by the energization of the B2H line.

	Target Execution Date: Quarter 3 of Calendar Year 2022	The New NITSAs and the Existing NITSAs will be updated to include three Points of Receipt (PORs) over which BPA can deliver energy to its customers located on IPC's system. The three PORs are as follows: AMPS POR, LaGrande POR, and Longhorn POR. The New NITSAs shall reflect the following provisions: a. Under the New NITSAs, IPC will plan for and reserve transmission capacity for the continued network service to BPA's SILS Customers' loads and ensure that it can reliably serve the load for the term of the contract prior to BPA assigning the PTP service agreements to PAC pursuant to Section 3(a)(11) above. b. The New NITSAs between BPA and IPC will permit BPA to assign service to specific Points of Delivery (PODs) to BPA's wholesale customers who take service at those PODs. Such assigned PODs will be served by a separate NITSA agreement between BPA's wholesale customer and IPC. The New NITSA between BPA and IPC will state that the customer requesting a separate NITSA for its POD must meet credit rating standards consistent with IPC's OATT. Notwithstanding assignment of the NITS service, BPA would remain entitled to all outstanding credits associated with the Funded Amounts (as defined in Section 3(b)(2) below) as long as BPA continues to be a NITS customer. c. IPC will maintain the current practice of letting BPA choose through the annual delivery allocation process the PODs where BPA will deliver power to serve its loads. The current PODs include LaGrande and AMPS. Once B2H is in service, the PODs will include LaGrande, Longhorn, and AMPS. d. BPA would pay the NT rate as established by IPC's OATT transmission formula rate. There shall be no adders or segmentation

		like actions which result in a rate above the NT rate and the amount BPA pays to IPC under the NT service agreement will be reduced as discussed in the NITSA Security Agreement. e. IPC will not charge BPA IPC's system losses for energy from BPA's Palisades resource used to serve load behind Goshen.
2.	***IPC & BPA*** ***New Agreement:*** ***NITSA Security and Risk Backstop Agreement*** ***Prepare First Draft – IPC: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 3 of Calendar Year 2022***	IPC and BPA will enter into an NITSA security and risk backstop agreement ("NITSA Security Agreement"), concurrently with the New NITSA and the purchase and sale agreement referenced in Section 3(b)(3) of this table. <u>Reimbursement If IPC Receives all Permits and Certificates of Public Convenience and Necessity (CPCN) for Construction of B2H</u> IPC will reimburse BPA for the transfer of BPA's Permitting Interest under the Joint Permitting Agreement in an amount consisting of BPA's investment in B2H prior to the transfer date (~$25m). BPA will also pay to IPC an additional $10 million upon execution of the New NITSAs and the NITSA Security Agreement with the intent of offsetting overall B2H project costs in IPC's rate base. The additional $10 million plus BPA's investment in B2H will be collectively referred to as the "Funded Amount." IPC will retain the Funded Amount as follows: If and when IPC obtains all necessary CPCNs and permits for the B2H Project (and all appeals, if any, have been resolved), IPC shall have until January 1, 2026 ("Commencement Date") to commence construction of B2H or to inform BPA of its intent to not pursue construction of B2H. (1) If IPC commences construction of B2H by or before the Commencement Date, then: a. Interest on the Funded Amount (~$35m) payable by IPC to BPA will accrue from the date of energization of B2H at the rate

		established in the applicable IPC tariff for customer funded projects; b. The Funded Amount and all accrued interest will be repaid to BPA starting year 11 following the energization date (the "Refund Commencement Date"), with repayment amortized over the remaining 10 years of the New NITSAs. i. IPC and BPA will incorporate the interest schedule and payment amortization as an exhibit to the NITSA Security Agreement; ii. If during the term of the New NITSAs BPA defaults on its payment obligations under the New NITSAs, IPC will be entitled to retain for its own account an amount equal to the defaulted payment obligation not to exceed the amount not reimbursed to BPA as of the default date; iii. BPA will not be considered in default for any amount not paid subject to a billing dispute; and iv. IPC may prepay the Funded Amount and interest thereon at any time without penalty. (2) If IPC does not commence construction of B2H by or before the Commencement Date or if IPC informs BPA before the Commencement Date of its intent to not proceed with B2H, then: a. IPC shall have 180 days from the Commencement Date (or notice to BPA of its intent to not proceed, whichever is earlier) to sell its Permitting Interests in the B2H Project; b. No later than the close of the above mentioned 180 days, IPC shall i. pay to BPA BPA's proportional share of any proceeds received from the sale of its Permitting Interest in the B2H Project (if any), and

		ii. Pay to BPA the $10 million BPA provided to IPC upon execution of the New NITSAs. <u>Risk Backstop if IPC does not Receive all Permits or CPCNs Necessary for constructing B2H.</u> If IPC does not obtain all necessary CPCNs and permits for the B2H Project, or any such CPCNs or permits are overturned on appeal, then (a) IPC will return to BPA the $10 million BPA provided to IPC upon execution of the New NITSAs; and (b) BPA will reimburse IPC for funding the additional 24.24% share of all B2H Permitting and Preconstruction Costs incurred after BPA transfers its 24.24% Permitting Interest to IPC. The reimbursement obligation will not include any costs related to Right of Way option acquisition or exercising Right of Way Options. The risk backstop commitment will remain in place until IPC obtains all necessary CPCNs and permits for the Project (and all appeals, if any, have been resolved). The intent of the backstop is only to assist IPC in mitigating the risk associated with receiving the approvals for the B2H Project; not to assist in mitigating business risk. The risk backstop commitment will be as follows: a. IPC will not compensate or reimburse BPA for costs expended by BPA on B2H prior to the transfer of the Permitting Interest to IPC (*i.e.*, ~$25m BPA has expended to date); b. BPA will reimburse 24.24% of actual B2H Project Permitting Costs incurred after IPC takes over funding 45% of the project. (Current estimates for 2021-2024 – Total B2H Project estimated at $9,125,466 with 24.24% of these costs estimated at $2,212,234); and c. BPA will reimburse 24.24% of actual B2H Project Pre-Construction Costs incurred after IPC assumes funding 45% of the project. (Current estimates for

		2021-2024 – Total B2H Project estimated at $9,403,564 with 24.24% of these costs estimated at $2,279,652). Collectively, these amounts set forth in a. through c. above will be the "Risk Backstop Amount." The Risk Backstop Amount will be adjusted, as necessary, to the extent that IPC receives grants or forms of other financial assistance from sources other than BPA or PAC. For example, if IPC received a government grant that defrayed the pre-construction costs of B2H, BPA's 24.24 % share of the pre-construction costs would be reduced accordingly.
3.	***Transfer of Interest in Joint Permitting Agreement:*** ***Prepare First Draft – IPC: Quarter 2 of Calendar Year 2022*** ***Target Execution Date: Quarter 3 of Calendar Year 2022***	IPC and BPA will execute a purchase and sale agreement, assignment, and other applicable transfer documents, concurrently with the New NITSAs, NITSA Security Agreement, and any related other agreements necessary, to transfer all of BPA's Permitting Interest under the Joint Permitting Agreement (and all of BPA's interest in the assets associated therewith) to IPC in exchange for IPC's agreement for repayment to BPA of BPA's investment in B2H through the Joint Permitting Agreement through the effective date of the definitive purchase and sale agreement contemplated in this Section 3(b) (or other date specified therein). The proposed purchase and sale agreement contemplated in this Section 3(b)(3) will contain representations, warranties, and covenants typical of a transaction of the nature contemplated by these proposed terms. The definitive agreements transferring BPA's Permitting Interest under the Joint Permitting Agreement and related assets will be executed prior to any activities BPA has indicated could impact federal environmental regulatory requirements under NEPA, so as to prevent additional delay in the development of B2H. Following the transfer of BPA's Permitting Interest (and associated assets) under the Joint Permitting Agreement to IPC, IPC will be solely responsible for funding an additional 24.24% share of all B2H Project Costs thereafter under Joint Permitting Agreement

		(which includes permitting and preconstruction costs), and IPC will be entitled to all rights, title, and interests and assets that BPA would otherwise obtain under the Joint Permitting Agreement if it were a remaining funding party thereto.

c) Ownership, Operation, and Maintenance Agreement: Defines IPC's and PAC's capacity and property ownership, and their roles and responsibilities for operating and maintaining the B2H Project ("***Ownership and Operation Agreement***"). IPC will prepare an initial draft of the Ownership and Operation Agreement based on the ownership interests below and otherwise consistent with the terms of the JOOA between IPC and PAC. Alternatively, in lieu of a new agreement, IPC and PAC may decide to amend the existing JOOA to cover the B2H Project assets.

Idaho Power	**PacifiCorp**	**BPA**
Project ownership: 45.45%	Project ownership: 54.55%	Project ownership: 0%

d) Construction Funding Agreement: Defines IPC's and PAC's roles and responsibilities in construction of the B2H Project ("***Construction Funding Agreement***"). IPC will prepare an initial draft of the Construction Funding Agreement consistent with the following terms:

1. Project In-Service Date	June 1, 2026
2. Scope	The Construction Funding Agreement covers all work necessary to construct the B2H Project by the Project In-Service Date, including any associated residual work after the Project In-Service Date, but excluding any work already covered by the Joint Permitting Agreement.
3. Project Delivery System	A competitive process is being completed to hire a Construction Manager / Constructability Consultant ("CM") for the B2H Project in 2022 to: (1) provide constructability feedback to the design engineer; and (2) collaborate with PAC and IPC to complete the BLM Construction Plan of Development and the Oregon Energy Facility Siting Council's Site Certificate amendments. The hiring process of the CM will be structured such that the CM may be retained to construct the B2H Project.

	IPC and PAC may mutually agree to modify the CM's role through the Construction Funding Committee (as defined in Section 10 below -***Project Funding and Committee***) without amending the Construction Funding Agreement.
4. Project Manager	IPC is the overall Project Manager for all B2H Project permitting, design, procurement, construction, except that BPA will be responsible for designing, procuring, and constructing the Longhorn substation as described in Section 3(a)(4) and relocating and replacing the BPA 69 kV line off Navy property as described in Section 3(a)(10). Although IPC is the Project Manager, PAC is not precluded from taking project management responsibilities for all or selected tasks associated with the B2H Project; provided that these delegations must be made by the Construction Funding Committee.
5. Construction Project Manager	IPC's role as Construction Project Manager will be generally consistent with the roles and responsibilities of the Permitting Project Manager set forth in Article IV of the Joint Permitting Agreement, provided that the permitting responsibilities not relevant to construction will be removed. IPC, as the Construction Project Manager, will provide monthly project updates, including updates on project activities, financials, forecasts, and invoices detailing costs incurred with breakdowns demonstrating all Parties' cost responsibilities based on their percentage shares. To provide the necessary flexibility to avoid delay/additional costs, the Construction Project Manager will administer and oversee all work necessary to construct the B2H Project within the approved budget, schedule and scope, and also have authority to approve any non-material changes to the B2H Project resulting in a price difference of less than $500k, so long as the overall B2H Project costs remain within the approved budget with the price change. All changes to the B2H Project resulting in a change in the approved budget, will require approval of the Construction Funding Committee.

6. Component Specifications	All B2H Project construction specifications shall meet or exceed all applicable state and federal design requirements and standards; provided that, such specifications may be modified by the Construction Funding Committee so long as the project complies with all applicable state and federal design requirements and standards.
7. Real Property Ownership	B2H real property, except Longhorn substation: IPC will acquire rights of way, grants, easements, or other interests in real property necessary to construct, operate and maintain the B2H transmission line and grant to PAC perpetual and sufficient rights of access, to be set forth in the Ownership and Operation Agreement. Longhorn Substation: Upon completion of BPA's obligations and responsibilities under NEPA, NHPA, and other requisite environmental compliance laws and if BPA decides to proceed with construction of Longhorn substation, BPA will continue to own all real property associated with the Longhorn substation, and in relation to the B2H Project equipment BPA shall grant to IPC and PAC perpetual and sufficient rights of access, to be set forth in one or more Longhorn Substation Agreements as described in Section 3(a)(4).
8. Equipment and Facilities Ownership	Equipment and facilities ownership will be consistent with the Ownership and Operation Agreement. B2H equipment/facilities, except Longhorn substation: IPC and PAC will jointly own as tenants in common the transmission line and all associated facilities and equipment, including all associated facilities located in Hemingway Substation as well as supporting communication facilities and B2H Project substation equipment. Longhorn Substation: Upon completion of BPA's obligations and responsibilities under NEPA, NHPA, and other requisite environmental compliance laws and if BPA decides to proceed with construction of Longhorn substation, BPA will own all equipment and facilities in the Longhorn substation, except the B2H specific equipment and facilities which will be jointly owned by IPC and PAC as tenants in common. BPA will grant IPC and PAC access rights to the equipment

	and facilities in Longhorn substation that are constructed as part of and necessary to the operation of the B2H transmission line facilities, to be set forth in one or more Longhorn Substation Agreements as described in Section 3(a)(4).
9. Material Procurement	All material specifications shall be in accordance with IPC's procurement policies and standards, unless otherwise agreed by the Construction Funding Committee to exceed the same.
10. Project Funding and Committee	<u>Funding</u>: IPC and PAC will fund the B2H Project consistent with their respective ownership shares. <u>Construction Funding Committee</u>: The Construction Funding Agreement shall create a Construction Funding Committee consistent with IPC and PAC's ownership interests in the B2H Project, and generally consistent with the Permit Funding Committee created by the Joint Permitting Agreement (Article III). The Project Manager's reporting requirements set forth in the above Section 5 (***Construction Project Manager)*** will be delivered to all members of the Construction Funding Committee prior to, and discussed during, each of the Committee's regularly-scheduled monthly meetings. Obligations, disputed amounts, and audit rights will be generally consistent with Article III of the Joint Permitting Agreement. The Project Manager will have flexibility to make day-to-day decisions associated with construction of the Project but will be required to seek resolution/approval from the Construction Funding Committee on larger dollar/impact decisions, consistent with that set forth in the above Section 5 (***Construction Project Manager***). BPA will be responsible for designing, procuring, and constructing the Longhorn substation as described in Section 3(a)(4) and relocating and replacing the BPA 69 kV line off Navy property, as described in Section 3(a)(10).
11. Payment Schedule	<u>Costs Accrued Prior to Agreement Execution</u>: Prior to executing the Construction Funding Agreement, IPC

	and PAC will have the opportunity to audit all accrued construction-related expenses included therein that have not otherwise been funded under the Joint Permitting Agreement. IPC and PAC will align on ownership shares prior to execution of the Construction Funding Agreement and pay their respective portions of accrued expenses within 30 days of the effective date of the Construction Funding Agreement. Until which time BPA fully divests its ownership interest in the B2H Project, the Parties acknowledge that the B2H Project is bound to compliance with NEPA, NHPA, and other environmental laws associated with federal agency action. Costs Incurred After Execution: Following execution of the Construction Funding Agreement, the Project Manager will invoice the Construction Funding Agreement participants monthly, requiring payment within 30 days of the invoice date.
12. Transfer/Assignment of Rights/Interests *(Some or all of these terms may be instead placed in the Ownership Agreement)*	IPC and PAC may sell some or all of their respective ownership interests in the B2H Project, together with associated capacity, subject to the Construction Funding Committee's agreement and approval of the terms of any such transaction; provided that, such approval will not be unreasonably withheld. IPC will not transfer or assign rights or interests in the B2H Project that would materially impact the BPA load service commitments set forth in Section 3(b) of this Term Sheet.
13. Term ***Early Termination*** ***Withdrawal***	Term: The term of the Construction Funding Agreement will extend through completion of B2H Project construction, as well as final billing and any reconciliation or mitigation associated with the final expenses, unless otherwise agreed by the Construction Funding Committee. Early Termination/Withdrawal: Absent approval of the Construction Funding Committee, no Party shall have a right to withdraw from the Construction Funding Agreement following the earlier of (1) awarding the B2H Project construction contract, or (2) commencing procurement of long-lead items and equipment.

	Assignments of IPC's or PAC's rights and obligations under the Construction Funding Agreement shall be managed pursuant to the above Section 12 (***Transfer/Assignment of Rights/Interests***).
14. Event of Default	Generally consistent with Article VIII of the Joint Permitting Agreement.
15. Force Majeure	Generally consistent with Article IX of the Joint Permitting Agreement.
16. Reps and Warranties	Generally consistent with Article X of the Joint Permitting Agreement.
17. Common Defense & Limitation of Liability	Generally consistent with Article XI of the Joint Permitting Agreement, except that the Article will be expanded to address construction claims.
18. Proprietary Information/Confidentiality	Generally consistent with Article XII of the Joint Permitting Agreement, except that the Article will provide IPC the ability to share information as necessary to work with potential and selected engineers and contractors.
19. Dispute Resolution	Generally consistent with Article XIII of the Joint Permitting Agreement.
20. Miscellaneous	Generally consistent with Article XIV of the Joint Permitting Agreement and including any standard terms that are necessary for PAC agreements (e.g. assignment and jury trial waiver provisions).

4. Additional Agreements. The Parties agree that they may consolidate any or all of the above-described Agreements and are not precluded from pursuing additional agreements, or amending existing agreements as needed, related to the B2H Project besides those discussed herein.

5. Expenses. Each Party will bear its own expenses (including attorneys' fees) incurred in connection with preparation, negotiation, and execution of this Term Sheet, including preparation, negotiation and execution of the Agreements described herein.

ACKNOWLEDGED AND AGREED TO BY THE PARTIES:

IDAHO POWER COMPANY

Signature: Ryan N. Adelman

Printed Name: RYAN N ADELMAN

Title: VP, POWER SUPPLY

Date: 1/18/22

PACIFICORP

Signature: Rick Link Digitally signed by Rick Link Date: 2022.01.18 11:11:21 -08'00'

Printed Name: Rick Link

Title: Senior Vice President, Resource Planning, Procurement and Optimization

Date: 01/18/2022

Signature: Rick Vail Digitally signed by Rick Vail Date: 2022.01.18 11:59:50 -08'00'

Printed Name: Rick Vail

Title: Vice President, Transmission

Date: 01/18/2022

BONNEVILLE POWER ADMINISTRATION

Signature: TINA KO Digitally signed by TINA KO Date: 2022.01.18 04:25:04 -08'00'

Printed Name: Tina Ko

Title: Vice President, Transmission Marketing a

Date: 1/18/2022

Signature: Digitally signed by KIM THOMPSON Date: 2022.01.18 07:32:28 -08'00'

Printed Name: Kim Thompson

Title: Vice President, Requirements Marl

Date: 1/18/2022

Certificate of Public Convenience and Necessity
Idaho Power Company's Standard Data Requests
Data Request Nos. 1-21

IDAHO POWER COMPANY'S STANDARD DATA REQUEST NO. 5:

Please provide all available regional transmission planning studies or analysis that supports the need for the proposed transmission line. In your response, please identify any necessary reliability or resiliency enhancements as it pertains to the proposed line.

RESPONSE TO IDAHO POWER COMPANY'S STANDARD DATA REQUEST NO. 5:

The B2H project has been identified as a regionally significant project, producing a more efficient or cost-effective plan in the Northern Tier Transmission Group's ("NTTG") 2007, 2009, 2011, 2013, 2015, 2017 and 2019 biennial regional transmission plans, and in the NorthernGrid, NTTG's successor regional planning organization, 2021 biennial regional transmission plan. Please see Attachments 1 through 8 for each of the regional transmission plans.

The B2H line will expand the bi-directional transfer capability of the Idaho to Northwest transmission path. NTTG and NorthernGrid planning studies identified the B2H project as providing reliability enhancements by eliminating predicted post-contingency thermal overload violations for transfers between the Northwest and Idaho Power during heavy flow hours. The line also was identified as providing a transmission service obligation benefit by providing available transmission capacity for Idaho Power customers and Bonneville Power Administration ("BPA") Southeast Idaho Customer needs.

NORTHERN TIER TRANSMISSION GROUP

Annual Planning Report – 2007

April 2, 2008

Preface

This report was prepared by Comprehensive Power Solutions, LLP, as part of its facilitation and coordination work for the Northern Tier Transmission Group. The members and other stakeholders participating in the effort to provide coordinated, efficient and effective planning for expansion of transmission within the Northern Tier footprint have been helpful in developing the content of this report.

While the report is made available to the public, neither Northern Tier or CPS accepts any duty of care to third parties who may wish to make use of or rely upon information presented in this report. CPS has exercised due and customary care in developing this report, but has not independently verified information provided by others and makes no further express or implied warranty regarding the report's preparation or content. Consequently, CPS and Northern Tier shall assume no liability for any loss due to errors, omissions or misrepresentations made by others.

This report may not be modified to change its content, character or conclusions without the express written permission of CPS and Northern Tier.

To ensure efficient, effective, coordinated use and expansion of the members' transmission systems in the Western Interconnection to best meet the needs of customers & stakeholders.

Figure 1: Map of Northern Tier Member Transmission Lines

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Figures

Tables

Summary

The Northern Tier Transmission Group was formed in the autumn of 2006 to establish a sub-regional planning process that would meet the needs of its members by coordinating the operation and expansion of transmission to serve customers and wholesale power markets. Northern Tier is also intended to meet the mandate set forth in the Federal Energy Regulatory Commission's Order No. 890, to provide greater transparency to regional transmission planning.

Northern Tier is a combined effort of transmission providers, state regulatory agencies, and other stakeholders.

This document is a first annual report on the organization, structure, activities, accomplishments and future plans for coordination and planning of transmission within the geographic footprint defined by the members' systems.

Following an overview of Northern Tier, this report describes the development and execution of a Fast Track Project Process to expedite needed transmission additions without waiting for design and development of a more permanent Biennial Planning Process.

A primary intent in forming the Northern Tier Transmission Group was to implement needed transmission projects and initiatives quickly, without being held back by the time-consuming and delaying processes that plagued development of RTO West and GridWest. The objective was to develop required organizational structures as needed, but in parallel with production of work products.

The Fast Track Project Process was used in 2007 to identify projects needed for reliability and to meet Transmission Service Requests. The Fast Track Process, open to stakeholder input and participation, was pursued at the same time that a more formalized Northern Tier Transmission Group Sub-Regional Planning process was designed to dovetail with the Western Energy Coordinating Council's Regional Planning Process. Other transmission providers, which would join the Northern Tier Transmission Group over time, were developing their own projects that, with their membership, would be included in the Northern Tier portfolio.

Development of these synchronous planning processes, designed to meet requirements of the Federal Energy Regulatory Commission's Order 890, are now complete but would have delayed needed transmission planning. 2007 saw the development of individual transmission providers' Order 890, Attachment K, filings, which defined their individual processes, and the development of Northern Tier's Biennial Planning Process.

The Northern Tier Projects are comprised primarily of 500 kV lines designed to connect the energy resource-rich regions of the Inland Northwest with the customer loads of the Pacific Northwest and Southwest, and the growing demands of Intermountain population centers.

Background

Between 2001 and 2006, a series of transmission planning processes took place in the Western Interconnection. Among these were the SSG-WI (Seams Steering Group – Western Interconnection) framework, and the RMATS (Rocky Mountain Area Transmission Study), which led to creation of the Rocky Mountain Sub-regional Planning Group. The Western Governors Association, in addition to the RMATS initiative, promoted the CDEAC (Clean and Diversified Energy Advisory Committee) and the WGA Study (Conceptual Plans for Electricity Transmission in the West).

Table 1: Existing and Prior Regional Transmission Studies

WGA: Conceptual Plans for Electricity Transmission in the West
SSG-WI: Seams Steering Group – Western Interconnection
NTAC: Canada-NW-California Transmission Study
Colorado Long-Range Transmission Planning Study
Nevada State Office of Energy – T4 Wind Project
RMATS: Rocky Mountain Area Transmission Study
Montana-Northwest Transmission Equal Angle Report
West of Hatwai System Upgrade Projects
Canada-to-Northwest Intertie Expansion
WECC Coordinated Phase Shifter Operation
Western Interconnection 2006 Path Utilization Study (Dept. of Energy)
CDEAC: Clean and Diversified Energy Advisory Committee Initiative

A Northern Tier Transmission initiative was announced on October 11, 2006, and its initial meeting was held November 8, 2006. Northern Tier was initiated by members of the Grid West regional transmission organization that remained following a number of departures in 2006, in order to carry on several beneficial initiatives that were underway, including coordinated sub-regional planning, common assured transfer capability methods and coordination, and a diversity interchange for area control errors. Its participants were involved in the RMATS project, which identified several needed expansion projects that now form the core of the Northern Tier Transmission Projects, as well as the ACE Diversity Interchange initiative.

The Northern Tier initiative led to formal creation of the Northern Tier Transmission Group as a sub-regional planning group and a part of the Western Energy Coordinating Council's Transmission Expansion Planning Policy Committee efforts.

The Transmission Expansion Planning Policy Committee was, like the Northern Tier Transmission Group, formed in response to the direction the federal government was taking in the FERC's Order 890 promulgating regional and sub-regional transmission planning. The objectives of Order 890 were to promote coordination, openness, transparency, information exchange, interconnection-wide participation, and dispute resolution.

In early 2007, the Northern Tier transmission providers undertook two parallel planning initiatives: Task I, to identify Fast Track projects, and a concurrent Task 2, to develop a biennial planning process in conjunction with the regional planning process being established by the Transmission Expansion Planning Policy Committee and the planning processes being set up by the other sub-regional groups within the Western Interconnection.

In 2007, Northern Tier completed the Task 1 Fast Track Project Identification and, for Task 2, completed the Biennial Planning Process Charter and Planning Agreement, and established the organizational structure to carry out the task. Execution of the Biennial Planning Process began in January of 2008 and is expected to produce the first Northern Tier Transmission Group Biennial Planning Report in the fall of 2009. This report describes the Task 1 Fast Track Project Process and its results, as well as the integration of transmission initiatives already in development by providers joining the Northern Tier Transmission Group.

The Northern Tier Transmission Group

NTTG focuses its efforts on the evaluation of transmission projects that move power across the sub-regional bulk transmission system servicing load in its footprint. The transmission providers belonging to Northern Tier serve nearly 2.7 million retail customers with over 27,500 miles of high voltage transmission lines. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, and parts of Washington and California.

NTTG is committed to coordinating sub-regional planning efforts with adjacent sub-regional groups and other planning entities. It is expected that the Western Electricity Coordinating Council will continue to be responsible for coordinating and promoting electric system reliability across the Western Interconnection through its role in regional reliability planning and facility rating, and by providing economic planning services to its members through its Transmission Expansion Planning Policy Committee.

NTTG performs both reliability and economic planning coordination, and has started by identifying projects that have been previously studied and which spurred interest from members within the NTTG service area. NTTG works with the WECC Planning Coordination Committee for reliability planning, the WECC TEPPC for economic planning, and is working to implement a framework for cooperation with neighboring sub-regional planning entities.

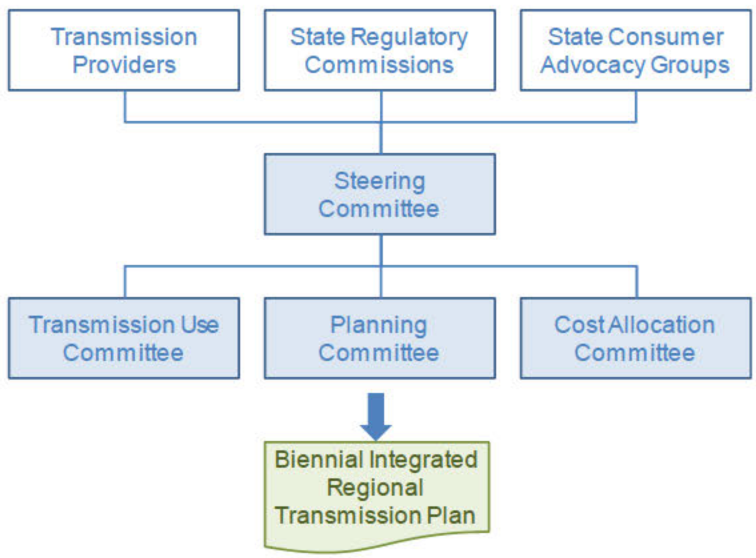


Figure 2: Structure of the Northern Tier Transmission Group

Stakeholder participation is important to the processes of the Northern Tier Transmission Group and all interested parties are encouraged to attend and contribute to the many stakeholder meetings conducted by the transmission use, planning and cost allocation committees, and in preparing, developing and analyzing planning studies. A chronology of 2007 activities is provided in Table 2, below.

NTTG – Chronology of 2007 Activities

Table 2: Chronology of NTTG Activities in 2007

Jan	9	Transmission Use Committee meeting
	30	Area Control Error Diversity Interchange presentation
	31	Public stakeholder meeting
Feb	16	FERC issues Order 890. Among other things, it requires a 'straw man' proposal outlining a process for complying with the planning principals adopted in the Final Rule.
Mar	13	Transmission Use Committee meeting
	14	Public stakeholder meeting to initiate development of the Straw Proposal.
	15	Order 890 Final Rule posted in the Federal Registry.
	23	Initial conference call to begin coordinating sub-regional planning with other groups in the Western Interconnection, discuss order 890 compliance.
Apr	4	Northern Tier co-chair discussed the group's efforts to comply with Order 890 with the Committee on Regional Electric Power Cooperation (CREPC).
	6	Public meeting with the Northwest Transmission Advisory Committee and Columbia Grid to discuss Order 890 compliance requirements and approaches to integration and cooperation.
	10	Northern Tier participated with the Western Electricity Coordinating Council in a public meeting to discuss planning roles and relationships among regional, sub-regional and transmission provider planning groups.
	14	Planning & Stakeholder meeting
	16-May 7	Open comment period for the Northern Tier Straw Proposal
May	23-24	Northern Tier public stakeholder meeting for final walkthrough and review of the Northern Tier Straw Proposal.
	29	Northern Tier Straw Proposal posted on the Northern Tier Web site and on the transmission providing members' OASIS sites.
Jun	13	Northern Tier presentation at FERC Technical Conference, Park City, Utah
Jul	9	Public stakeholder meeting – Planning
	10	Transmission Use Committee meeting
Aug	20	Public stakeholder meeting – Planning
Oct	22	Public stakeholder meeting – Planning
Nov	7	Public stakeholder meeting
	13	Public stakeholder meeting – Planning
	16	Cost Allocation meeting
Dec	17	Joint Cost Allocation & Planning meeting

Transmission Queue – NTTG Companies

The Northern Tier Transmission Group's member transmission providers elicit requests for transmission service from generation builders, electricity users and others in the first quarter of each year in accordance with their Open Access Transmission Tariffs. Figure 3, below, shows the amounts of capacity requested in the 2007 solicitation, along hypothetical paths between different regions within the Northern Tier footprint.

Most of these requests are for service beyond current and forecasted Assured Transfer Capability, given the existing transmission system and planned loads and resources.

To meet these needs in a timely fashion, a "Fast-Track" planning process was established and a set of transmission additions were identified.

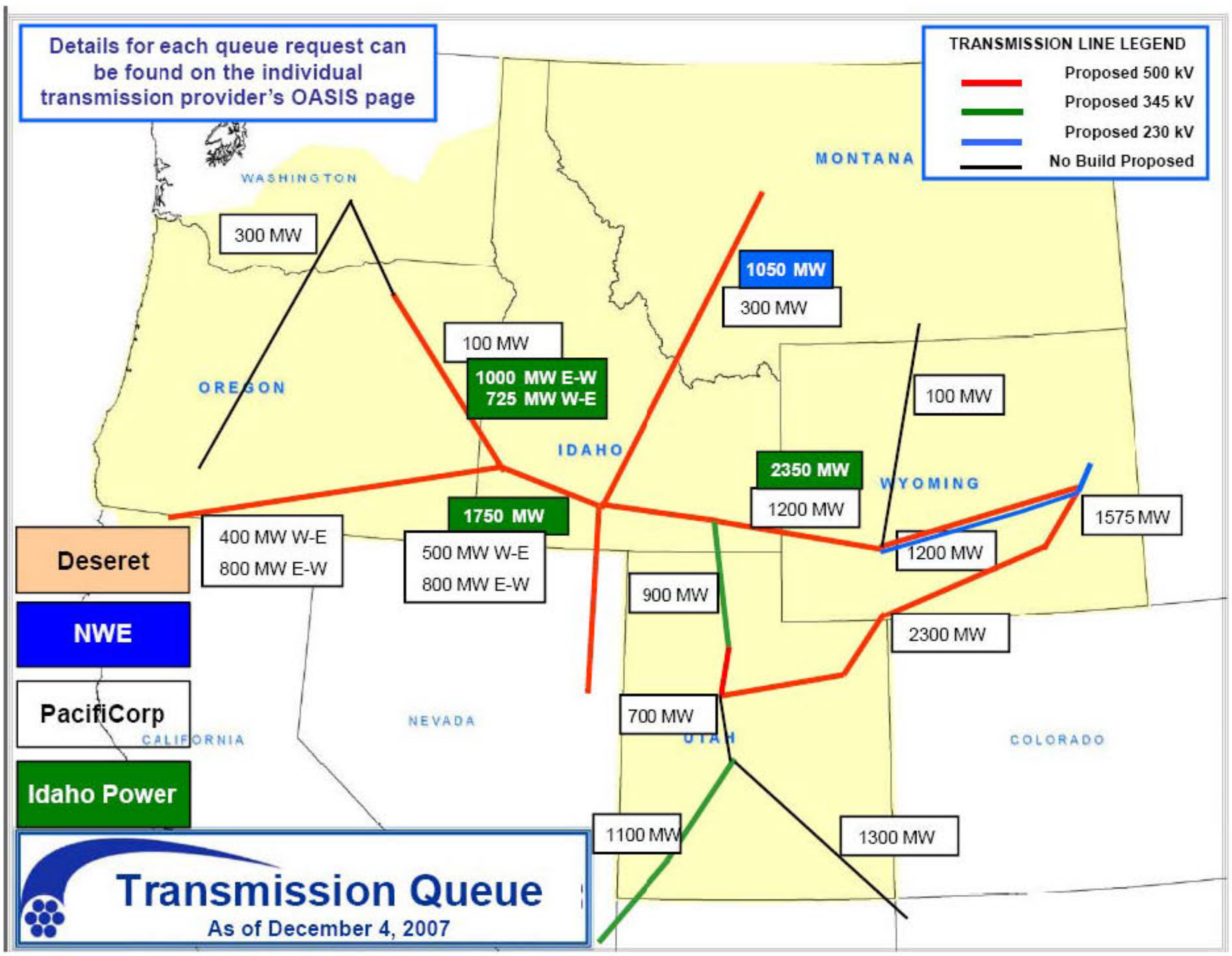


Figure 3: Northern Tier 2007 Transmission Request Queue

The Northern Tier Fast-Track Planning Process

Here are the steps followed in the fast-track planning process:

1) Review, with stakeholders, past transmission provider studies and additional data to identify congested transmission that impedes efficient and reliable operation of the grid
2) Collect and review information available from the Western Electricity Coordinating Council and others regarding future projects that affect the Northern Tier footprint
3) Review the RMATS and SSG-WI congestion studies, and historical Available Transmission Capacity and utilization data from the Northern Tier Transmission Use Committee
4) Acquire, review and align loads and resources and Integrated Resource Plan data for member transmission providers, augmenting and revising to accommodate shareholder input
    a) Update and finalize 5-, 10- and 15-year load projections
5) Tabulate Available Transmission Capacity and Transmission Service Requests from member transmission providers
6) Aggregate load and resource needs, locating them geographically and compare to existing transmission path capabilities to determine if additional transmission construction is needed
7) Review expansion requirements with stakeholders
8) Identify hub and spoke candidates
9) Review RMATS and other studies' recommended capacity expansions
10) Northern Tier transmission providers select transmission expansion candidates, identifying Fast Track Projects by June 30, 2007
11) Each project sponsor develops a technical study plan that:
    a) Identifies interested parties
    b) Identifies affected parties
    c) Invites participation in study efforts
    d) Coordinates with other regional and sub-regional planning groups
    e) Establish meeting times and locations, coordinated via Northern Tier with other sub-regional planning groups and the Western Electricity Coordinating Council
    f) Defines a technical studies process to be integrated with the WECC Regional Planning Review and Three-Phase Rating Process
12) Each project sponsor performs required WECC Regional Planning Review Process studies, Phase I, Phase II rating studies, and submit to Northern Tier Planning Committee to review and present to stakeholders
13) Northern Tier facilitates project implementation and coordination with the Western Electricity Coordinating Council and other sub-regional planning groups.
14) Cost Allocation Committee processes Fast-Track Projects in the 2008 Biennial Planning Process as a pilot project

The NTTG Fast-Track Projects

Figure 6, below, is a map of the Western Interconnection showing the set of transmission improvements designed by the Northern Tier transmission providers to accommodate projected needs for future capacity. The lines comprise the 'Fast-Track Projects' which provide for pressing development needs and constitute the first iteration of the Northern Tier planning process.

The primary benefit of the Fast-Track expansion plan is the timely connection of substantial and diverse resource development in the sparsely populated Mountain States with population centers along the West Coast and in the Desert Southwest. In addition, the interties will allow significant diversity transactions among the distinctly different climate, weather and resource regimes of the Western Interconnection.

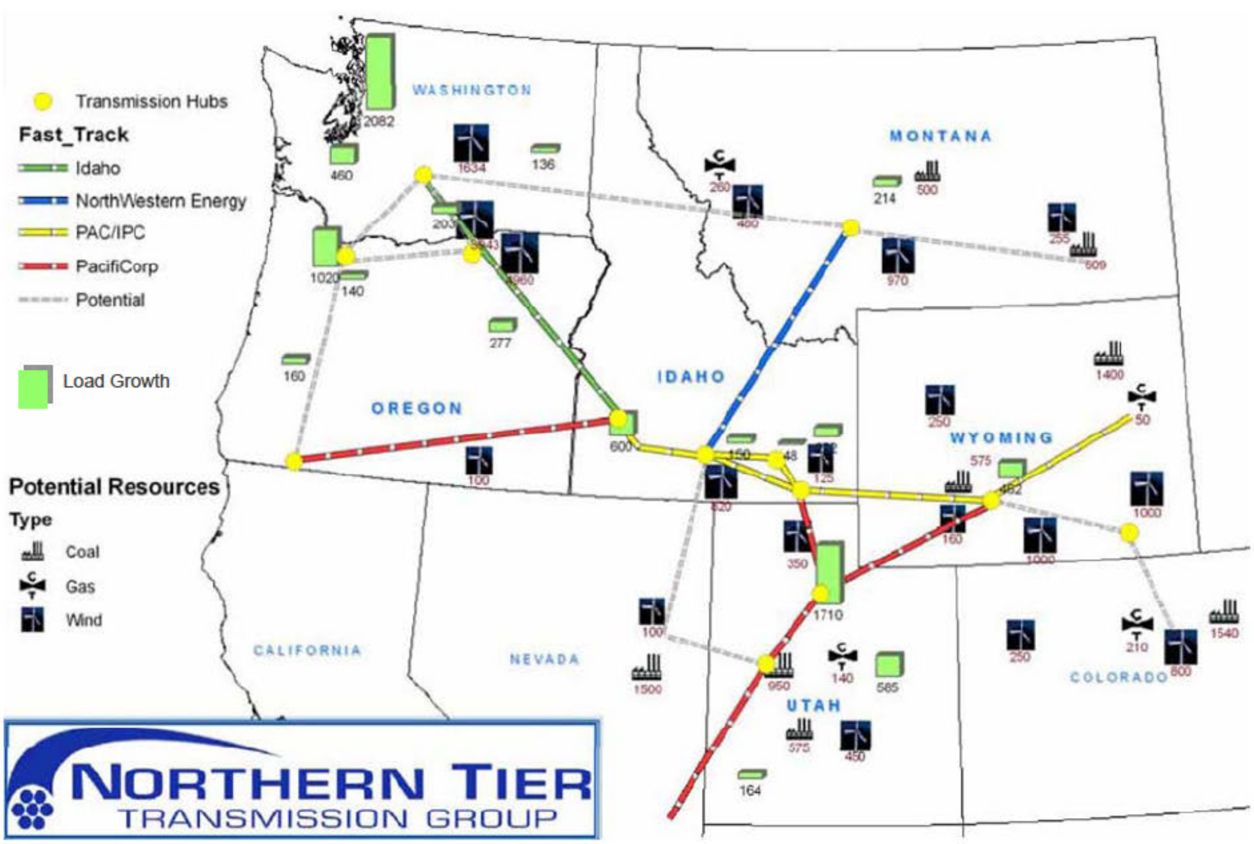


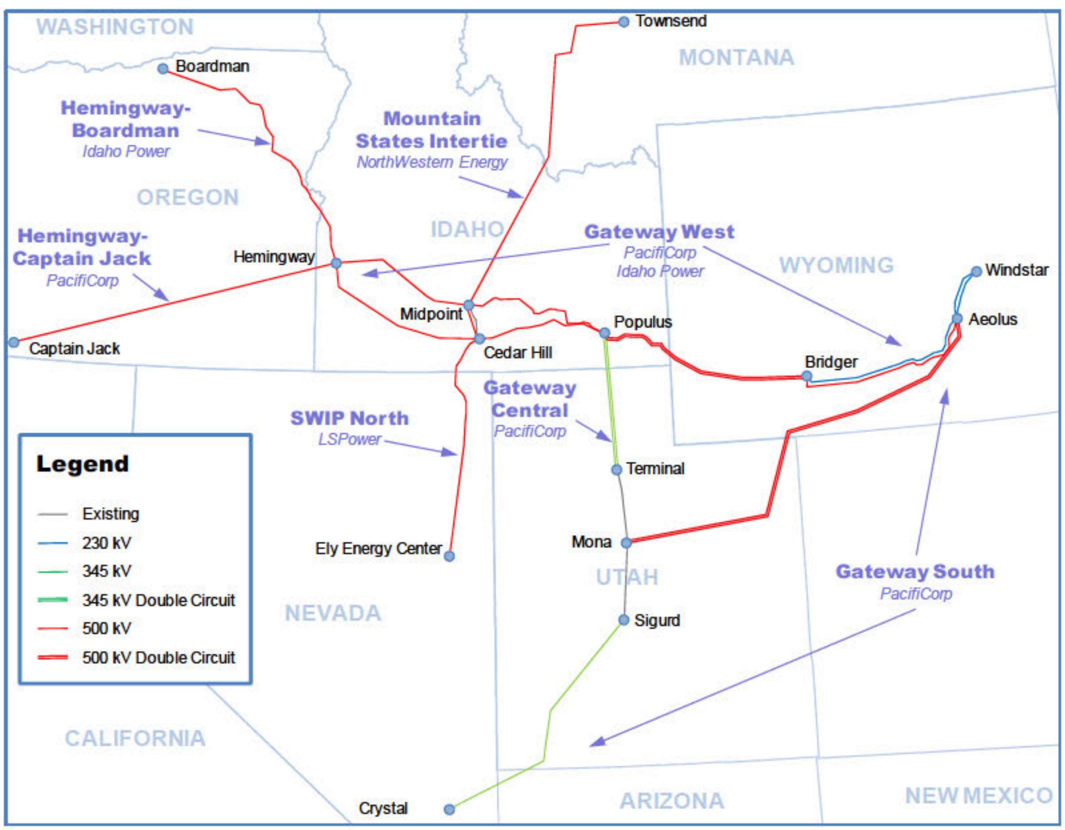
Figure 4: Northern Tier Fast-Track Project Map with Potential Resource Additions

The table and map on the next page show the principal projects in the Fast-Track Program, their points of termination, voltages, potential routes, current status and anticipated completion dates.

Table 3: Fast-Track Project Data

Project Name	Voltage (kV)	States	Length (Miles)	WECC Rating Phase	Permit Status	In-Service Year
Gateway South	500/345	WY, UT, NV	450±	In Phase 1	Applications Submitted	2014
Gateway West	500/230	WY, ID,OR	650	In Phase 1	Applications Submitted	2012
Gateway Central	345	ID, UT	136	In Phase 1		2010
Hemingway-Boardman	500	ID, OR	230	In Phase 1	Applications Submitted	2012
Hemingway-Captain Jack	500	ID, OR	320	In Phase 1		2014
Mountain States Transmission Intertie	500	MT, ID	460	Phase 1 Complete	In Permitting Process	2013
SouthWest Intertie Project - North	500	ID, NV	230	In Phase 1	Active in Siting	2011

Figure 5: Map of Fast-Track Transmission Showing Voltage & Points of Connection



NTTG Project Development Timelines

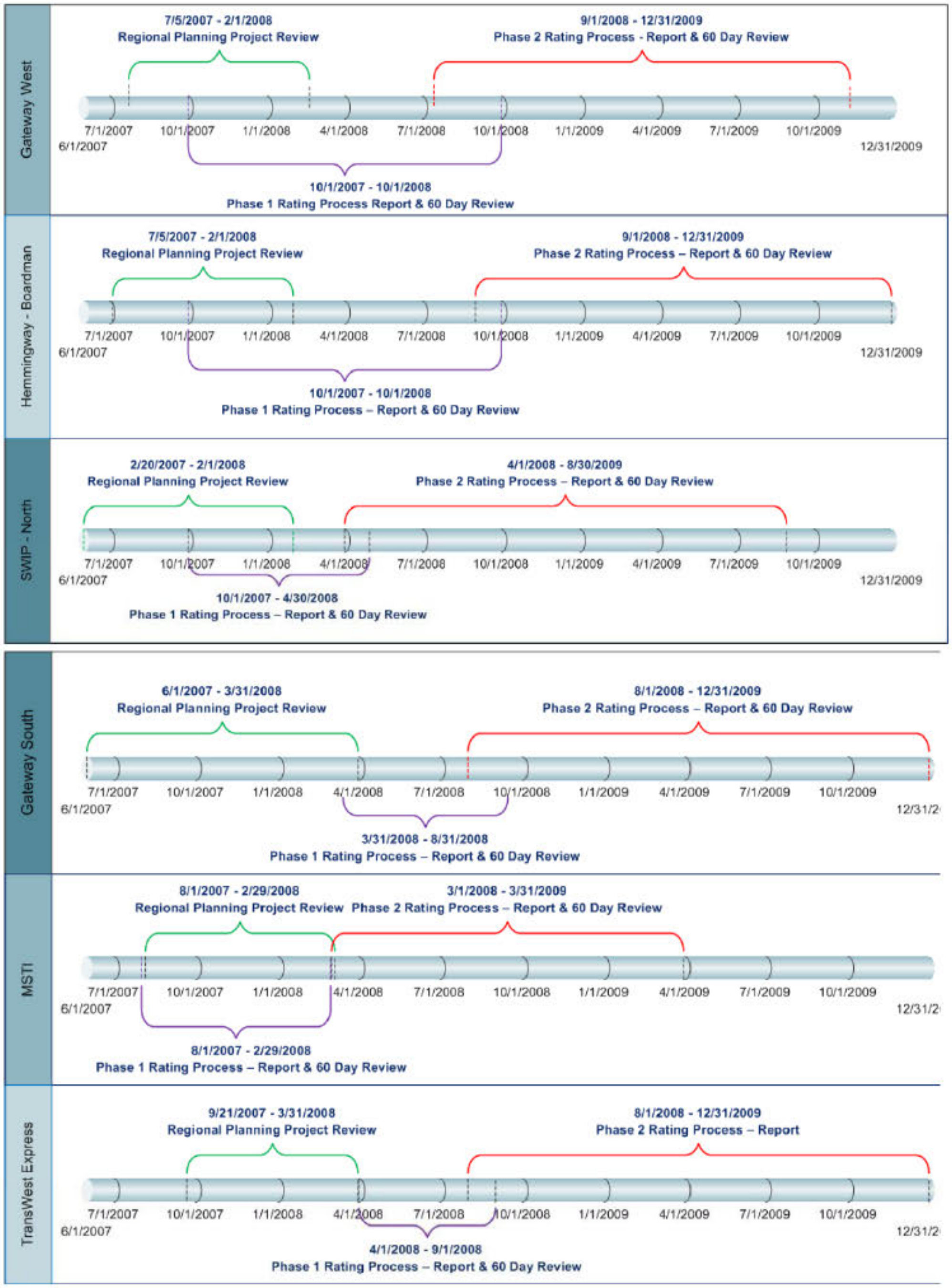


Figure 6: Development Timelines for Northern Tier Projects

The Sub-Regional Planning Process

In addition to and in parallel with their Fast-Track Project activities, the Northern Tier Transmission Group and its member transmission providers developed, in 2007, individual Attachment K planning processes and a two-phase sub-regional Northern Tier Biennial Planning Process. Initiated in January, 2008, the steps of the Biennial Planning Process include:

Phase 1: Northern Tier Transmission Group Planning Process

1. Annual Planning Process – identify needs, least cost expansion project alternatives, technical benefits, and project costs.
2. Planning Committee – identify expansion beneficial projects with sponsor-recommended cost and benefit allocations.
3. Cost Allocation Committee – reviews identified projects, applies principles and recommends likely cost allocation.
4. Planning Committee – develops and circulates a Draft Annual Expansion Plan.
5. NTTG Steering Committee – approves the draft expansion plan.
6. Final Annual Expansion Plan – includes likely cost and benefit allocation estimates for the given planning assumptions.
7. Planning Estimates – for expansion projects, congestion and re-dispatch, and additional assured transfer capability, costs and cost allocations are prepared by the Economic Study Process with input from the Transmission Use Committee.
8. Customer Decision Process – customers, other stakeholders and interested parties are informed of and asked to comment on the plan and its estimated impacts, costs and benefits.
9. Formal Open Access Transmission Tariff Service Request Process – customers make network transmission and point-to-point transmission requests via the transmission providers' Open Access Transmission Tariffs and planning for firm needs and reliability is undertaken by members.

Phase 2: Transmission Provider Project Implementation Process

1. Transmission providers and project sponsors will finance projects, facilitate permitting, and implement their formal Open Access Transmission Tariff processes.
2. Service Request Aggregation Process – Northern Tier Transmission Group may facilitate open seasons or coordinate requests made of individual transmission providers as appropriate and requested.
3. Steering Committee – may initiate coordinated queues and consolidated transmission service request processes in the future.

4. Transmission Providers' Formal Open Access Transmission Tariff Process
5. Transmission Providers – undertake transmission construction, including detailed planning, permitting and building.
6. Transmission Providers – each undertakes its own regulatory approval and rate process.

Relationships among Planning Entities in the West

Transmission planning in the Western Interconnection has evolved to incorporate three distinct levels activity: Transmission providers, sub-regional transmission groups, and regional planning entities. The relationships among regional, sub-regional and individual transmission providers are shown in the following diagram:

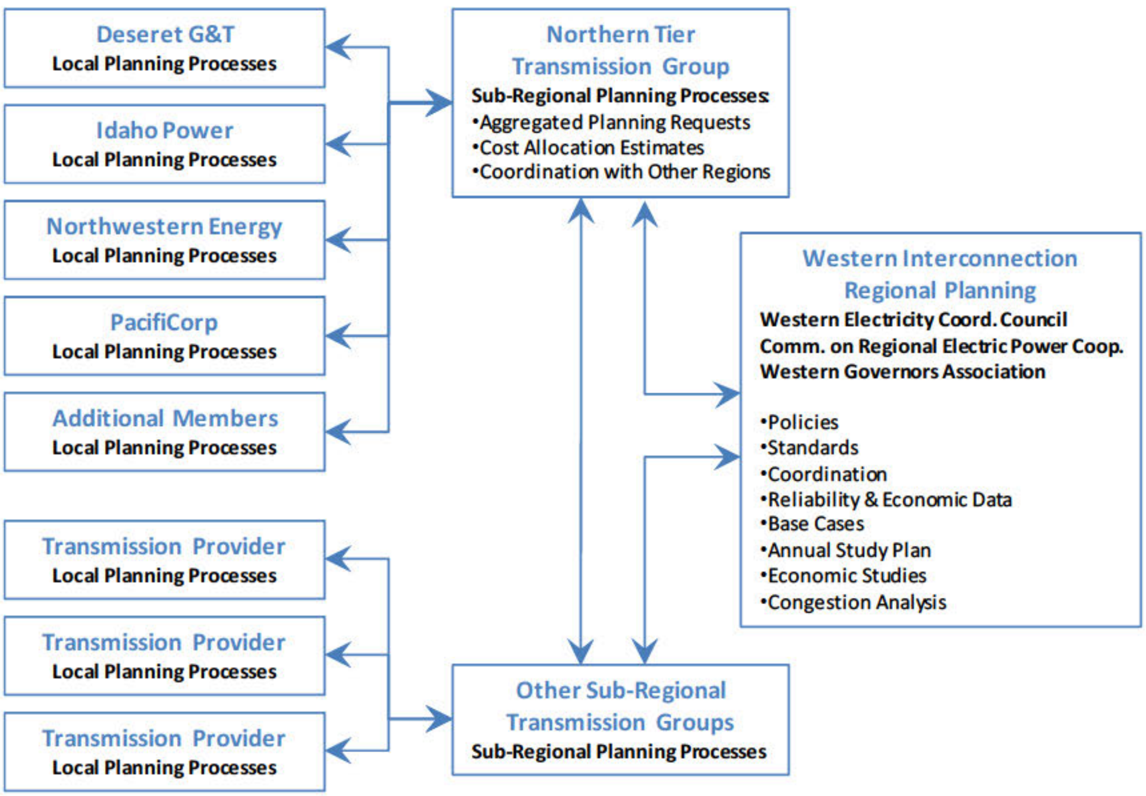


Figure 7: Three-level Planning Process in the Western Interconnection

Individual transmission providers were once (for the most part) fully-integrated generation, transmission and distribution utilities that, with deregulation, have now changed focus to provide equal access to all markets and customers.

The transmission providers each develop and maintain an Open Access Transmission Tariff that receives and acts on requests for transmission service in accordance with a well-defined procedure. The transmission providers also assess future load and resource developments to plan the evolution of an efficient transmission system, and undertake reliability analysis and improvements.

Where service requests and other identified needs call for the development of transmission that involves participation of multiple transmission providers within a sub-regional transmission group's footprint, the planning and analysis of improvements are coordinated at the sub-regional level. Projects that span greater distances are planned, analyzed and developed in coordination with other sub-regional groups or at the regional WECC level.

Regional and Sub-Regional Planning Timelines

The Northern Tier Transmission Group's planning timelines are designed to coordinate with those of the Western Electricity Coordinating Council, with a two-year cycle for transmission expansion and reliability and a one-year economic study cycle that examines preliminary plans for the first year of the biennial cycle, and draft plans for the second year of the preceding cycle.

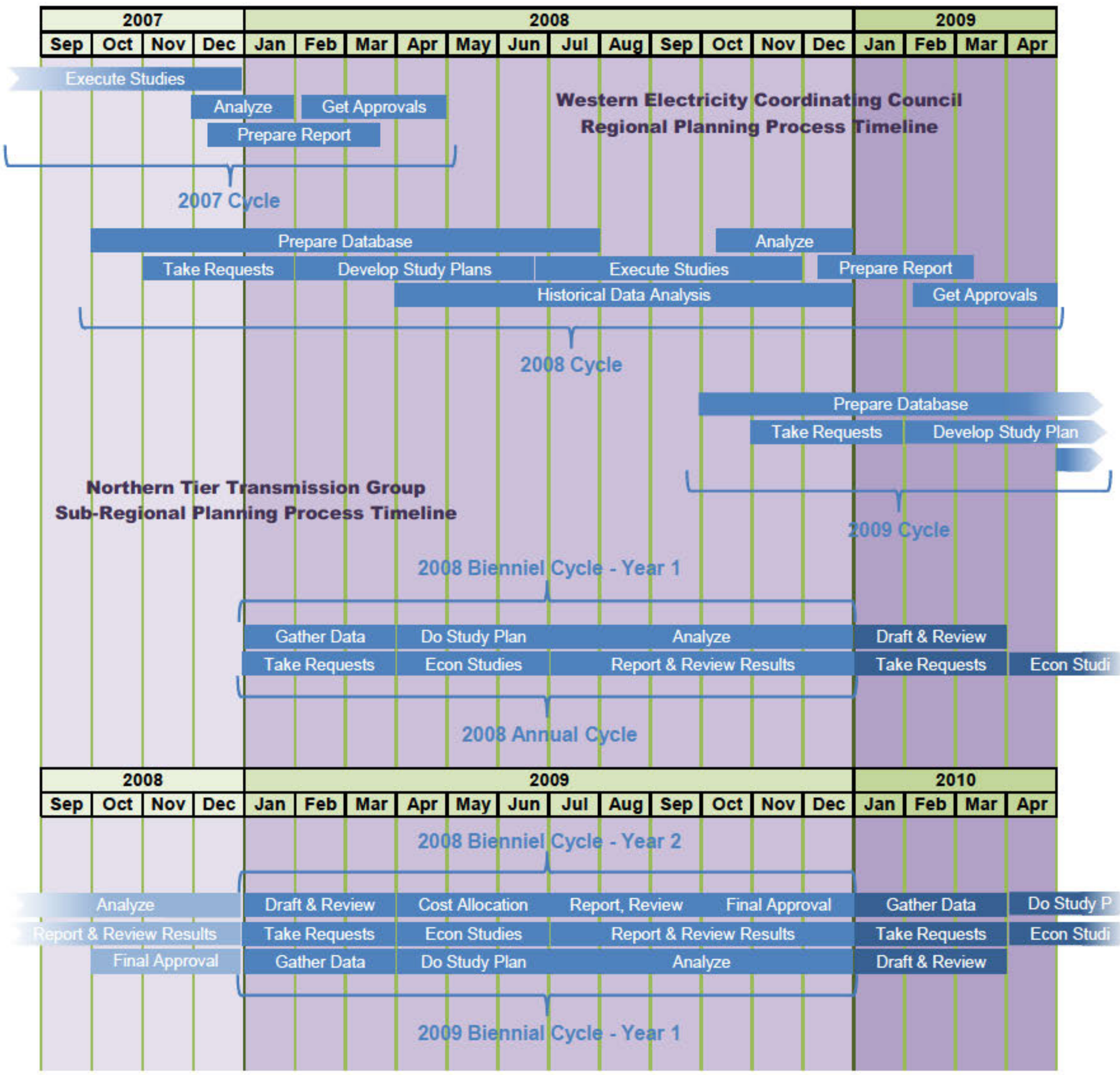


Figure 8: Timelines for Regional & Sub-Regional Planning

Details of the Northern Tier Transmission Projects

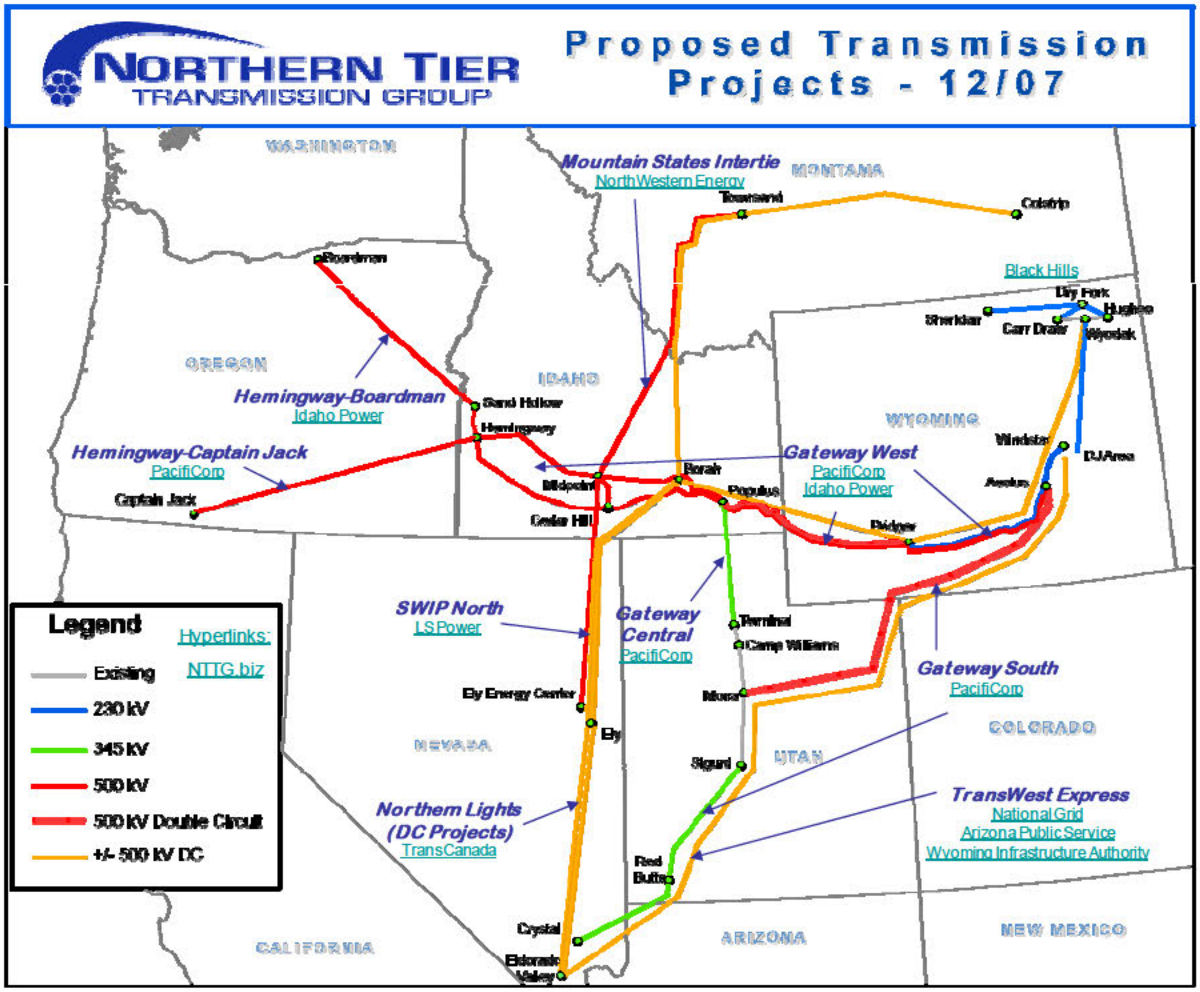


Figure 9: Proposed Transmission Projects as of December 2007

The following pages provide maps and descriptions of major components of the Northern Tier Transmission Group's projects. Following these overviews, in the table of References, are links to Web pages containing additional information for the projects.

Note: At the time of this report, the Sigurd-Crystal segment of the Gateway South was being evaluated in the WECC Phase 1 Rating Process as a 500-kV line.

Hemingway to Boardman Transmission Project

The project consists of a single-circuit 500-kV transmission line with a proposed bi-directional rating of 1000 MW stretching about 230 miles from Hemingway substation (formerly Melba) southeast of Boise, Idaho, to a new substation being planned near Boardman, in north-central Oregon.

This project, sponsored by Idaho Power, is designed to provide for anticipated service-area load growth and to meet transmission service requests. By 2017, Idaho Power forecasts an additional 800 MW of Idaho native load. Further, Idaho Power is obligated, pursuant to its Open Access Transmission Tariff, to plan and expand its transmission system based on needs of its network customers and eligible customers that agree to expand the Idaho Power transmission system.

Figure 10: Map of Hemingway-to-Boardman Transmission Project

Constraints on the existing Idaho to Northwest transmission path (Path 14) prevent Idaho Power from meeting transmission requests currently in its queue. Path 14 is currently rated at 1,200 MW with a summer operating transfer capability of 1090 MW west-to-east, and is fully subscribed.

The Hemingway-to-Boardman Transmission Project was initiated in response to a transmission request submitted by Idaho Power's merchant group and was identified in Idaho Power's 2006 Integrated Resource Plan to access Pacific Northwest energy resources to serve Idaho Power's growing customer needs.

The Rocky Mountain Area Transmission Study (RMATS) of 2004 evaluated many expansion scenarios, with the Phase 1 Report including a Midpoint-to-Oregon transmission path as a recommended transmission path to support the development of Wyoming resources beyond the RMATS study footprint, providing an estimated annual savings of $516 million.

A Regional Planning Review Group was established and held its first meeting on September 7, 2007, with additional stakeholder meetings on October 17 and November 13. Meeting notices, presentations and minutes were posted on Idaho Power's OASIS Web site (http://www.oatioasis.com/ipco/index.html).

Hemingway to Captain Jack Transmission Project

Northern Tier Transmission Group member PacifiCorp is sponsoring the development of a 500-kV transmission line from the Hemingway substation at Melba, Idaho (southeast of Boise), to the Bonneville Power Administration's Captain Jack substation near Bonanza in Northern California. The single-circuit line will span approximately 320 miles and is planned to be in service in 2014.

The existing Midpoint-to-Summer Lake 500 kV line between South Central Idaho and Southern Oregon will add a terminus at the Hemingway substation. The lines will provide a robust pathway for energy between the Pacific Coast and the Inland West.

Figure 11: Map of Hemingway to Captain Jack Transmission Project

Southwest Intertie Project (SWIP) North

The Southwest Intertie Project is being developed by LS Power, LLC, under the name Great Basin Transmission, LLC, in cooperation with Idaho Power, which holds the permits. Great Basin purchased an exclusive option to build the SWIP from Idaho Power, which has studied the project for a number of years.

The project is being approached in two segments, with the SWIP North segment being part of the Northern Tier Transmission Group's Fast-Track Project. SWIP North is a 500-kV single-circuit line that will be built between the Midpoint substation in South Central Idaho and the White Pine Generating Station near Ely, Nevada.

The initial proposed rating for the Midpoint-White Pine line is 2,000 MW in each direction, subject to results of the WECC Phase 1 Comprehensive Progress Report. The line is proposed to be in service in 2011.

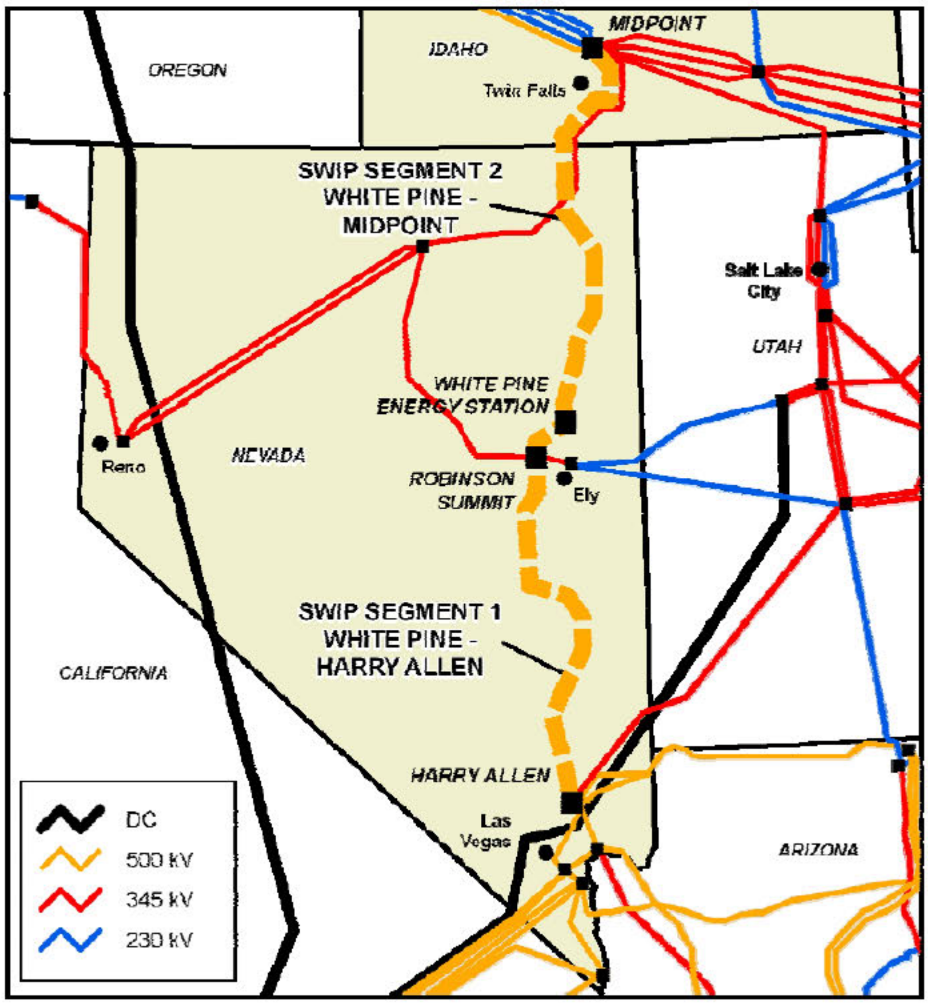


Figure 12: Map of Southwest Intertie Project (SWIP)

Mountain States Transmission Intertie Project

The Mountain States Transmission Intertie (MSTI, pronounced ‘misty’) is sponsored by Northwestern Energy and will provide a 500-kV link of approximately 460 miles between a new Townsend substation in Southwestern Montana and the Midpoint substation in South Central Idaho. An intermediate connection will be made at the existing Mill Creek substation.

The MSTI will be built to meet transmission service requests and to relieve constraints on the region’s existing transmission system. The project will also improve transmission system reliability, meet growing electricity demand in the region, provide regional energy diversification and make a positive economic impact on the area. The project is planned to be in service in 2013, and has a proposed north-south rating of 1,500 MW and a prospective south-north rating of 950 MW.

The Townsend substation will tie into two existing 500-kV east-west interties approximately mid-way between the existing Broadview and Garrison substations. The new line will have series compensation and a phase-shifting transformer to control power flow. Series capacitors will be located at the Midpoint substation, while a substation for the phase-shifting transformer and additional series capacitors will be built near the Mill Creek substation.

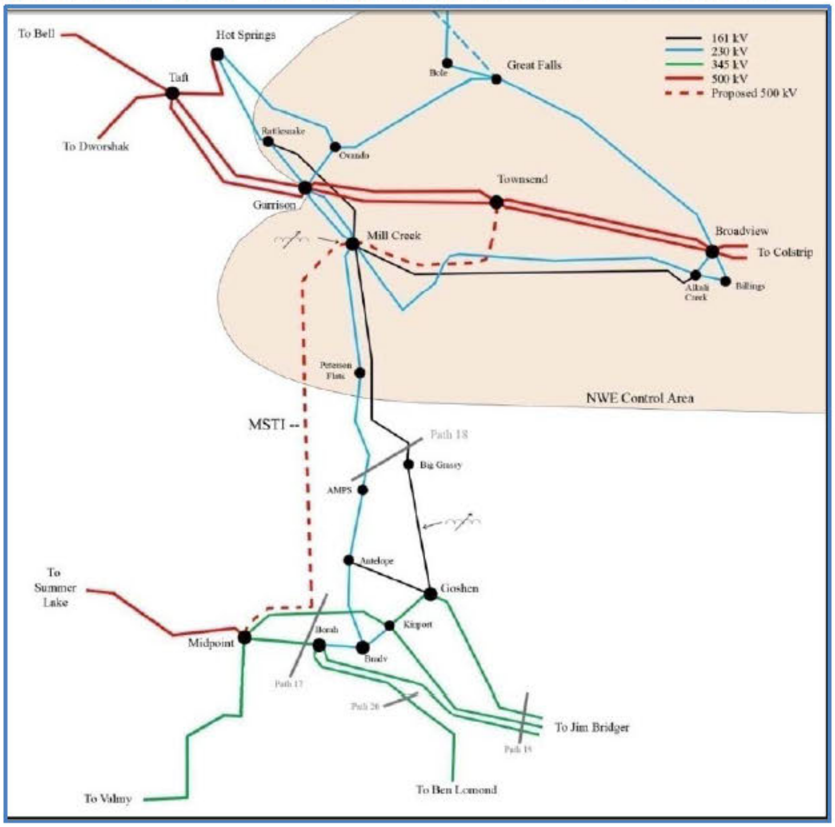


Figure 13: Potential Route of MSTI (Dashed Line)

Northwestern Energy initiated both the WECC Regional Planning Process and Path Rating Process in 2007. NWE submitted the Final Regional Planning Project Report to complete the Regional Planning Process in March 2008 after a 30-day comment period. In early April, NWE will finalize and submit its Comprehensive Progress Report to the Western Electricity Coordinating Council for the required 60-day comment period to complete the Phase 1 Path Rating Process.

Gateway West Transmission Project

The Gateway West Transmission Project is sponsored by Idaho Power and PacifiCorp, and is planned to provide for growth in load within the service territory of the two companies. The project will also meet their obligation to plan for and expand their transmission systems based on the needs not only of native load customers but network customers and eligible customers that agree to expand the transmission system.

The project was announced in May of 2007. It is a part of PacifiCorp's broader Energy Gateway initiative, which also encompasses the Gateway South and Gateway Central Transmission Projects. The project is comprised of a number of new substations and a new, primarily 500-kV pair of lines from a new Windstar substation near the Dave Johnston power plant in Eastern Wyoming to the Hemingway substation near the western border of Idaho.

The project has a proposed combined rating of 3,000 MW, and will parallel three existing WECC-defined bulk power transmission paths: TOT 4A (Path 37), Bridger West (Path 19), and Borah West (Path 17). Besides the terminating Windstar and Hemingway substations, new stations will be built at Aeolus (to integrate new generation resources and to provide connection with the Gateway South Project), Populus (to connect with Path C transmission into Utah), and at Cedar Hill (to tie the more southern of the two lines into the Midpoint substation for increased reliability).

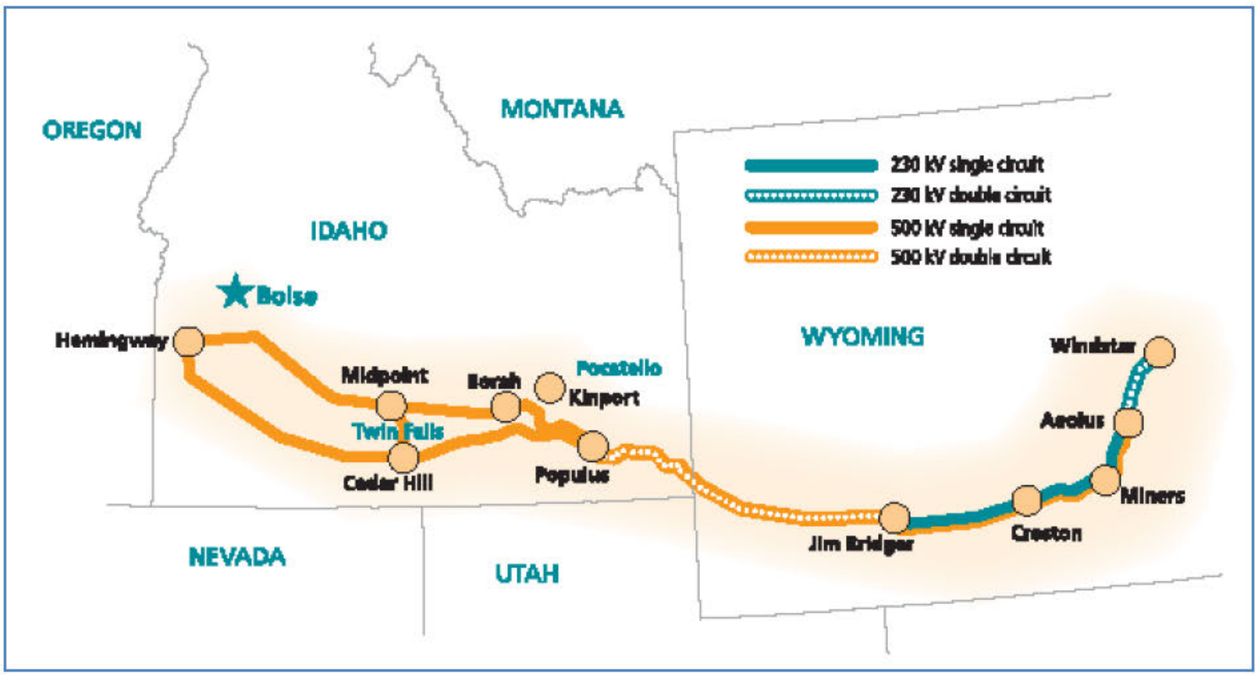
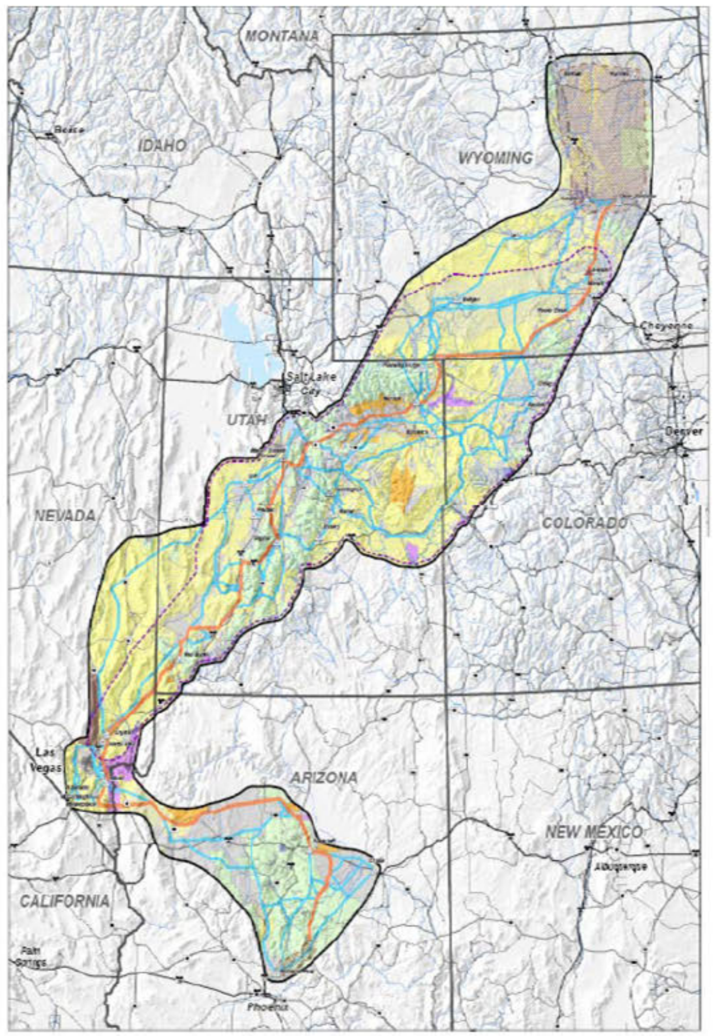


Figure 14: Map of the Gateway West Transmission Project

Gateway South and TransWest Express

The Gateway South Transmission Project is part of PacifiCorp's Energy Gateway initiative and proposes new high-voltage transmission between Wyoming and Southern Nevada. Arizona Public Service, the Wyoming Infrastructure Authority and National Grid are proposing a similar line from Wyoming through Southern Nevada and prospectively on to the Phoenix, Arizona area.



Recognizing a number of common interests and similar planning and development requirements, the participants in the two projects an interim agreement in August of 2007 to pursue initial development while more complex technical and regulatory issues were considered.

The joint effort undertook a common project team implementation strategy and resource deployment, led by National Grid, coordinating Regional Planning and Rating Review processes, coordinating environmental permitting, and engaging in a common stakeholder and public outreach.

Each project would undertake its own right-of-way filings, WECC rating process and regulatory filings.

The Gateway South project calls for a 500-kV line from the proposed new Aeolus substation in Southeast Wyoming to the Mona substation in Central Utah, to be completed by 2013. A 345-kV line will be built from the existing Sigurd substation (about 50 miles south of Mona), through the Red Butte substation in the southeast corner of Utah, to the Crystal substation north of Las Vegas, Nevada, with completion scheduled for 2012.

Gateway Central Transmission Project

PacifiCorp is sponsoring a double-circuit 345-kV transmission line from a new Populus substation near Downey, Idaho, 136 miles south to the existing Terminal substation near the Salt Lake International Airport west of Salt Lake City, Utah. The line is being developed in two segments that will link north of Ogden, Utah, at the Ben Lomond substation. The southern segment is planned to be in service in March of 2010, while the northern segment is targeted for June, 2010.

The line is intended to increase the ability to deliver electricity to the fast-growing population along the Wasatch front of Utah in an efficient and cost-effective manner.

The new transmission lines and expanded substations will also provide for improved reliability and operational flexibility with future generation resources, including renewable resources such as wind

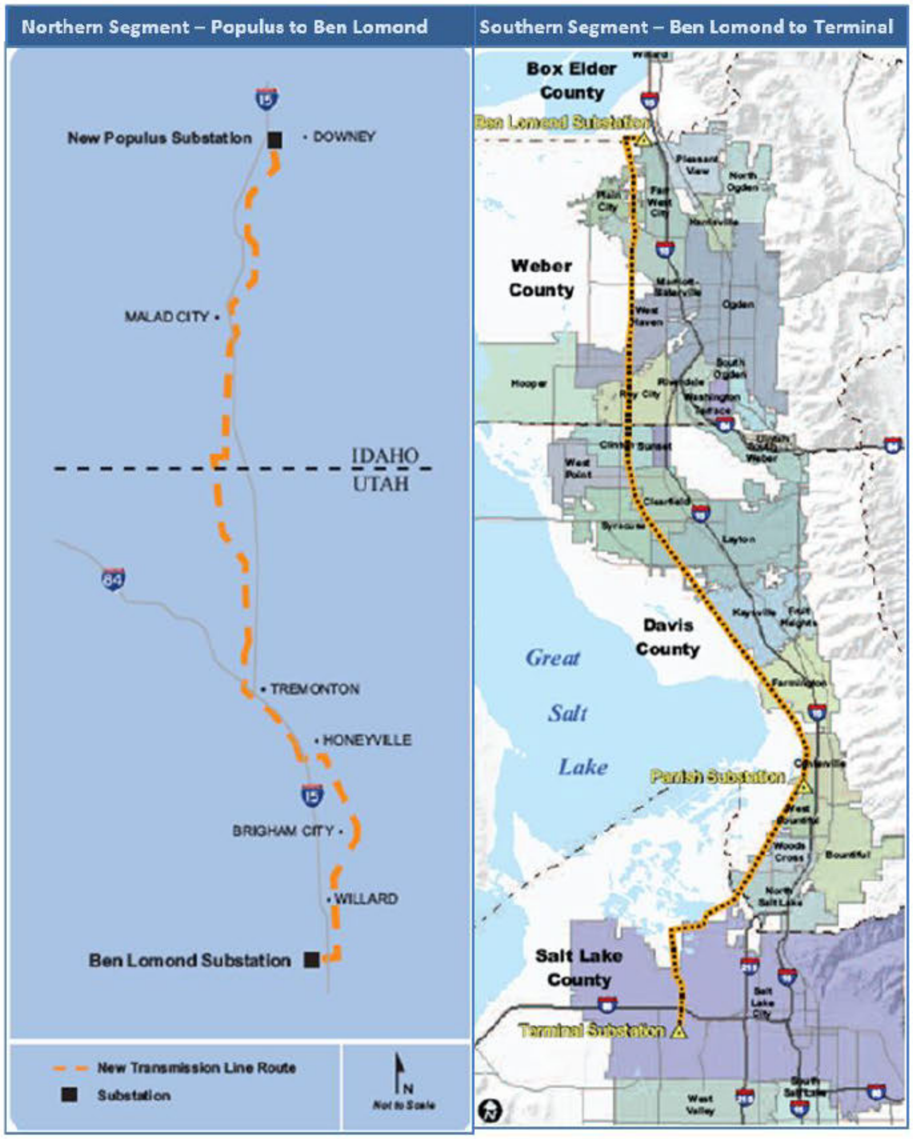


Figure 16: The Gateway Central Transmission Project

NorthernLights Transmission– Inland Project

NorthernLights is a TransCanada initiative that proposes three major high-voltage direct current (HVDC) transmission lines linking low cost, environmentally attractive fossil fuelled and renewable generation with growing loads in the Pacific Northwest, Nevada, Arizona and California.

The NorthernLights initiative consists of two projects – the Celilo Project between Northern Alberta and the Bonneville Power Administration's Big Eddy substation next to the high voltage direct current inverter station at Celilo near The Dalles, Oregon, and the Inland Project connecting Montana and Wyoming generation to Las Vegas and electricity users in Southern California and the Desert Southwest.

The Celilo Project is being developed in coordination with the Western Electricity Coordinating Council and the ColumbiaGrid regional transmission group.

The Inland Projects consist of two HVDC transmission lines to Las Vegas, with one line beginning in Wyoming and the other in Montana. Several major inter-regional high voltage transmission paths are already interconnected at substations in the Southern Nevada area.

The lines will connect wind generation resources in Montana, Wyoming and other western states with growing loads in Southern Nevada, Arizona and California.

Extension of the Inland Project lines to southern California and Arizona is contemplated as market conditions evolve.

Current plans call for the two 500-kV direct current lines to be energized in 2014. It is anticipated that they will carry up to 3,000 megawatts each and cost between $1.5 and $2.0 billion to construct.

Internet Links and Other References

Regional Planning

- Western Electricity Coordinating Council
  (http://www.wecc.biz)
  - Transmission Expansion Planning Policy Committee
    Western Interconnection economic transmission expansion planning support
  - Planning Coordination Committee
    Evaluate transmission design and expansion, recommend criteria for reliable operation
- Committee on Regional Electric Power Cooperation
  (http://www.westgov.org/wieb/site/crepcpage/)
  A committee of the Western Governors Association's Western Interstate Energy Board

Sub-Regional Planning

- Northern Tier Transmission Group
  (http://www.nttg.biz)
- ColumbiaGrid
  (http://www.columbiagrid.org)
- WestConnect (and Sub-Groups)
  (http://www.westconnect.com/planning.php)
  - Colorado Coordinated Planning Group
  - National Renewable Energy Laboratory
  - Sierra Pacific Planning Group
  - Southwest Area Transmission

Northern Tier Transmission Group Members

- Deseret Generation & Transmission
  (http://www.oasis.pacificorp.com/oasis/dgt/main.html)
- Idaho Power Company
  (http http://www.oatioasis.com/ipco/index.html)
- Northwestern Energy
  (http://www.oatioasis.com/NWMT/index.html)
- PacifiCorp
  (http://www.oasis.pacificorp.com/oasis/ppw/main.htmlx)
- Utah Associated Municipal Power Systems
  (http://www.uamps.com)

Integrated Resource Plans

- Idaho Power Company
  (http://www.idahopower.com/energycenter/irp/2006/)
  Idaho Power is currently developing its 2008 Integrated Resource Plan, and preliminary information will be made available on its Web site as it is evolved.

- NorthWestern Energy
  (http://www.northwesternenergy.com/display.aspx?Page=Default_Supply_Electric&Item=16)
  NorthWestern does not produce an 'Integrated Resource Plan', *per se*, but they maintain and make available an "Electric Default Supply Resource Procurement Plan.'

- PacifiCorp
  (http://www.pacificorp.com/Navigation/Navigation23807.html)
  PacifiCorp's currently posted plan was completed in May of 2007, and development of the 2008 IRP is currently underway.

Additional Information for Northern Tier Transmission Projects

- Hemingway to Boardman
- Hemingway to Captain Jack
- Gateway Central
  (http://www.pacificorp.com/Article/Article79647.html)
- Gateway South
- Gateway West
  (http://www.idahopower.com/newsroom/projnews/Gateway/)
- NorthernLights
  (http://www.transcanada.com/company/northernlights.html)
- Mountain States Transmission Intertie
  (http://www.msti500kv.com/default.htm)
- Southwest Intertie Project - North
- Transwest Express
  (https://transwest.azpsoasis.com/)

NORTHERN TIER TRANSMISSION GROUP

2008-2009 Biennial Transmission Plan

Final Report

High-Voltage Transmission Construction in Montana

November 25, 2009

NORTHERN TIER
TRANSMISSION GROUP

Approved: December 8, 2009

Preface

This report was prepared by Comprehensive Power Solutions, LLC, ("CPS") as part of its facilitation and coordination work for the Northern Tier Transmission Group. The members and other stakeholders participating in the effort to provide coordinated, efficient and effective planning for expansion of transmission within the Northern Tier footprint played critical roles in developing the content of this report.

Particularly important to the studies underlying this report is the work done by the members of the Northern Tier Planning Committee's Technical Work Group and Economic Studies Project Team, whose participants are engineers from the member Transmission Providers.

While the report is made available to the public, Northern Tier and CPS accept no duty of care to third parties who may wish to make use of or rely upon information presented in this report. CPS has exercised due and customary care in developing this report, but has not independently verified information provided by others and makes no further express or implied warranty regarding the report's preparation or content. Consequently, CPS and Northern Tier shall assume no liability for any loss due to errors, omissions or misrepresentations made by others.

This report may not be modified to change its content, character or conclusions without the express written permission of CPS and Northern Tier.

To ensure efficient, effective, coordinated use and expansion of the members' transmission systems in the Western Interconnection to best meet the needs of customers & stakeholders.

Figure 1: Map Illustrating Northern Tier Members' Principal Transmission Lines

The extensive high-voltage transmission network of the Northern Tier Transmission Group's Transmission Providers reaches to all states of the US Western Interconnection.

Contents

Figures

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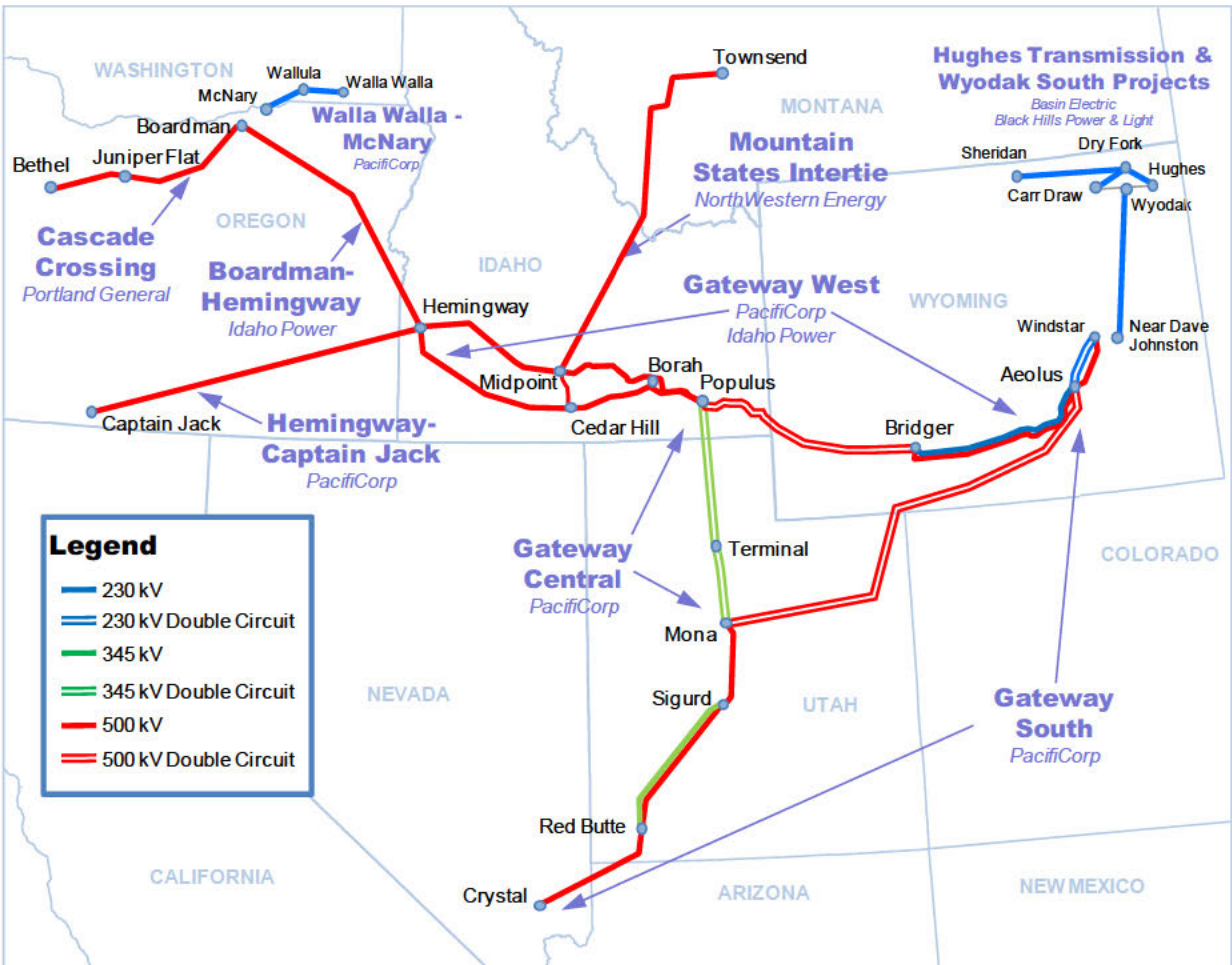
Projects

Results

The Northern Tier Transmission Group's (NTTG's or Northern Tier's) 2008-2009 biennial plan was produced through its public processes in conjunction with related activities of the NTTG Cost Allocation Committee and NTTG Transmission Use Committee. Technical studies have demonstrated the resulting plan to be capable of reliably meeting the identified needs established in the study plan.

Figure 2: Northern Tier Transmission Group Planned Transmission Additions



Planning is an iterative process and must work in concert with local transmission plans and Integrated Resource Plans, where they exist. This Northern Tier transmission plan is a result of a 'bottom-up' load service process to ensure that the transmission planned for the Northern Tier footprint can reliably serve forecasted load growth and conditions established by data submittals and stakeholder input during the process. There may be broader regional needs outside of the Northern Tier footprint unmet by this plan, which are expected to be addressed as part of regional, interconnection-wide efforts reconciling 'bottom-up' and 'top-down' study efforts.

This plan establishes the baseline main grid transmission configuration for the Northern Tier footprint for the planning horizon ending in 2018. This planned transmission should be used as a 'base plan' to inform other planning processes. While we cannot assure the plan will be implemented as designed, it represents the best information available during the current planning cycle. Changing needs or new information will be accommodated through appropriate data submittals during the next planning cycle.

This plan identifies a number of specific projects. However, the technical analysis was performed on the premise that the entire transmission plan is in service in 2018. Path and project ratings are determined separately through Western Electricity Coordinating Council (WECC) processes and are the responsibility of each project's sponsor(s). Commercial subscription and capacity commitments are administered by each Transmission Provider under their Open Access Transmission Tariff (OATT).

Summary

The Northern Tier Transmission Group was created in the autumn of 2006 as a forum where all interested parties, including transmission providers, customers and state regulators might participate in planning, coordinating and implementing a robust transmission system.

The Northern Tier Transmission Group Planning Committee was formed to coordinate transmission planning for the Northern Tier footprint[1] and to coordinate with other sub-regional planning groups and the Western Electricity Coordinating Council's planning committees. Northern Tier's planning process is designed to be open, transparent and participatory, with transmission providers, regulators, customers and other stakeholders encouraged to join the committees' activities and meetings and attending semi-annual stakeholder meetings.

Execution of the Planning Committee's charter is through the biennial planning process that is broken into eight quarters and is paralleled by a four-quarter economic studies process that repeats annually to cover the two years of the biennial planning cycle. The biennial plan spans ten years and its purpose is to coordinate the bulk electric system transmission plans of member transmission providers, to provide for the integration of new generation, and to reduce transmission congestion. This final plan reports the efforts and results of the first biennial cycle.

The cycle began in January 2008 with a three-month window of opportunity for stakeholders to submit data for loads, resources and transmission projects to be studied, and to submit requests for economic congestion studies. Through this window, Northern Tier received a significant dataset for proposed 230, 345 and 500 kV transmission projects. The purposes and needs for the proposed projects range from providing access to generation to serving future network load growth, relieving congestion between member utilities and allowing other Western utilities to access resource-rich areas within the Northern Tier footprint.

[1] The Northern Tier footprint encompasses service territories of NTTG Funding Agreement signatories.

Through the economic study window, Northern Tier members received two requests for economic studies (one determined to be local and one regional) and one request for study of a hypothetical transmission project that was determined to be best studied within the power flow-based biennial analysis.

Based on this information, the second quarter was dedicated to developing a study plan and the appropriate study assumptions. The Planning Committee decided to focus power flow studies on two seasons – a heavy summer case where demands would be at their greatest, and a light autumn case, where the resource-rich areas in the Northern Tier footprint would produce the largest surplus of generation over low seasonal loads for export to other areas in the West. The absence of sub-regional economic study requests in the first quarter allowed work to focus on developing data and processes for the power flow studies.

The third and fourth quarters were allotted to development of these coordinated heavy summer and light autumn base cases. A Technical Work Group, consisting of planning engineers from the member transmission providers, began with formal base cases developed by the Western Electricity Coordinating Council (WECC) which were then modified to include the agreed loads and resources and correctly-defined transmission projects.

The completed base cases were then subjected to contingency analyses (N-1 and credible N-2 contingencies, as provided by participating transmission engineers for their respective companies) and any resulting departures from NERC Standard and WECC Standard requirements were examined. All thermal overloads and voltage excursions were verified and the resulting power flow studies were deemed acceptable.

Work in 2009 (the second half of the biennial cycle) began with preparation and review of the draft transmission report, and with conduct of the second economic study request.

Again, there were no economic study requests that would require production cost modeling or congestion analysis. However, the Planning Committee elected to perform an economic analysis using the WECC Transmission Expansion Planning Policy Committee's published case, with the addition of the Northern Tier portfolio of planned transmission projects. This was primarily intended to establish and test the modeling process, but provided useful information on path utilization and congestion.

The Planning Committee also decided to perform additional power flow studies. After examining the ability of the Northern Tier transmission system to serve loads in the Northern Tier footprint, a series of power flow scenario studies was undertaken to examine the impacts of exporting additional generation out of the Northern Tier footprint to the Pacific Northwest and the Desert Southwest. The scenarios were not intended to probe the limits of the transmission projects to carry power, as that function is being undertaken in considerable detail by the project sponsors via their WECC Project Rating Review processes. The Technical Work Group found that the additional generation and exports did not result in unresolved voltage or flow violations.

The biennial planning process concludes with the preparation, review and acceptance of this report. In January, 2010, the second biennial planning cycle will begin, with data, models and processes enhanced by the experiences and results of the first cycle.

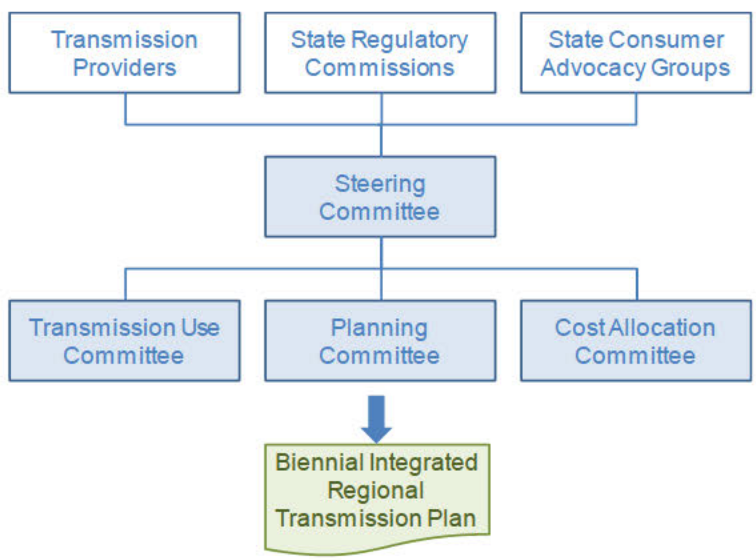
Introduction

This is the final report of the 2008-2009 Biennial Transmission Plan of the Northern Tier Transmission Group. The eight-quarter planning process is designed to develop a coordinated transmission plan for a sub-region of the Western Interconnection defined by participating transmission providers with common issues and interests. The process solicits and incorporates anticipated loads, resources and transmission projects that impact the Northern Tier footprint on a sub-regional level.

The report begins with a review of the background and evolution of the Northern Tier Transmission Group, its current organization, and the planning process it is undertaking. The relationship between the Northern Tier Transmission Group and other sub-regional and regional activities is outlined and their synchronized planning cycles described.

The report then looks at the study methodology, assumptions, data, and analyses underlying the planning effort in the 2008-2009 cycle. The studies performed during the biennium are reviewed and their results summarized.

Figure 3: Structure of the Northern Tier Transmission Group



Background

The Northern Tier Transmission Group (Northern Tier or NTTG) began its work in 2007 as the next step in a series of regional and sub-regional organizations working to evolve a coordinated inter-utility and stakeholder-involved transmission planning process.

One founding principle of Northern Tier is to fulfill FERC Order 890 requirements that local Transmission Providers participate in regional and sub-regional planning. Additional detail on the history underlying the current organization is available in the 2007 Annual Planning Report published April 2, 2008 and accessible on the Northern Tier web site, at http://www.nttg.biz.

The Northern Tier Transmission Group

NTTG focuses its efforts on the evaluation of transmission projects that move power across the sub-regional bulk electric transmission system, servicing load in its footprint and delivering electricity to external markets. The transmission providers belonging to Northern Tier serve over 3 million retail customers with nearly 3,000 miles of high voltage transmission lines. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, and parts of Washington and California.

NTTG works with the WECC Planning Coordination Committee for reliability planning, the WECC TEPPC for economic planning, and is working to implement a framework for cooperation with neighboring sub-regional planning entities.

Northern Tier Members

The Northern Tier Transmission Group's organizational structure has multiple levels, as shown in Figure 3 above. With regard to planning, overall direction is provided by the Steering Committee, whose membership at the end of 2009 was as follows:

- Idaho Public Utilities Commission
- Oregon Public Utility Commission
- Montana Public Service Commission
- Montana Consumer Counsel
- Utah Public Service Commission
- Wyoming Public Service Commission
- Deseret Power Electric Cooperative
- Idaho Power Company
- NorthWestern Energy
- PacifiCorp
- Portland General Electric
- Utah Associated Municipal Power Systems

The Planning Committee executes the planning process defined by the Planning Committee Charter and at the end of 2008 had members from the following organizations:

- Basin Electric
- Black Hills Power
- Deseret Power Electric Cooperative
- Horizon Wind
- Idaho Power
- NorthWestern Energy
- PacifiCorp
- Portland General Electric
- TransCanada
- Utah Associated Municipal Power Systems
- Idaho Office of Energy Resources
- Montana Public Service Commission
- Wyoming Public Service Commission

Coordination within the Northern Tier Footprint

Each of the Transmission Providers belonging to Northern Tier is also responsible for transmission planning for its own service area and for any Balancing Authority Areas it administers. This local transmission planning process is, for each Transmission Provider in Northern Tier, designed to parallel and interact with the planning done at Northern Tier.

The local planning process is conducted in greater depth than the sub-regional process, both in terms of its analysis of finer detail (lower voltages and system dynamics), and more extensive construction detail, as the Transmission Provider is responsible for path ratings, project financing, permitting and approvals, and execution of the build.

Northern Tier provides a mechanism for coordinating appropriate load and resource data and for coordinating the analysis of the existing sub-regional transmission system augmented by a number of proposed transmission projects that impact the planning decisions, system adequacy and operation of multiple Transmission Providers. These are commonly high voltage projects. Throughout 2008 and 2009, efforts were made to ensure proper coordination among the Northern Tier Transmission Providers' transmission plans.

Coordination with Others in the Western Interconnection

NTTG is committed to coordinating sub-regional planning efforts with adjacent sub-regional groups and other planning entities. In addition to working directly with the ColumbiaGrid and WestConnect sub-regional planning groups, Northern Tier relies on the data collection, validation and transmission modeling work done by the Western Electricity Coordinating Council (WECC, the Regional Reliability Organization) and the Northern Tier biennial transmission plan reported here is consistent with the work of the WECC.

The WECC provides valuable service to transmission planners across the Western Interconnection through its role in regional reliability planning and facility rating, and by providing economic planning data and analysis to its members through its Transmission Expansion Planning Policy Committee.

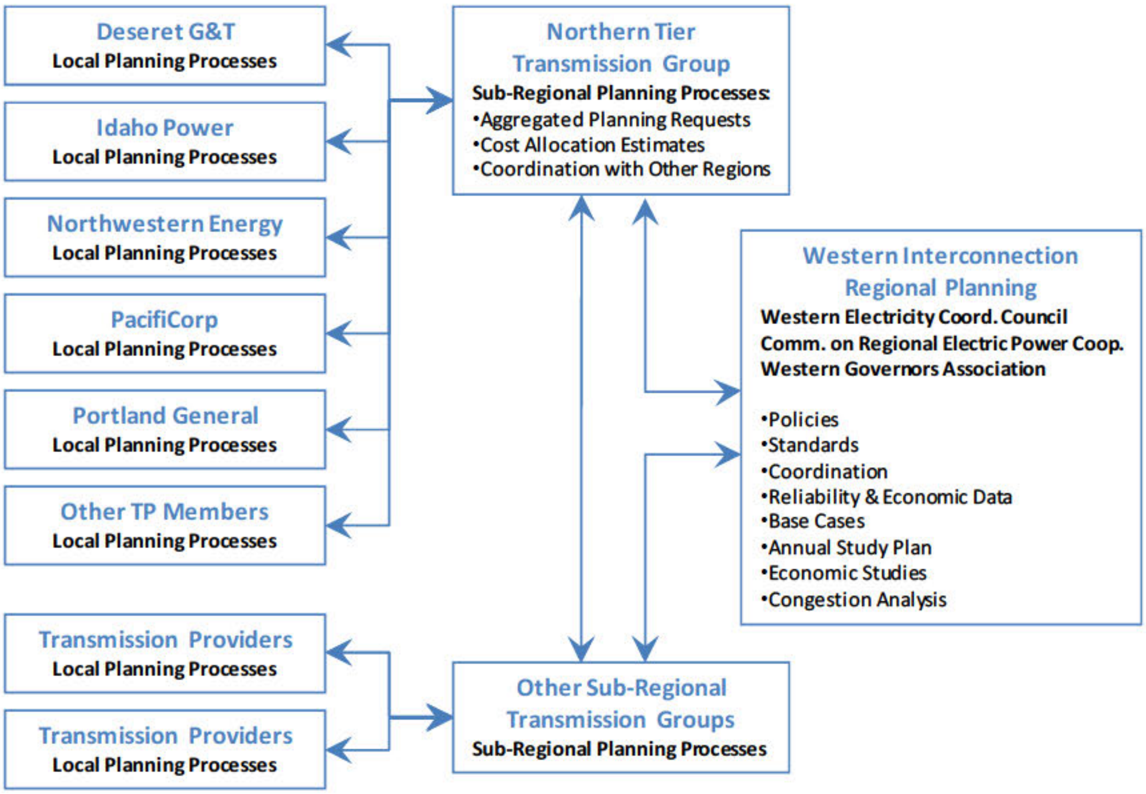
Relationships among Planning Entities in the West

Transmission planning in the Western Interconnection has evolved to incorporate three distinct organizational levels of activity: Transmission providers, sub-regional transmission groups, and regional planning entities. The relationships among regional, sub-regional and individual transmission entities are illustrated in Individual Transmission Providers were once (for the most part) fully-integrated generation, transmission and distribution utilities that, with deregulation, have now changed focus to provide equal access to all markets and customers.

Figure 4

Individual Transmission Providers were once (for the most part) fully-integrated generation, transmission and distribution utilities that, with deregulation, have now changed focus to provide equal access to all markets and customers.

Figure 4: Three-level Planning Process in the Western Interconnection



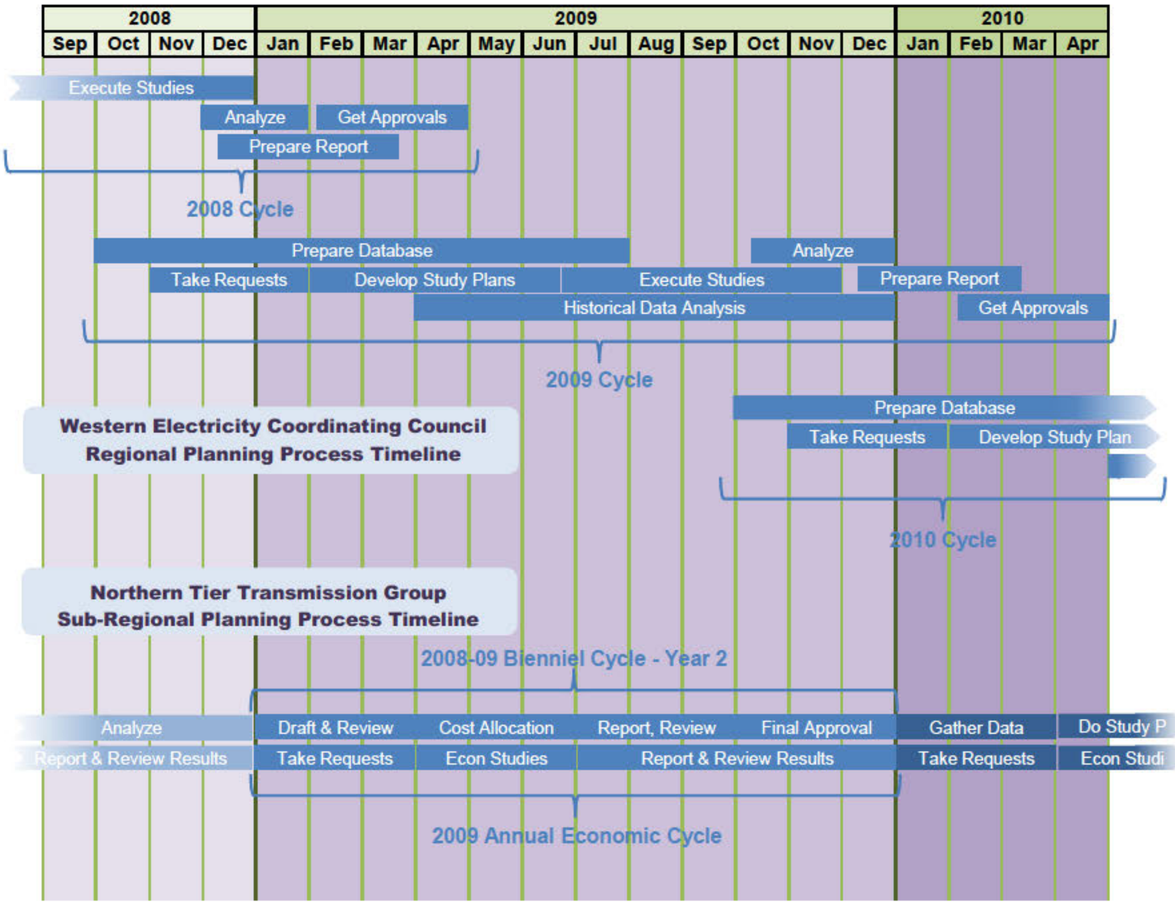
The Transmission Providers each develop and maintain an Open Access Transmission Tariff process that receives and acts on requests for transmission service in accordance with a well-defined procedure. The Transmission Providers also assess future load and resource developments to plan the evolution of an efficient transmission system, and undertake reliability analysis and improvements.

Where service requests and other identified needs call for the development of transmission that involves participation of multiple Transmission Providers within a sub-regional transmission group's footprint, the planning and analysis of improvements are coordinated at the sub-regional level. 2008 was a startup year for sub-regional planning groups and as Northern Tier and others undertook their first sub-regional planning cycles, relationships and coordination were forged among Transmission Providers in the sub-regional groups.

At the regional level, establishment of the WECC's Transmission Expansion Planning Policy Committee provided a foundation for coordination on regional issues and completes a framework that addresses regional, sub-regional and local issues.

The Northern Tier Transmission Group's planning timelines are designed to coordinate with those of the Western Electricity Coordinating Council, with a two-year cycle for transmission expansion and reliability and a one-year economic study cycle that examines preliminary plans during the first year of the biennial cycle, and draft plans during the second year of the cycle.

Figure 5: Timelines for Regional & Sub-Regional Planning



NTTG – Review of 2008-2009 Planning Activities

Stakeholder participation is important to the processes of the Northern Tier Transmission Group and all interested parties are encouraged to attend and contribute to the many stakeholder meetings conducted by the Transmission Use, Planning and Cost Allocation committees, and in preparing, developing and analyzing planning studies. A chronology of activities in the 2008-2009 biennial planning cycle is provided below.

The Northern Tier Planning Committee conducted conference calls on a frequent basis during the biennium, where the planning process was developed and managed, and assumptions, data and methodology were discussed and agreed.

The Planning Committee decided to perform studies using the staff of member Transmission Providers, taking advantage of their internal expertise and software tools. A Technical Work Group was formed, to separate detailed technical and model discussions from the policy-level Planning Committee, and to provide proper control of confidential information.

At the end of 2008, an Economic Studies Project Team was similarly formed to plan and perform any needed economic studies resulting from its request for studies during the first quarter of 2009.

Table 1: Chronology of Northern Tier Activities in 2008 and 2009

2008	Jan	16-17	Public Semi-Annual Stakeholder Meeting
	Mar	6	Planning Data Posted
	Apr	8	Public Stakeholder Meeting
	May	20	Draft Study Plan Posted
	May	30	Public Stakeholder Webinar
	Jun	16	Public Stakeholder Webinar
	Jul	24-25	Public Semi-Annual Stakeholder Meeting
	Sep	18	Final Study Plan Posted
	Oct	17	Work Plan Supplement Posted
	Nov	12	Public Stakeholder Webinar
2009	Jan	28	Public Semi-Annual Stakeholder Meeting
	Feb	06	Transmission Plan Draft Report Posted
	Feb	25	Public Stakeholder Webinar
	May	27	NTTG Planning Overview Meeting with FERC OER
	Jun	3	Public Stakeholder Webinar
	Jul	22	Public Semi-Annual Stakeholder Meeting

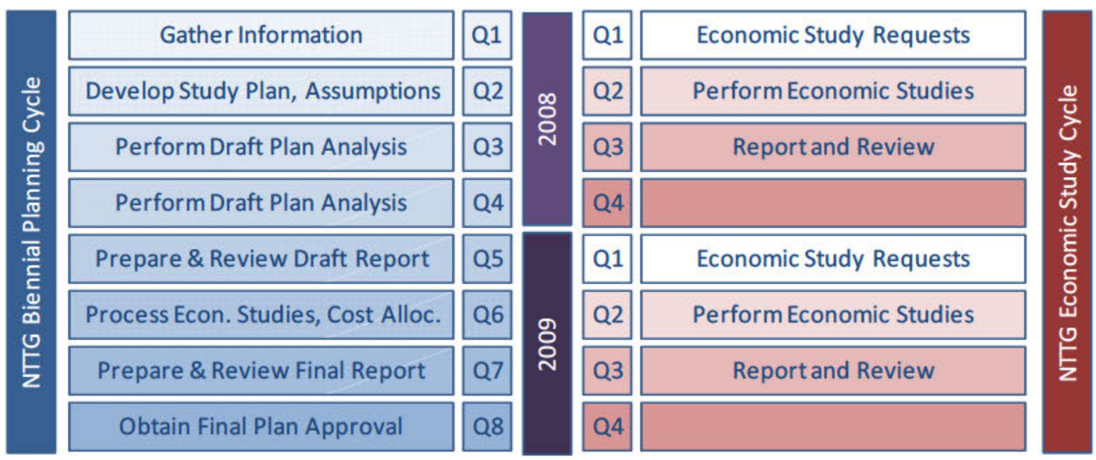
Details of the Eight-Quarter Northern Tier Planning Process

The overall biennial transmission planning process at Northern Tier is broken down into eight quarters and two tracks. A four-quarter economic study cycle is repeated twice during the biennial cycle; the first iteration evolves from the previous biennial cycle's final plan and provides guidance to the next biennial plan's development; while the second economic study cycle analyzes the draft plan and informs decisions made in creating the final plan of the current cycle.

Figure 6 diagrams this process for the current 2008-2009 cycle. The overall planning process runs across all eight quarters and is described in further detail in the Northern Tier Transmission Group's Planning Committee Charter.

A four-quarter economic study cycle is repeated twice during the biennial cycle; the first iteration evolves from the previous biennial cycle's final plan and provides guidance to the next biennial plan's development; while the second economic study cycle analyzes the draft plan and informs decisions made in creating the final plan of the current cycle.

Figure 6: NTTG Eight-Quarter Biennial Process



Adequacy Study – Methodology

Time Frame and Time Scale

The Northern Tier Planning Committee Charter and the Attachments K to most of the member Transmission Providers' Open Access Transmission Tariffs place the planning horizon at least ten years out. Consequently, this study examines the year 2018.

Demand forecasts prepared for integrated resource plans and other electricity planning processes most often use integrated one-hour demands, that is, the average demand for electricity over a one-hour period. Loads and resources used in this study are consistent with this practice.

Base Cases Selected

Northern Tier relied, for its study development, on power flow base cases developed by the WECC and its members. Standard practice across the Western Interconnection, use of the WECC base cases provides the benefit of a massive data collection and vetting process that would otherwise be impossible to match by the sub-regional groups individually.

The Northern Tier Planning Committee chose two base cases appropriate to the Northern Tier footprint from those made available by the WECC. WECC Base Cases are developed for the four seasons, and designed to stress the transmission system at times of heaviest demand in the winter and summer, and at times of lowest demand in spring and autumn when power is moved from remote low-cost resource areas to high-cost population centers.

Annual maximum one-hour demands for the WECC occur during the summer months of June to August, principally due to high levels of air conditioning and other cooling, and so the Planning Committee decided to use a heavy summer case. The WECC had recently prepared such a case for the 2018 operating year, and so the 2018 Heavy Summer Base Case, 18HS1A1, was used as the basis for the Northern Tier analysis.

With forecasts calling for the likely construction of substantial resources in the Northern Tier footprint – well in excess of local demands – significant transmission will be required to move power to distant demand centers. This need is exacerbated by the lack of correlation between wind generation and local demand patterns, and the presence of large amounts of base-load, or flat-loaded, thermal generation. Consequently, the greatest need for inter-regional transmission may occur at times when local load is at its minimum, and so a light autumn case was also selected.

Most WECC base cases are developed for times of overall stress for the Western Interconnection (heavy summer and heavy winter), limiting the selection of cases on which to base the Northern Tier light autumn analysis. The 2010 Light Autumn Base Case, 10LA1SA1, is the most recent WECC case for the season and formed the basis for the NTTG light autumn case.

Modifications & Procedure

Development of the Northern Tier cases by the Technical Work Group was divided into four tasks, led by Transmission Provider engineers. The tasks were focused on loads, resources, and the two base cases. Participating engineers determined the load and resource modifications to be made for their own Balancing Areas, based on data submitted in the Q1 collection and updated to reflect improved information. The engineers then submitted them to the load and the resource task teams.

Each Transmission Provider's participating engineer also provided a definition of the transmission projects they were responsible for, in the form of what were termed 'mod-decks' that consisted of text files defined in either the '.raw' format used by the PTI PSS/E model, or the '.epc' format used by the GE PSLF model. These mod-decks were converted as necessary and incorporated into the developing base cases.

After the addition of each set of transmission modifications, the model was solved (without the load and resource modifications) and passed on to the next engineer. After the projects were included and checked, the loads and resources were enabled and the resulting 2018 case solved. The case was then subjected to contingency analysis.

This process was completed for the heavy summer case, but encountered difficulties when the light autumn case was undertaken. It was evident that conversion of the case between PTI and GE models was introducing instabilities that were difficult to remedy. Consequently, development of the light autumn case was completed and the case analyzed entirely on the PTI platform.

Contingencies Considered

The power flow analyses performed in developing this plan were done in a manner consistent with those done in the Transmission Providers' local planning studies. They began with all transmission elements available in a so-called N-0 run. Non-governor power flow analyses were run on the heavy summer and light autumn base cases, with thermal overloads and voltage excursions examined and addressed. By design, no post-transient voltage stability or transient stability studies were run.

Single-contingency (N-1) studies were then performed, wherein individual transmission line segments or transformers were taken out of service to determine whether the resulting network could properly serve loads with available resources. Again, non-governor power flow runs were examined for thermal overloads and excessive voltage excursions. A limited number of credible common-mode (N-2) outages were also examined.

Details regarding the contingencies studied are not reported here in order to comply with Confidential Energy Infrastructure Information (CEII) requirements. Such details are available, following proper security clearance, from member Transmission Providers and project sponsors.

Economic and Congestion Studies – Methodology

Objective

In accordance with its charter, the Northern Tier Planning Committee will perform a limited number of economic and congestion studies of the sub-regional grid under requested configurations of loads, resources and transmission. In assessing the economic value of potential generation additions and load changes, as well as new transmission projects, it is important to have an indication of how much economical energy generation is unable to reach loads due to congested transmission and the economic benefit of relieving that congestion. The Planning Committee's Economic Studies Project Team will use appropriate tools (whether spreadsheet models or complex hourly commitment and dispatch simulators) to provide such estimates for agreed studies.

Base Case Selected

The WECC Transmission Expansion Planning Policy Committee's Technical Advisory Subcommittee undertook a substantial study program in 2008 to develop and exercise an hourly security-constrained economic dispatch model for the entire Western Interconnection. The subcommittee and its several work groups developed and incorporated detailed modeling data for over 3,000 generating units, over 15,000 transmission buses and more than 20,000 transmission line segments in 43 load areas. The 2017 PC1A1' TEPPC case was selected for the Northern Tier study. That case included the level of renewable resources mandated for the 2017 time frame by Renewable Portfolio Standards in effect at the time the case was developed, amounting to about

Modeling Platform

Northern Tier relies on its transmission provider members to perform necessary studies, including engineers and computer systems. The Economic Studies Program Team chose to employ the models and staff of PacifiCorp and Idaho Power to perform economic studies. The companies use the GridView and PROMOD models, respectively, which are complex hourly electricity commitment and dispatch programs which incorporate detailed transmission calculations and are designed to minimize production costs.

Procedure

Engineers added the portfolio of studied transmission projects to the TEPPC case using modification files developed by project sponsors. On one platform, the modification files were successfully imported directly into the model, while the other required manual modeling of the projects.

Each simulation was then run through one iteration over the 8,760 hours of the 2017 study year. Flows over monitored interfaces were then exported and examined.

Assumptions and Data

As described above, the power flow studies performed by Northern Tier were derived from base cases developed by the WECC. Modifications were made only to the loads, resources and transmission network of the Northern Tier member Transmission Providers, except where specifically noted below.

Load Modeling

Loads in the selected WECC Base Cases were modified to reflect the data submitted in the Quarter 1 data collection process and the forecasts produced by Transmission Providers as part of their Integrated Resource Planning or, where no IRP was done, official load forecasts used in other published planning processes. The non-coincidental summer peak loads submitted by Transmission Providers were used as the basis for calculating corresponding light autumn off-peak loads.

The Technical Work Group used hourly loads reported to the Federal Energy Regulatory Commission on Form 714 for the five years 2003 to 2007. These were averaged for the Rocky Mountain Power Pool (which is approximately representative of the Northern Tier footprint) and the specific hours at which the minimum autumn and maximum summer loads occurred were identified. The ratio of loads on these hours for each of the Transmission Providers' sub-areas were calculated and that ratio applied to the forecasted 2018 summer peak load to derive a light autumn demand forecast. This calculation and the resulting loads used in the Northern Tier studies are summarized in The forecasted loads for each sub-area were distributed to the modeled buses within the sub-area using the autumn and summer factors applied to the bus-level loads in the heavy summer case.

Table 3. The forecasted loads for each sub-area were distributed to the modeled buses within the sub-area using the autumn and summer factors applied to the bus-level loads in the heavy summer case.

Table 2: Determination of representative heavy summer and light autumn hours

Region	Regional Autumn Minimum	Day	Hour	Regional Summer Peak	Day	Hour	Ratio: Autumn / Summer
WECC Total	83,161	22-Oct	4	174,243	26-Jul	16	48%
AZNMNV	10,322	29-Oct	5	36,662	16-Aug	17	28%
CAISO	25,172	2-Apr	5	67,575	26-Jul	16	37%
NWPP	13,153	4-Sep	4	24,647	15-Aug	16	53%
RMPP	14,190	24-Sep	4	30,110	18-Jul	16	47%
CANADA-AL	7,627	22-May	5	9,035	28-Jun	15	58%
CANADA-BC	5,210	2-Jul	6	12,120	14-Jul	13	63%

The forecasted loads for each sub-area were distributed to the modeled buses within the sub-area using the autumn and summer factors applied to the bus-level loads in the heavy summer case.

Table 3: Computation and application of Autumn/Summer ratios by sub-area

State(s)	TEPPC Area	24 Sep 04:00	18 Jul 16:00	Autumn/ Summer	Summer Forecast	Autumn Estimate
ID	FAR EAST	215	471	46%	1,144	526
ID	GOSH	199	518	38%	2,274	874

ID	MAGIC VLY	471	941	50%	521	261
ID	TREAS VLY	909	2,155	42%	2,288	961
MT	NWMT	915	1,727	53%	1,906	1,010
OR	PGN	1,791	3,596	50%	4,331	2,166
OR, WA	PACW	1,668	3,115	54%	3,651	1,972
WY	SW WYO	762	873	87%	1,056	921
WY	BIG HORN	245	235	104%	858	895
WY	CENTL WYO	242	311	78%	723	563
UT N	UT N	2,499	5,663	44%	7,679	3,389
UT S	UT S	297	584	51%	3,132	1,593

Resource Modeling

Resources established in the selected WECC Base Cases were modified to reflect the data submitted in the Quarter 1 data collection process. Data were examined to eliminate duplication or differences in size, location, or characteristics. Resources were coordinated and agreed among the study analysts and, upon proper protection via aggregation or labeling, were reviewed and agreed to by stakeholders.

Each Transmission Provider was responsible for matching loads, resources and interchanges for its Balancing Authority Area. For the conceptual power line from Montana to the Mid-Columbia area (see the Transmission Modeling section below), generation from selected turbines at large hydroelectric projects on the Upper, Middle and Lower Columbia River was reduced by 1,000 megawatts to allow study of the impact resulting from a transfer of that magnitude from Central Montana to the Northwest.

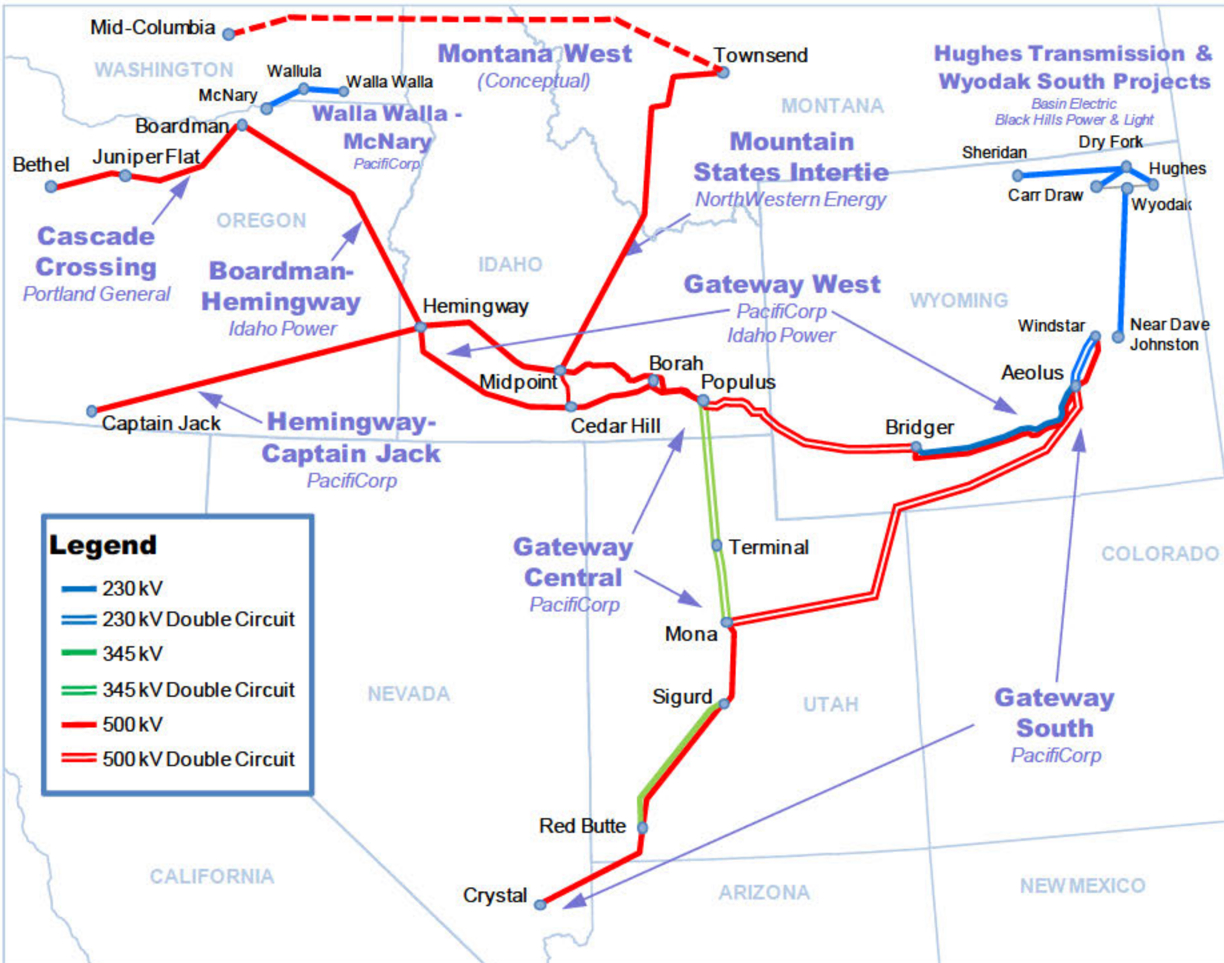
Transmission Modeling

For proposed projects to be considered in the Northern Tier planning process and 10-year planning case reliability performance modeling, sponsors must provide planning data for their projects on a basis comparable to transmission providers that are obligated to serve in or across the Northern Tier footprint. This planning data needs, at a minimum, to include source and ultimate sink identification and transfer requirements such that the appropriate generation and load patterns may be modeled in the studies.

Participants in the Technical Work Group exchange planning data in the first and second quarters of the biennial cycle, whereupon generation and load scenarios are identified and transmission options determined and studied. The Technical Work Group received the required technical data for the projects modeled in the draft plan process. Transmission lines included in the studies were those for which such technical details were made available and for which loads and resources that would make use of the project were identified, together with their points of delivery and receipt.

Further description of the projects studied is located in Appendix B of this report. The details provided there include links to the projects' web sites.

Figure 7: Projects analyzed for the Northern Tier transmission study

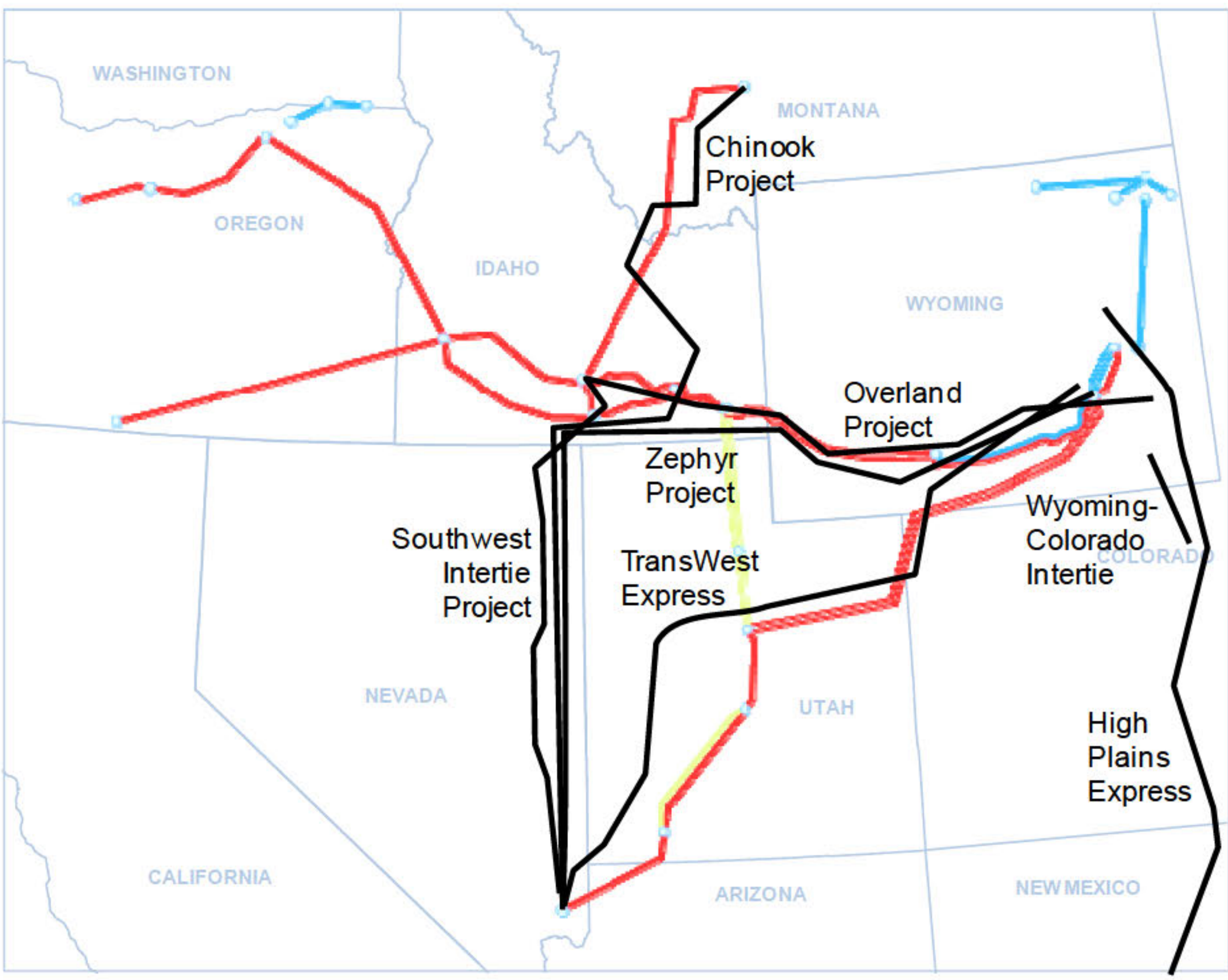


The 2007 Annual Planning Report also included four transmission projects, not sponsored by Northern Tier members, which are focused on serving load requirements outside of the Northern Tier footprint. These projects include the Southwest Intertie Project (North), the TransWest Express project, and the Chinook and Zephyr projects (identified in the 2007 Report as the 'Northern Lights Transmission Project – Inland Project'). These projects are in various stages of the WECC Regional Project Planning Review and Rating processes and have made progress on siting and permitting similar to progress by the projects analyzed by Northern Tier. However, required planning data as defined in the Planning Committee Charter was not made available for these projects during the Northern Tier study process for the 2008-2009 biennial cycle.

In addition to the independent projects (those not sponsored by NTTG members) identified in the 2007 Annual Planning Report, there several other projects with terminals within the Northern Tier footprint that are also being pursued by independent developers including the High Plains Express project, the Overland Intertie project, and the Wyoming-Colorado Intertie project. The general routing plans for these projects are sketched in Figure 8. As these projects develop and planning data is made available, they can be included in upcoming biennial planning cycles.

Sponsors of these projects may also elect to ask (during the appropriate request window) a member Transmission Provider, Northern Tier, or TEPPC to perform an economic planning study including their proposal that would determine the effect of their project on congestion and economic performance. No such requests were received by NTTG from these projects for the current cycle, though some projects are included in this year's TEPPC study process.

Figure 8: Additional projects not included in the Northern Tier study cycle



Results and Observations

Power Flow Studies

The studies performed during the first year of modeling at Northern Tier were focused on the adequacy of proposed transmission in meeting projected loads and resources ten years in the future. Integrating a number of projects into a case developed by multiple parties was challenging but was successfully accomplished. During the second year, a set of scenarios was designed to determine the ability of the network to export additional generation to adjoining sub-regions.

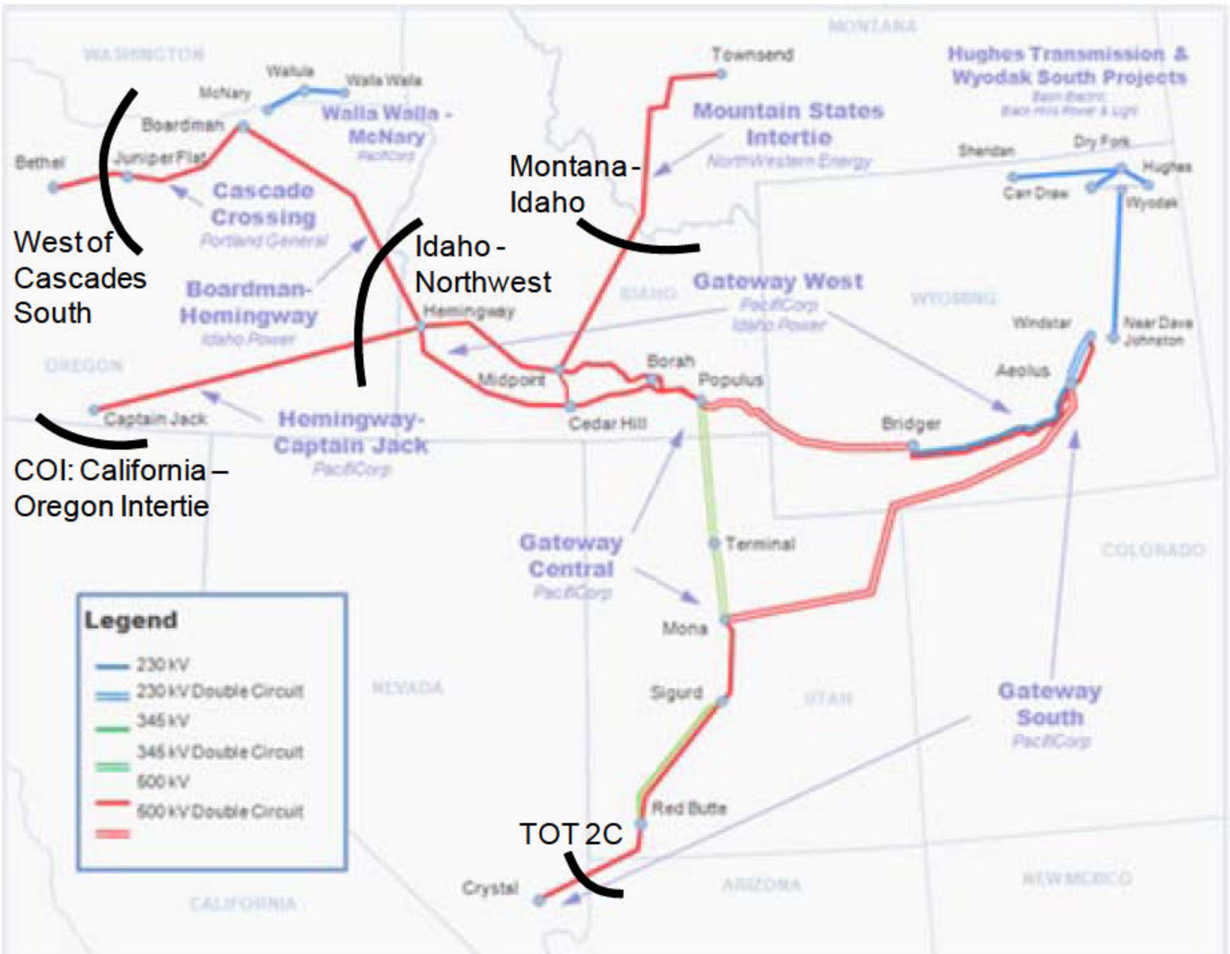
Table 4: Matrix of export scenarios to be considered

Potential Resource Capacity (MW) available in case for export to specified Sink					
Transfers to the Pacific Northwest - Puget Sound area					
Source	**BA**		**Heavy Summer Case**	**Light Autumn Case**	**Comment**
IDAHO POWER					
Borah 500	IPC		250 MW	250 MW	
Midpoint 500	IPC		450 MW	950 MW	
Heminway 500	IPC		750 MW	750 MW	
NORTHWESTERN ENERGY					
Townsend	NWE		1000 MW	1000 MW	In addition to WECC Path 9
PACIFICORP					
Jim Bridger 500	PACE		1,000 MW	1,000 MW	
PORTLAND GENERAL					
Lower Columbia	PGE			400 MW	
Central Oregon	PGE			300 MW	
Portland Area	PGE			900 MW	

Potential Resource Capacity (MW) available in case for export to specified Sink					
Transfers to the Arizona - Phoenix area					
PORTLAND GENERAL					
Lower Columbia	PGE			400 MW	
Central Oregon	PGE			300 MW	
Portland Area	PGE			900 MW	

The cases run were subjected to contingency analysis, which revealed voltage or flow excursions that were either rectified or identified as artifacts of the computer modeling. Nearly all such anomalies were associated with planned facilities for which final and detailed specifications are not yet available, voltages which can be adjusted by switching capacitors or reactors, or which occur at non-load buses. Participating engineers reviewed the results of the studies with regard to their own transmission systems and reported their acceptance of the studies.

Figure 9: Significant paths for which flows are reported



The following table summarizes megawatt flows in the base study and representative scenarios across several significant interfaces within and at the boundaries of the Northern Tier footprint.

Figure 10: Megawatt flows on significant paths under alternative export scenarios

Scenario	MT-ID	ID-NW	TOT-2C	WOCS	COI
Base Case (No Additional Exports)	-172	1,013	714	3,852	-2,801
Hemingway 750 MW to Puget Sound	-189	1,578	810	3,934	-2,923
Townsend 1,000 MW to Puget Sound	871	1,781	814	3,935	-2,937
Bridger 1,000 MW to Puget Sound	-355	1,498	835	3,934	-2,984

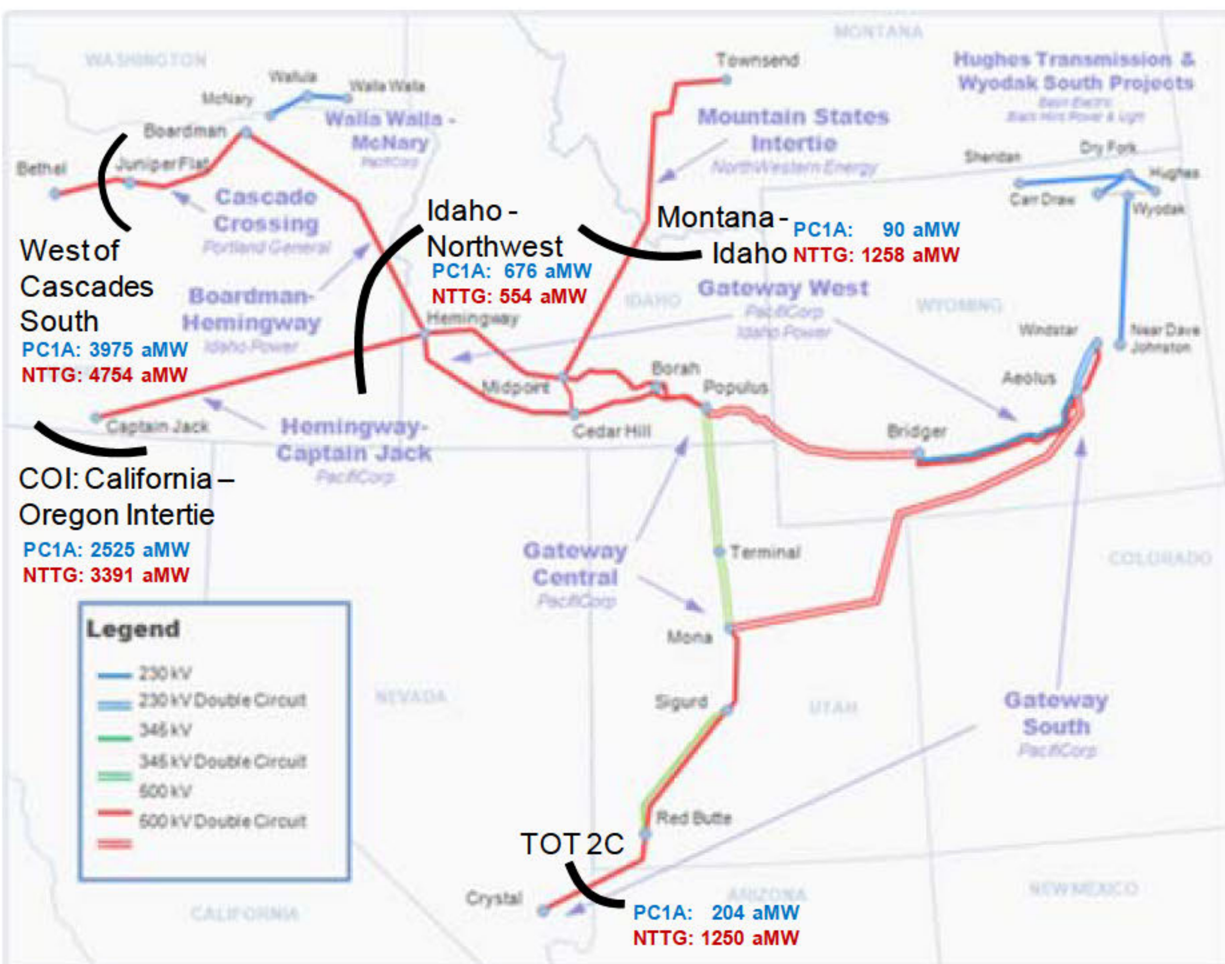
Portland 900 MW to Puget Sound	-187	1,001	738	3,715	-2,794
Portland 900 MW to Phoenix Area	-48	790	922	3,839	-2,312

Economic and Congestion Studies

No economic congestion studies were performed at Northern Tier in 2008, as no viable requests were received. In 2009, the Planning Committee elected to perform an hourly study of the transmission portfolio included in the reliability studies. The study provided an opportunity to test the modeling systems used by the committee, to examine the model-reported use of transmission paths, and to gain confidence in the ability of the models to address Northern Tier economic and congestion issues.

The Economic Studies Project Team extracted and studied the hourly flows across the same set of interfaces reported above for the power flow studies. The diagram below shows the average annual energy flows across the paths, with and without the portfolio projects.

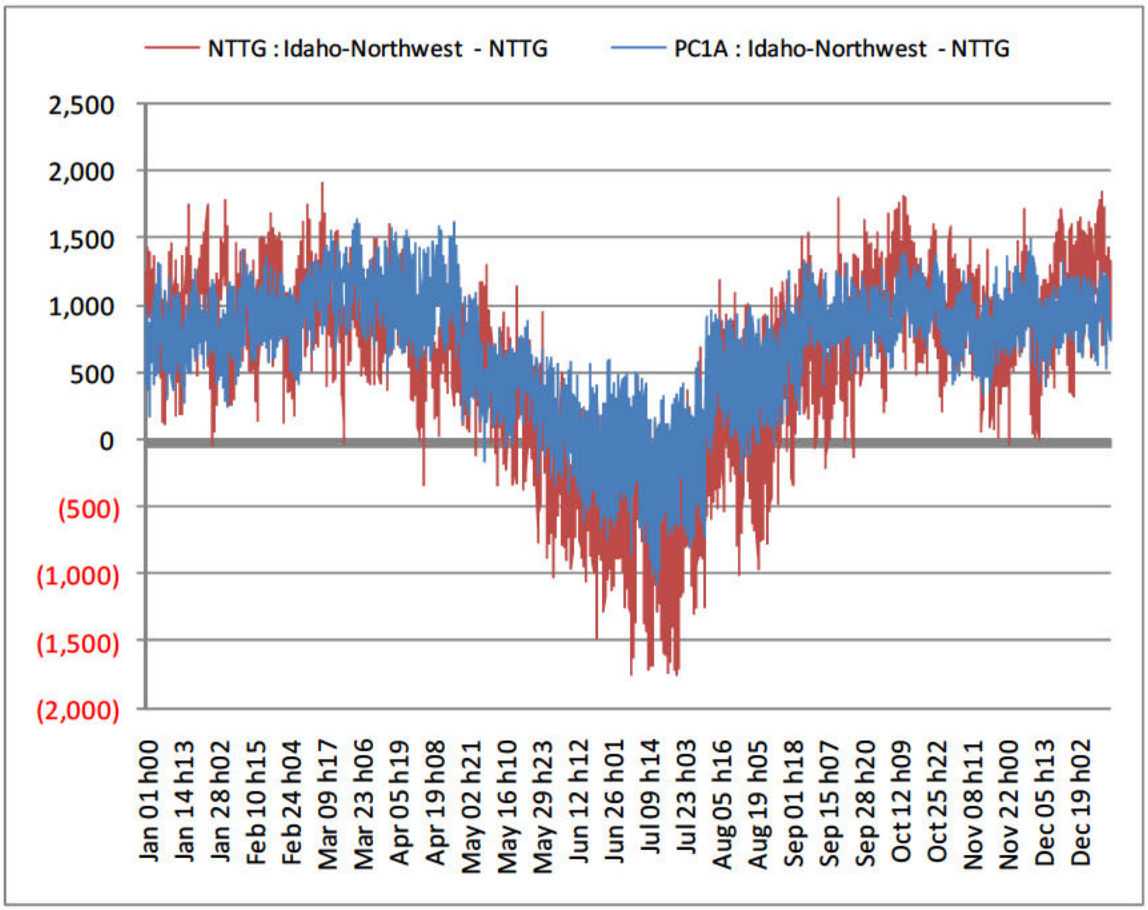
Figure 11: Energy flows on significant paths with and without portfolio transmission



The MSTI line was added to the WECC Montana-Idaho path, the Gateway South project to the TOT-2C path, Gateway West to the Bridger West path, the Boardman-Hemingway and Hemingway-Captain Jack lines to the Idaho-Northwest path, and the Cascade Crossing project to the West of Cascades South path in calculating flows.

The following chart shows the chronological flows across one of the interfaces, from Idaho to the Northwest (and from the Northwest to Idaho when negative), for the hours of the study year. The red line shows flows with the portfolio transmission, and indicates increased flows into Idaho during the summer months and increased diurnal exchanges across the entire year (to the Northwest during off-peak hours and to Idaho during on-peak hours).

Figure 12: Hourly flows across the Idaho-Northwest path with & without studied projects



Execution of the two security-constrained economic commitment and optimal dispatch models produced comparable results, though model evaluation and comparison was not an objective of the project. The Economic Studies Project Team reviewed and accepted the study, which was presented at the Northern Tier Stakeholders' Meeting in July, 2009.

Northern Tier Transmission Group

2008-2009 Biennial Plan

Appendices

Gateway Central Project under Construction at the Populus Substation in Idaho

Appendix A: Internet Links and Other References

Regional Planning

- Western Electricity Coordinating Council
  (http://www.wecc.biz)
  - Transmission Expansion Planning Policy Committee
    (http://www.wecc.biz/committees/BOD/TEPPC/default.aspx)
  - Planning Coordination Committee
    (http://www.wecc.biz/committees/StandingCommittees/PCC/default.aspx)
- Western Interstate Energy Board (WIEB)
  (http://www.westgov.org/wieb /)
  The energy arm of the Western Governors Association

Sub-Regional Planning

- Northern Tier Transmission Group
  (http://www.nttg.biz)
- ColumbiaGrid
  (http://www.columbiagrid.org)
- WestConnect (and Sub-Groups)
  (http://www.westconnect.com/planning.php)
  - Colorado Coordinated Planning Group
  - National Renewable Energy Laboratory
  - Sierra Pacific Planning Group
  - Southwest Area Transmission
- Transmission Coordination Working Group (TCWG)
  (http://www.nwpp.org/tcwg/)

Northern Tier Transmission Group Members

- Deseret Generation & Transmission
  (http://www.oasis.pacificorp.com/oasis/dgt/main.html)
- Idaho Power Company
  (http http://www.oatioasis.com/ipco/index.html)
- Northwestern Energy
  (http://www.oatioasis.com/NWMT/index.html)

- PacifiCorp
  (http://www.oasis.pacificorp.com/oasis/ppw/main.htmlx)

- Portland General Electric
  (http://www.oatioasis.com/pge/index.html)

- Utah Associated Municipal Power Systems
  (http://www.uamps.com)

Integrated Resource Plans

- Idaho Power Company
  (http://www.idahopower.com/AboutUs/PlanningForFuture/irp/default.cfm)
  Idaho Power is undertaking development of its 2009 Integrated Resource Plan, which should be complete by the end of 2009.

- NorthWestern Energy
  (http://www.northwesternenergy.com/display.aspx?Page=Default_Supply_Electric&Item=16)
  NorthWestern does not produce an 'Integrated Resource Plan', *per se*, but they maintain and make available an "Electric Default Supply Resource Procurement Plan.'

- PacifiCorp
  (http://www.pacificorp.com/es/irp.html)
  PacifiCorp's currently posted plan was completed in May of 2007, and development of the 2008 IRP is currently underway.

Additional Information for Transmission Projects

- Boardman to Hemingway
  (http://www.boardmantohemingway.com/)

- Cascade Crossing
  (http://www.oatioasis.com/pge/index.html) Click on 'Cascade Crossing Project' in the left-side column.

- Hemingway to Captain Jack
  (http://www.pacificorp.com/tran/tp/eg/shhtcj.html)

- Gateway Central
  (http://www.pacificorp.com/tran/tp/eg/gc.html)

- Gateway South
  (http://www.pacificorp.com/tran/tp/eg/gs.html)

- Gateway West
  (http://www.pacificorp.com/tran/tp/eg/gw.html)

- High Plains Express
  (https://www.highplainsexpress.com/)

- Mountain States Transmission Intertie
  (http://www.msti500kv.com/)

- Overland Intertie
  (http://www.swipos.com/overland_intertie.htm)
- Southwest Intertie Project
  (http://www.swipos.com/index.htm)
- TransCanada Zephy and Chinook Transmission Lines
  (http://www.transcanada.com/company/zephyr_chinook.html)
- Transwest Express
  (https://transwestexpress.net/)
- Wyoming-Colorado Intertie
  (http://wcintertie.com/)

Appendix B: Project Details

This appendix provides detail for the projects included in the 2008 adequacy studies, in the format designed within the context of the WECC TEPPC data collection process.

NOTE: The information provided in this appendix is dynamic and may not reflect current project configurations or the assumptions used at the time Northern Tier analyses were performed. The information is collected and provided here for convenience; specific data should be confirmed on the project sponsor's Web site or via processes posted on their respective OASIS systems.

The segments collected here include (in generally east-to-west order):

(To jump to the first page for a given project, hold the CTRL key down and click on the name.)

[2] Project 8 is now the same as Project 4: Gateway South, Mona – Crystal.

[3] Portland General's Cascade Crossing project was previously referred to as Southern Crossing.

Project 1: Hughes Transmission Project

Project name: (TEPPC #49)	**Hughes Transmission Project**
Project overview:	
• Purpose (renewable delivery, etc.)	Meet load growth needs in Northeastern Wyoming, increased system reliability.
• New or upgrade	New
• Estimated in-service date	2009
• Estimated transfer capability/rating (MW)	
Project sponsor(s):	
• Organization name(s)	Basin Electric Power Cooperative
• Project website (hyperlink)	
• Project information contact for updates (name, phone and e-mail)	Matthew Stoltz (Basin Electric Power Cooperative) 701-557-5647 mstoltz@bepc.com
• Date of last information update	February 6, 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	230 kV
• Point of origin	Hughes and Carr Draw Substations, WY
• Point of termination	Sheridan Substation, WY
• Intermediate points of interconnection	Dry Fork Substation, WY
• General route	
• Length in miles	Approximately 140 miles (105 miles Hughes to Sheridan and 35 miles Dry Fork to Carr Draw)
• Conductor size and % compensation	
• Estimated cost (optional)	

• Other related projects	
Project map: (website hyperlink)	
Project status:	
(provide information as applicable indicating both current status and next steps) • Type project – conceptual, planned, or under-construction	Under Construction
• WECC Regional Planning and Project Rating Review Status	Not Applicable
• WECC reports submitted (Significant Additions and/or Annual Progress)	Yes
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	June 2008 to August 2009
Analytic studies: (provide information as available)	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 2: Wyodak South Project

Project name: (TEPPC #50)	**Wyodak South 230 kV Project**
Project overview:	
• Purpose (renewable delivery, etc.)	Meet load growth, provide increased reliability, increase transfer capability into and out of system.
• New or upgrade	New
• Estimated in-service date	2010
• Estimated transfer capability/rating (MW)	550 MW
Project sponsor(s):	
• Organization name(s)	Black Hills Power
• Project website (hyperlink)	
• Project information contact for updates (name, phone and e-mail)	Eric Egge (Black Hills Corp) 605-721-2646 eric.egge@blackhillscorp.com
• Date of last information update	February 5, 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	230 kV
• Point of origin	Donkey Creek (near Gillette), WY
• Point of termination	Near Dave Johnston (near Glenrock), WY
• Intermediate points of interconnection	Pumpkin Buttes (near Wright), WY
• General route	South and east from Donkey Creek to Pumpkin Buttes and south to the DJ area.
• Length in miles	Approximately 110 miles (50 miles Donkey Creek to Pumpkin Buttes and 60 miles Pumpkin Buttes to DJ Area)
• Conductor size and % compensation	1272 ACSR

• Estimated cost (optional)	
• Other related projects	
Project map: (website hyperlink)	
Project status:	
• Type project – conceptual, planned, or under-construction	Planned/Under Construction
• WECC Regional Planning and Project Rating Review Status	
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	2008 to mid-2010
Analytic studies: (provide information as available)	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 3: Mountain States Transmission Intertie

Project name: (TEPPC #22)	**Mountain States Transmission Intertie** (MISTI) (Townsend-Midpoint 500 kV)
Project overview:	
• Purpose (renewable delivery, etc.)	MSTI will relieve transmission constraints between Montana and Idaho and promote the development and delivery of the substantial renewable energy resources in NorthWestern's service area to customers in the West.
• New or upgrade	New
• Estimated in-service date	2014
• Estimated transfer capability/rating (MW)	1500 MW north to south 950 MW south to north
Project sponsor(s):	
• Organization name(s)	Northwestern Energy
• Project website (hyperlink)	http://www.msti500kv.com/about/aboutproject_nav.html
• Project information contact for updates (name, phone and e-mail)	John Leland (406) 497-3383 John.Leland@NorthWestern.com
• Date of last information update	14 Nov 2009
Other project participant(s):	None
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Townsend, MT
• Point of termination	Midpoint, ID
• Intermediate points of interconnection	None
• General route	See maps.
• Length in miles	Approx 430 Miles
• Conductor size and % compensation	70% compensation
• Estimated cost (optional)	
• Other related projects	NorthWestern will construct a series of generator lead lines from high wind areas in Montana to Townsend. The size, location and routing of these lines will be determined through an open season solicitation to be

	conducted in the first quarter of 2010.
Project map: (website hyperlink)	http://www.msti500kv.com/routes_maps/alternatives.html and eliminated routes at http://www.msti500kv.com/routes_maps/consideredElim.html
Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Completed Regional Planning and Phase 1 Path Rating Review processes, and expect to finish Phase 2 by year-end 2009.
• WECC reports submitted (Significant Additions and/or Annual Progress)	Regional Planning Report, Phase 1 Comprehensive Progress Report, Annual Progress Reports, and Significant Additions Report.
• WECC power flow base cases where represented	Not included in WECC base cases at this time.
• Regulatory applications and approvals (permitting, siting, etc.)	Final EIS is expected Sep. 2010. Substantially all federal, state and county permits and approvals are expected to be obtained by fall of 2011.
• Estimated construction schedule	2011-2014; in-service 2014.
Analytic studies:	
• Economic screening with assumptions	The successful open season participants will provide the economic screening.
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	The economic analysis for MSTI will be a result of an open season solicitation for Transmission Service from customers. MSTI is not a transmission line for serving network load from a vertically integrated utility.
• Power flow and stability analysis	NWE has completed power flow and stability analysis for MSTI. These studies were necessary to progress through the WECC Regional Planning Process and the WECC Phase 1 Path Rating studies necessary for the Comprehensive Progress Report.
• WECC Path Rating studies	MSTI is in Phase 2 of the WECC Path Rating process, with completion expected by year-end 2009. Phase 1 and the Regional Planning Process are complete.
• Siting studies	Siting application submitted in MT and ID, expect completion in 2010.

• Environmental impact statement	Draft EIS expected 1st quarter 2010, Final by Sep 2010.

Project 4: Gateway South, Sigurd – Crystal

Project name: (TEPPC #9)	**Gateway South Project, Sigurd – Crystal 500 kV**
Project overview:	
• Purpose (renewable delivery, etc.)	Delivery of renewable energy; increased capacity to reliably serve load
• New or upgrade	New
• Estimated in-service date	2014 for 345 kV Sigurd – Red Butte (Red Butte – Crystal under review)
• Estimated transfer capability/rating (MW)	600 MW for Sigurd – Red Butte in 2014; up to 1500 MW bidirectional with Red Butte – Crystal and Mona to Sigurd
Project sponsor(s):	
• Organization name(s)	PacifiCorp
• Project website (hyperlink)	http://www.pacificorp.com/Article/Article79647.html
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	345 kV for Sigurd – Red Butte, 500kV for later segments
• Point of origin	Sigurd, UT
• Point of termination	Crystal (near Las Vegas), NV
• Intermediate points of interconnection	None
• General route	
• Length in miles	About 330 miles (160 miles for Sigurd – Red Butte)
• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Gateway West and Gateway South
Project map: (website hyperlink)	http://www.pacificorp.com/Article/Article79554.html
Project status:	

• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	
Analytic studies:	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 5: Gateway South, Aeolus – Mona

Project name: (TEPPC #10)	**Gateway South Project, Aeolus - Mona**
Project overview:	
• Purpose (renewable delivery, etc.)	Delivery of renewable energy from Wyoming to Utah and Desert Southwest and provides backup for Gateway west. In addition, the proposed line will help to maintain system reliability and support new renewable energy development.
• New or upgrade	New
• Estimated in-service date	2017-2019
• Estimated transfer capability/rating (MW)	1500 MW, up to 3000 MW bidirectional
Project sponsor(s):	
• Organization name(s)	PacifiCorp
• Project website (hyperlink)	http://www.pacificorp.com/Article/Article82892.html
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Aeolus (near Medicine Bow), WY
• Point of termination	Mona, UT
• Intermediate points of interconnection	None
• General route	
• Length in miles	Approximately 395 miles
• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Gateway West and Gateway South
Project map: (website hyperlink)	http://www.pacificorp.com/Article/Article79554.html
Project status:	

• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	
Analytic studies: (provide information as available)	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 6: Gateway Central, Populus – Terminal

Project name: (TEPPC #11.1)	**Gateway Central Project, Populus-Terminal**
Project overview:	
• Purpose (renewable delivery, etc.)	Meet load growth, provide increased reliability, increase transfer capability between the east and west control area, facilitate delivery of power and provide greater operational flexibility.
• New or upgrade	New
• Estimated in-service date	2010
• Estimated transfer capability/rating (MW)	700 MW up to 1,400 MW
Project sponsor(s):	
• Organization name(s)	PacifiCorp
• Project website (hyperlink)	http://www.pacificorp.com/Article/Article79647.html
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 Jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	345 kV
• Point of origin	Populus (near Downey), ID
• Point of termination	Terminal (near Salt Lake), UT
• Intermediate points of interconnection	Ben Lomond (near Ogden), UT
• General route	Along the I-15 corridor.
• Length in miles	Approximately 135 miles
• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Gateway West projects, Gateway South projects
Project map: (website hyperlink)	http://www.pacificorp.com/File/File84707.pdf
Project status:	

• Type project – conceptual, planned, or under-construction	Under Construction
• WECC Regional Planning and Project Rating Review Status	Phase 3
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	2009-2010
Analytic studies:	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 7: Gateway Central, Mona – Oquirrh

Project name: (TEPPC #11.2)	**Gateway Central Project, Mona -Oquirrh**
Project overview:	
• Purpose (renewable delivery, etc.)	Meet load growth, provide increased reliability and improved operational flexibility in conjunction with future generation resources, including renewable resources such as wind.
• New or upgrade	New
• Estimated in-service date	2012
• Estimated transfer capability/rating (MW)	700 MW up to 1,500 MW
Project sponsor(s):	
• Organization name(s)	PacifiCorp
• Project website (hyperlink)	http://www.pacificorp.com/Article/Article77800.html
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV and 345 kV
• Point of origin	Mona substation near Mona, in Juab County
• Point of termination	Oquirrh (West Jordan), UT
• Intermediate points of interconnection	
• General route	.
• Length in miles	Approximately 86 miles
• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Gateway West projects, Gateway South projects
Project map: (website hyperlink)	http://www.pacificorp.com/Article/Article79554.html
Project status:	

• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	2012
Analytic studies: (provide information as available)	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 8: Gateway Central, Sigurd – Red Butte – Crystal

This project is now the same as Project 4: Gateway South, Sigurd – Crystal.

Project 9: Gateway West, Windstar – Jim Bridger

Project name: (TEPPC #20.1)	**Gateway West Transmission Project, Windstar – Jim Bridger**
Project overview:	
• Purpose (renewable delivery, etc.)	Delivery of new resources in transmission service request queues, to ensure reliable electric service to customers and to also accommodate regional needs for integrating renewable and other resource development.
• New or upgrade	New
• Estimated in-service date	2017
• Estimated transfer capability/rating (MW)	700 MW, Windstar to Aeolus 700 MW up to 1500 MW, Aeolus to Bridger, 3000 MW with full plan
Project sponsor(s):	
• Organization name(s)	PacifiCorp and Idaho Power
• Project website (hyperlink)	http://www.tops.pacificorp.com/oasis/ppw/energygateway.html http://www.oatioasis.com/IPCO/IPCOdocs/OASIS_Transmission_Projects.pdf http://www.gatewaywestproject.com/
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 Jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	230 kV and 500 kV
• Point of origin	Windstar (near Casper), WY
• Point of termination	Jim Bridger (near Rock Springs), WY
• Intermediate points of interconnection	Aeolus (near Medicine Bow), WY
• General route	Southeast Windstar-Aeolus and west Aeolus-Jim Bridger
• Length in miles	298 miles (approximately)

• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Other Gateway West segments, Gateway South, and Populus-Terminal
Project map: (website hyperlink)	http://www.oatioasis.com/IPCO/IPCOdocs/GW_Corridor_Map_04-01-08.pdf
Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	
Analytic studies:	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• Siting studies	BLM is the lead NEPA agency. http://www.wy.blm.gov/nepa/cfodocs/gateway_west/
• Environmental impact statement	Expect the draft EIS spring 2009, final EIS early 2011, and Record of Decision in late 2011

Project 10: Gateway West, Jim Bridger - SE Idaho

Project name: (TEPPC #20.2)	**Gateway West Transmission Project, Jim Bridger – Southeast Idaho**
Project overview:	
• Purpose (renewable delivery, etc.)	Delivery of new resources in transmission service request queues, to ensure reliable electric service to customers and to also accommodate regional needs for integrating renewable and other resource development.
• New or upgrade	New
• Estimated in-service date	2014-2017
• Estimated transfer capability/rating (MW)	700 MW, up to 1500 MW phase 1, 3000 MW full plan
Project sponsor(s):	
• Organization name(s)	PacifiCorp and Idaho Power
• Project website (hyperlink)	http://www.tops.pacificorp.com/oasis/ppw/energygateway.html http://www.oatioasis.com/IPCO/IPCOdocs/OASIS_Transmission_Projects.pdf http://www.gatewaywestproject.com/
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 Jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Jim Bridger, near Rock Springs, WY
• Point of termination	Populus (near Downey), ID
• Intermediate points of interconnection	None
• General route	Generally near Bridger-Borah and Bridger-Kinport 345 kV lines
• Length in miles	Approximately 191 miles
• Conductor size and % compensation	

• Estimated cost (optional)	
• Other related projects	Other Gateway West segments, Gateway South, and Populus-Terminal
Project map: (website hyperlink)	http://www.gatewaywestproject.com
Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	
Analytic studies:	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• Siting studies	BLM is the lead NEPA agency. http://www.wy.blm.gov/nepa/cfodocs/gateway_west/ http://www.gatewaywestproject.com/
• Environmental impact statement	Expect the draft EIS spring 2010, final EIS early 2011, and Record of Decision in late 2011

Project 11: Gateway West, SE Idaho – S Central Idaho

Project name: (TEPPC #20.3)	**Gateway West Transmission Project, Southeast Idaho – South Central Idaho**
Project overview:	
• Purpose (renewable delivery, etc.)	Increased capacity to serve and reliably deliver energy to customers; support new renewable and other resource development
• New or upgrade	New
• Estimated in-service date	2016-2017
• Estimated transfer capability/rating (MW)	700 MW, up to 1500 MW in phase 1, 3000 MW full plan
Project sponsor(s):	
• Organization name(s)	PacifiCorp and Idaho Power
• Project website (hyperlink)	http://www.tops.pacificorp.com/oasis/ppw/energygateway.html http://www.oatioasis.com/IPCO/IPCOdocs/OASIS_Transmission_Projects.pdf http://www.gatewaywestproject.com/
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 Jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Populus (near Downey), ID
• Point of termination	Midpoint, ID
• Intermediate points of interconnection	None
• General route	Populus-Borah-Midpoint or Populus-Cedar Hill-Midpoint
• Length in miles	Approximately 135 miles
• Conductor size and % compensation	
• Estimated cost (optional)	

• Other related projects	Other Gateway West segments, Gateway South, and Populus-Terminal
Project map: (website hyperlink)	http://www.gatewaywestproject.com/
Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• Estimated construction schedule	
Analytic studies:	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.gatewaywestproject.com/
• Siting studies	BLM is the lead NEPA agency. http://www.wy.blm.gov/nepa/cfodocs/gateway_west/
• Environmental impact statement	Expect the draft EIS spring 2010, final EIS early 2011, and Record of Decision in late 2011

Project 12: Gateway West, S Central Idaho – SW Idaho

Project name: (TEPPC #20.4)	**Gateway West Transmission Project, South Central Idaho – Southwest Idaho**
Project overview:	
• Purpose (renewable delivery, etc.)	Increased capacity to serve and reliably deliver energy to customers; support new renewable and other resource development
• New or upgrade	New
• Estimated in-service date	2016-2017
• Estimated transfer capability/rating (MW)	700 MW, up to 1500 MW in phase 1, 3000 MW full plan
Project sponsor(s):	
• Organization name(s)	PacifiCorp and Idaho Power
• Project website (hyperlink)	http://www.tops.pacificorp.com/oasis/ppw/energygateway.html http://www.oatioasis.com/IPCO/IPCOdocs/OASIS_Transmission_Projects.pdf http://www.gatewaywestproject.com/
• Project information contact for updates (name, phone and e-mail)	Jamie Austin (PacifiCorp) 503-813-5396 Jamie.austin@pacificorp.com
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Midpoint, ID and Cedar Hill (near Twin Falls), ID
• Point of termination	Hemingway, ID
• Intermediate points of interconnection	None
• General route	Midpoint-Hemingway, Cedar Hill-Hemingway
• Length in miles	Approximately 149 miles
• Conductor size and % compensation	
• Estimated cost (optional)	

• Other related projects	Other Gateway West segments, Gateway South, and Populus-Terminal
Project map: (website hyperlink)	http://www.gatewaywestproject.com
Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• Estimated construction schedule	
Analytic studies: (provide information as available)	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	Comprehensive Progress Report was approved February 9, 2009 and is available at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3203
• Siting studies	BLM is the lead NEPA agency. http://www.wy.blm.gov/nepa/cfodocs/gateway_west/
• Environmental impact statement	Expect the draft EIS spring 2010, final EIS early 2011, and Record of Decision in late 2011

Project 13: Boardman – Hemingway

Project name: (TEPPC #21)	**Boardman-Hemingway** 500 kV (B2H)
Project overview:	
• Purpose (renewable delivery, etc.)	Delivery of generating resources, market access and transmission service requests
• New or upgrade	New
• Estimated in-service date	2015
• Estimated transfer capability/rating (MW)	This project would increase import capability from the Northwest into Idaho by approximately 850 MW and export capabilities by approximately 800 MW (with Gateway West in service). The project is undergoing independent WECC rating with expected ratings of 1300 MW west-to-east and 800 MW east-to-west (1400 MW with the Gateway West project in service providing additional source capabilities, removing constraints near Midpoint).
Project sponsor(s):	
• Organization name(s)	Idaho Power
• Project website (hyperlink)	http://www.boardmantohemingway.com/
• Project information contact for updates (name, phone and e-mail)	Kip Sikes 208-388-2459 dsikes@idahopower.com
• Date of last information update	10/22/2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Boardman, OR
• Point of termination	Hemmingway (near Boise), ID
• Intermediate points of interconnection	
• General route	Northeastern Oregon to Southwestern Idaho
• Length in miles	300 miles (approximately)
• Conductor size and % compensation	Triple-bundle 1272 Bittern (3000 MVA thermal limit), up to 70% compensation – pending under study

• Estimated cost (optional)	$600 million
• Other related projects	None required – being studied independently, as well as with interactions with other projects
Project map: (website hyperlink)	Current maps available at: http://www.boardmantohemingway.com/documents/map_project_location.pdf
Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 2
• WECC reports submitted (Significant Additions and/or Annual Progress)	Comprehensive Progress Report was approved February 9, 2009 and is available at http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3201
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	Rating study cases being used are 2012-HS, and 2010/12-LA, 2015-HS BLM NEPA and ODOE-EFSC siting processes have begun public scoping. Permitting and ROW is expected to continue through mid 2011
• Estimated construction schedule	2013-2015
Analytic studies:	
• Economic screening with assumptions	NTTG Cost Allocation process and project review information is included at http://www.oatioasis.com/IPCO/IPCOdocs/IPC_HEMINGWAY_TO_BOARDMAN_Cost_Allocation_Proces.pdf
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	Phase 1 Comprehensive Progress Report at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3201
• WECC Path Rating studies	Phase 1 Comprehensive Progress Report at: http://www.wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=getit&lid=3201
• Siting studies	Siting information including preferred and alternative routes are on the web site at:

	http://www.boardmantohemingway.com/maps.aspx
• Environmental impact statement	After company-sponsored public routing is completed, the BLM will re-issue an NOI with Scoping anticipated in early Spring of 2010 and a draft EIS anticipated in Winter 2010.

Project 14: Hemingway – Captain Jack

Project name: (TEPPC #31)	**Hemingway-Captain Jack**
Project overview:	
• Purpose (renewable delivery, etc.)	Increased system flexibility and reliability between PacifiCorp's East and West Control Areas, relieve congested paths Idaho to Northwest and connect to resource centers in Wyoming to Southern Oregon loads; support new renewable energy development.
• New or upgrade	New
• Estimated in-service date	Timing under review
• Estimated transfer capability/rating (MW)	1500 MW bidirectional
Project sponsor(s):	PacifiCorp
• Organization name(s)	http://www.pacificorp.com/Article/Article79647.html
• Project website (hyperlink)	Jamie Austin (PacifiCorp) 503-813-5396 jamie.austin@pacificorp.com
• Project information contact for updates (name, phone and e-mail)	
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Hemmingway (near Boise), ID
• Point of termination	Captain Jack (near Malin), OR
• Intermediate points of interconnection	None
• General route	South southwest across eastern Oregon
• Length in miles	Approximately 375 miles
• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Gateway West Projects
Project map: (website hyperlink)	http://www.pacificorp.com/Article/Article79554.html

Project status:	
(provide information as applicable indicating both current status and next steps) • Type project – conceptual, planned, or under-construction	Conceptual
• WECC Regional Planning and Project Rating Review Status	Phase 1
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	
Analytic studies: (provide information as available)	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 15: Walla Walla – McNary

Project name: (TEPPC #32)	**Walla Walla – McNary**
Project overview:	
• Purpose (renewable delivery, etc.)	Reliable service for growing load; support new renewable energy development
• New or upgrade	New
• Estimated in-service date	Timing under review
• Estimated transfer capability/rating (MW)	400 MW bidirectional
Project sponsor(s):	PacifiCorp
• Organization name(s)	http://www.pacificorp.com/Article/Article79865.html
• Project website (hyperlink)	Jamie Austin (PacifiCorp) 503-813-5396 jamie.austin@pacificorp.com
• Project information contact for updates (name, phone and e-mail)	
• Date of last information update	October 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	230 kV
• Point of origin	Walla Walla, WA
• Point of termination	McNary (near Umatilla) OR
• Intermediate points of interconnection	Wallula, WA
• General route	West from Walla Walla substation to Wallula substation then along Columbia River to McNary substation.
• Length in miles	Approximately 56
• Conductor size and % compensation	
• Estimated cost (optional)	
• Other related projects	Gateway West Projects
Project map: (website hyperlink)	http://www.pacificorp.com/File/File82623.pdf
Project status:	

• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 1
• WECC reports submitted (Significant Additions and/or Annual Progress)	
• WECC power flow base cases where represented • Regulatory applications and approvals (permitting, siting, etc.)	
• Estimated construction schedule	
Analytic studies:	
• Economic screening with assumptions	
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	
• Power flow and stability analysis	
• WECC Path Rating studies	
• Siting studies	
• Environmental impact statement	

Project 16: Cascade Crossing

Project name: **(TEPPC #33)**	**Cascade Crossing**
Project overview:	
• Purpose (renewable delivery, etc.)	Meet Generation Interconnection & Network Integration Transmission Service Requests
• New or upgrade	New
• Estimated in-service date	Second quarter, 2015
• Estimated transfer capability/rating (MW)	1500 MW proposed WECC project rating
Project sponsor(s):	
• Organization name(s)	Portland General Electric Company
• Project website (hyperlink)	http://www.oatioasis.com/pge/index.html
• Project information contact for updates	Philip Augustin, 503-464-7783 philip.augustin@pgn.com
• Date of last information update	October 2, 2009
Other project participant(s):	
Project characteristics:	
• Voltage class	500 kV
• Point of origin	Boardman OR, (new substation) near Coyote Springs plant
• Point of termination	Salem OR, existing Bethel substation
• Intermediate points of interconnection	New substations at Juniper Flat , Boardman
• General route	New right-of-way from the Coyote Springs plant to the Boardman plant, then the proposed Project Study Corridor is adjacent to existing transmission corridors as much as possible for the entire route from Boardman to Bethel.
• Length in miles	200 miles
• Conductor size and % compensation	Triple Bundled 1272 ASCR or equivalent, uses 70% compensation
• Estimated cost (optional)	
• Other related projects	See TCWG and NTTG lists of projects
Project map: (website hyperlink)	http://www.oatioasis.com/pge/index.html

Project status:	
• Type project – conceptual, planned, or under-construction	Planned
• WECC Regional Planning and Project Rating Review Status	Phase 1 in progress; Report under review by Project Rating Review group
• WECC reports submitted (Significant Additions and/or Annual Progress)	Submitted in 2008/09 Annual Progress Report
• WECC power flow base cases where represented	Not represented in WECC cases
• Regulatory applications and approvals (permitting, siting, etc.)	Preliminary permitting and siting in progress
• Estimated construction schedule	Begin in 2011
Analytic studies:	
• Economic screening with assumptions	In progress
• Detailed economic analysis and cost/benefit including consideration of alternatives or new technologies	In progress
• Power flow and stability analysis	Studies have been completed and additional studies are underway
• WECC Path Rating studies	Regional Planning finalized, Phase I Studies are in progress
• Siting studies	In progress
• Environmental impact statement	In progress

NORTHERN TIER TRANSMISSION GROUP

2010-2011 Biennial Transmission Plan

Final Report

December 1, 2011

Approved: 10.31.11 NTTG Planning Committee
Approved: 11.29.11 NTTG Steering Committee

This is the final report of the 2010-2011 Biennial Transmission Plan of the Northern Tier Transmission Group. It's our second biennial report, and we think it's our best work yet. The report represents the collective efforts of many people. Our thanks go out to the numerous Northern Tier transmission provider engineers and Comprehensive Power Solutions staff who did yeoman's work in soliciting and collecting the data, running the analyses, listening to and incorporating feedback, and preparing the studies. They did a commendable job, and we're proud of their product.

We'd also like to thank you, our stakeholders, for your interest and participation in NTTG public processes. You helped make this a better plan.

If you're familiar with our 2008-2009 report, you'll notice some differences. Right off, this report is bigger. We've included more data to support our findings, and we've included more background and appendices for those of you who want to dig deeper. More fundamentally, we eliminated the use of multi-season WECC base cases to do reliability testing, an approach that had created some hurdles in the 2008-2009 report. In a nutshell, the new method, which is described in detail in the report, pinpointed five critical hours of transmission congestion and peak loads. Studying the effects of load growth and new generation on the transmission system at these hours formed the core of the study.

The study confirms what many of you already suspect, that our region will need new transmission to connect electricity consumers with new sources of energy. The good news is that our transmission providers already are planning to build those transmission projects. However, the study also shows that any large new generation projects, such as the wind power resources simulated in the study, will require additional AC or DC transmission beyond what's planned. We hope this report bolsters that work, and adds to the larger job of building a more reliable grid throughout the West.

We invite you to read the report critically. Let us know if you have any comments or suggestions to improve our next report. Our contact information is on the back page.

Thanks again for your interest, not only in this report, but in the larger issue of energy system reliability. Through your participation, you've contributed to ensuring a more reliable transmission system for the nearly 3.5 million retail customers in the NTTG subregion who depend on us for safe, dependable and least-cost electricity.

We encourage you to stay involved as we begin work on the 2012-2013 biennium planning process.

Sincerely,

Kip Sikes, 2010 Chair and John Leland, 2011 Chair NTTG Planning Committee

Disclaimer

This report was prepared by the members of the Northern Tier Transmission Group (Northern Tier) and other stakeholders participating in the effort to provide coordinated, efficient and effective planning for expansion of transmission within the Northern Tier footprint. While Northern Tier cannot assure the plan will be implemented as designed, it represents the best information available during the current planning cycle. Changing needs or new information will be accommodated through appropriate data submittals during the next planning cycle.

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Northern Tier Transmission Group Mission: To ensure efficient, effective, coordinated use and expansion of the members' transmission systems in the Western Interconnection to best meet the needs of customers and stakeholders.

Map Illustrating Northern Tier Members' Principal Transmission Lines

The extensive high-voltage transmission network of the Northern Tier Transmission Group's transmission providers reaches to all states of the U.S. Western Interconnection.

Contents

Figures

Tables

Abstract

The study plan sought to determine transmission system improvements needed for reliable operation in the year 2020 within the Northern Tier Transmission Group footprint in the western United States. First, the transmission study established the inadequacy of the existing transmission system to reliably handle forecasted 2020 load. Next, Core Cases examined five hours representing times of heavy load, import and export stress. Power flow reliability analysis on the five Core Cases demonstrated the adequacy of expected transmission upgrades to reliably integrate planned energy resources and serve forecasted NTTG system load. Finally, Scenario Cases applied four different wind generation configurations against the five Core Cases. The resource additions in these Scenario Cases exceeded the capability of the NTTG transmission system and its expected upgrades. Therefore, the study plan concluded, the NTTG system will require additional AC and/or DC transmission to serve forecasted load under these resource expansion scenarios.

Executive Summary

The Northern Tier Transmission Group (Northern Tier or NTTG) transmission plan establishes the baseline main grid transmission configuration for the Northern Tier footprint for the planning horizon ending in 2020. This planned transmission should be used as a "base plan" to inform other planning processes.

The transmission planning process had three goals: 1) identify transmission needs of transmission customers; 2) identify and evaluate transmission congestion that impedes efficient operation of electricity markets; and 3) consider the impacts on congestion of potential new generation facilities or new transmission projects. This year's NTTG planning process used a bottom-up approach, which rolled up the NTTG transmission providers' transmission plans, informed by other project developers' input, as the starting point for the planning studies described below.

The study plan sought to determine – given a limited number of load and resource scenarios – the general transmission improvements needed for feasible system operation at times of transmission stress 10 years in the future. It is the second biennial plan developed by NTTG.

Planning and preparation of the report took place over a two-year, eight-quarter span. Two planning cycles ran on parallel tracks. One track comprised the biennial transmission planning cycle. The other track included two annual economic congestion study cycles. Both planning cycles began in January 2010 and concluded with the final approval and publication of this report at the end of 2011. In completing these study cycles, a Technical Work Group developed the biennial transmission study and an Economic Studies Team planned and performed requested economic congestion studies. In January 2012, a third biennial planning cycle will begin, with data, models and processes enhanced by the experiences and results of the first two cycles.

The report begins with a review of the background and evolution of the Northern Tier Transmission Group, its current organization and the planning process. The relationship between the Northern Tier Transmission Group and other subregional and regional activities is outlined and their synchronized planning cycles described.

The report explains the study methodology, assumptions, data and analyses underlying the planning effort in the 2010-2011 cycle. The studies performed during the biennium are reviewed and their results summarized.

Over the biennium, NTTG received 45 economic study requests, most of which were regional in nature. But three were deemed relevant for study due to their subregional nature. The three subregional requests were clustered into one study to assess the impact of the transmission expansion on resource additions in Montana. In general, the economic analysis found that additional transmission is needed to accommodate increases in wind energy resources beyond those presently planned.

The biennial transmission study was comprised of three components: 1) a Null Case, 2) five Core Cases and 3) four resource development Scenario Cases.

The Null Case projected how the existing transmission system would perform 10 years in the future with assumed load growth (and an increase in the existing generation output) but without the addition of new transmission or energy resources. The Null Case concluded that the existing transmission system is inadequate to reliably serve estimated 2020 load and requires additional transmission capacity.

However, the power flow reliability analysis of the Core Cases demonstrated that the Foundational Transmission Projects, developed by the SPG Coordination Group[1] and adopted by the Western Electricity Coordinating Council's Transmission Expansion Planning Policy Committee (TEPPC), increase the system capability to reliably integrate planned energy resources and serve the forecasted NTTG system load. These Core Cases were developed by exporting production cost simulation data to a power flow program for five hours representing: heavy load hours, maximum export hours and maximum import hour. The Core Cases contained the base system and resource and loading conditions for the Scenario Cases that followed.

Finally, the Scenario Cases applied four different wind generation configurations against the five Core Cases – 20 scenarios in all. Each study hour within a Scenario Case was evaluated using load flow analysis to identify the minimum amount of transmission improvements required to reduce transmission path flows to acceptable reliability levels. Single element (N-1) contingency analysis was performed on all five study hours for each scenario to evaluate the performance of the system. Each of these scenarios is examined in the report. The resource additions in these Scenario Cases exceeded the

[1] The SPG Coordination Group (SCG) is composed of representatives from each TEPPC-recognized Sub-regional Planning Group (SPG), including Canada. The purpose of the SCG is to develop the Foundational Transmission Projects List (List) for use in developing TEPPC's interconnection-wide plans.

capability of the NTTG transmission system and its Foundational Transmission Projects. Therefore, the NTTG system will require additional AC and/or DC transmission to accommodate these resources.

Chapter 1 - Background

The Northern Tier Transmission Group

One founding principle of the Northern Tier Transmission Group (Northern Tier or NTTG) is to fulfill Federal Energy Regulatory Commission (FERC) Order 890 requirements that local Transmission providers participate in regional and subregional planning. Northern Tier was created in fall 2006. The group began its work in 2007 as a forum where all interested stakeholders, including transmission providers, customers and state regulators, might participate in planning, coordinating and implementing a robust transmission system.

Additional detail on the history underlying the current organization is available in the 2007 Annual Planning Report published April 2, 2008 and accessible on the Northern Tier web site, http://www.nttg.biz.

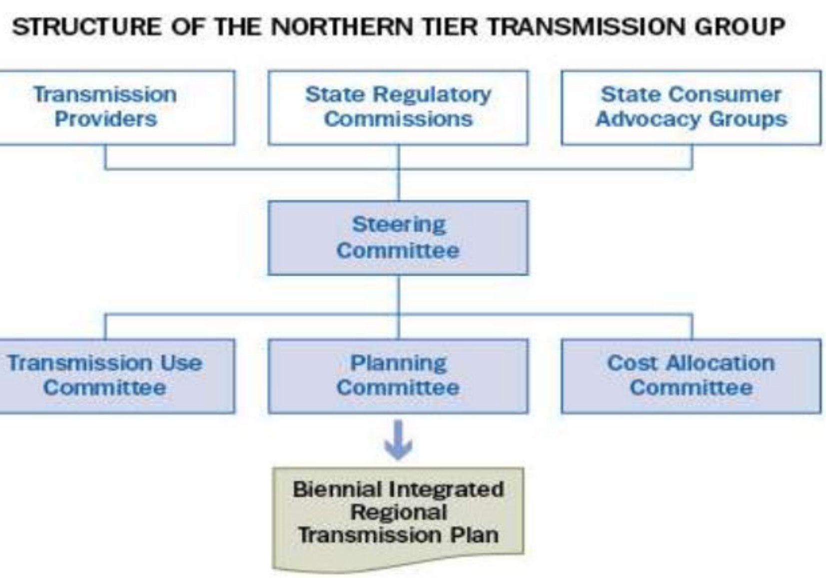


Figure 1-1 – Structure of the Northern Tier Transmission Group

NTTG focuses its efforts on the evaluation of transmission projects that move power across the subregional bulk electric transmission system, serving load in its footprint and delivering electricity to external markets. The transmission providers belonging to Northern Tier serve the nearly 3.5 million retail customers with nearly 3,000 miles of high voltage transmission lines. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, and parts of Washington and California.

NTTG works with the WECC Planning Coordination Committee for reliability planning, the WECC TEPPC for economic planning, and neighboring subregional planning entities.

Northern Tier Members

The Northern Tier Transmission Group's organizational structure has multiple levels, as shown in Figure 1.1 above. Overall planning direction is provided by the Steering Committee, whose membership at publication was as follows:

- Idaho Public Utilities Commission
- Oregon Public Utility Commission
- Montana Public Service Commission
- Montana Consumer Counsel
- Utah Public Service Commission
- Wyoming Public Service Commission
- Deseret Power Electric Cooperative
- Idaho Power Company
- NorthWestern Energy
- PacifiCorp
- Portland General Electric
- Utah Associated Municipal Power Systems

Transmission Planning Committee

The NTTG Planning Committee was formed to coordinate transmission planning for the Northern Tier footprint[2] and to coordinate with other subregional planning groups and the Western Electricity Coordinating Council's planning committees. Execution of the Transmission Planning Committee's charter occurs through the biennial planning process. Northern Tier's planning process is designed to be open, transparent and participatory. Transmission providers, regulators, customers and other stakeholders are encouraged to join the committee's activities and meetings, including semi-annual stakeholder meetings.

NTTG's 2010-2011 biennial plan was produced through its public processes in conjunction with related activities of the NTTG Cost Allocation Committee and NTTG Transmission Use Committee.

At publication, the Planning Committee had members from the following organizations:

[2] The Northern Tier footprint encompasses service territories of NTTG Funding Agreement signatories.

- Basin Electric
- Black Hills Power
- Deseret Power Electric Cooperative
- Gaelectric, LLC
- Grasslands Renewable Energy
- Idaho Power
- NextEra Energy Resources
- NorthWestern Energy
- PacifiCorp
- Portland General Electric
- Riverbank Power Corporation
- Sea Breeze Pacific
- TransCanada
- Utah Associated Municipal Power Systems
- Idaho Office of Energy Resources
- Montana Public Service Commission
- Wyoming Public Service Commission

Coordination Within the Northern Tier Footprint

Planning is an iterative process and must work in concert with local transmission plans and Integrated Resource Plans, where they exist. This Northern Tier transmission plan uses a bottom-up load service process, employing stakeholder data and input to ensure that the transmission planned for the Northern Tier footprint can reliably serve forecasted load growth and conditions. While this plan addresses transmission issues and solutions within the Northern Tier footprint, it is an informational plan that does not require construction and does not seek to accommodate broader regional needs.

Each of the Northern Tier transmission providers is also responsible for transmission planning and implementation for its own service area and for any Balancing Authority areas it administers. This local transmission planning process is designed to parallel and interact with the planning done at Northern Tier.

The local planning process digs deeper than the subregional process, in terms of its analysis both of finer detail (lower voltages and system dynamics) and more extensive construction detail. The transmission provider's responsibilities include path ratings, project financing, permitting and approvals, and construction.

The NTTG planning process provides a mechanism for coordinating stakeholder load and resource data, as well as for considering potential non-transmission provider transmission projects. Additionally, this process coordinates analysis of the existing subregional transmission system and the proposed projects that affect the transmission of electricity throughout the NTTG footprint.

Coordination with Others in the Western Interconnection

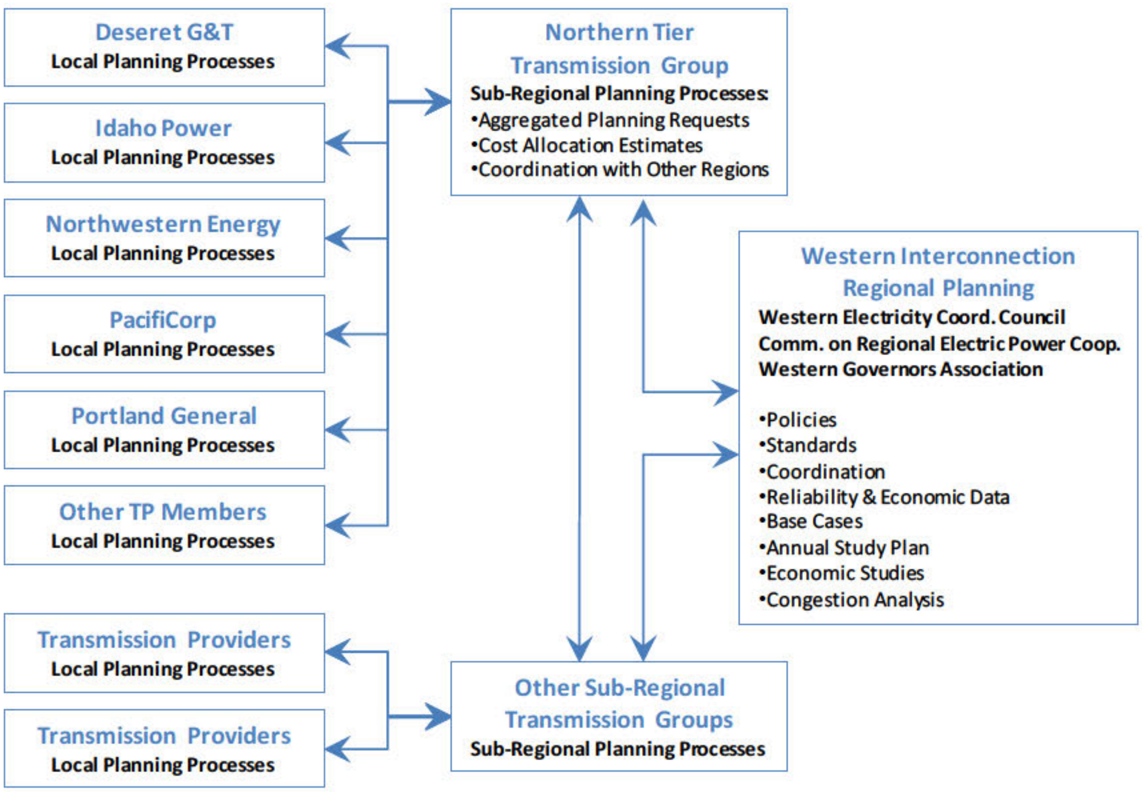
NTTG is committed to coordinating subregional planning efforts with adjacent subregional groups and other planning entities. In addition to working directly with the ColumbiaGrid and WestConnect subregional planning groups, Northern Tier relies on the data collection, validation and transmission modeling work done by WECC, the regional reliability organization. This Northern Tier transmission plan is consistent with the work of WECC.

WECC provides valuable services to transmission planners across the Western Interconnection. WECC's services include providing regional reliability planning and facility rating, and supplying economic planning data and analysis to its members through its Transmission Expansion Planning Policy Committee (TEPPC).

Relationships Among Planning Entities in the West

Transmission planning in the Western Interconnection has evolved to incorporate three distinct organizational levels: transmission providers, subregional transmission groups and regional planning entities. The relationships among regional, subregional and individual transmission entities are illustrated in Figure 1.2 below.

Figure 1-2 – Three-level Planning Process in the Western Interconnection

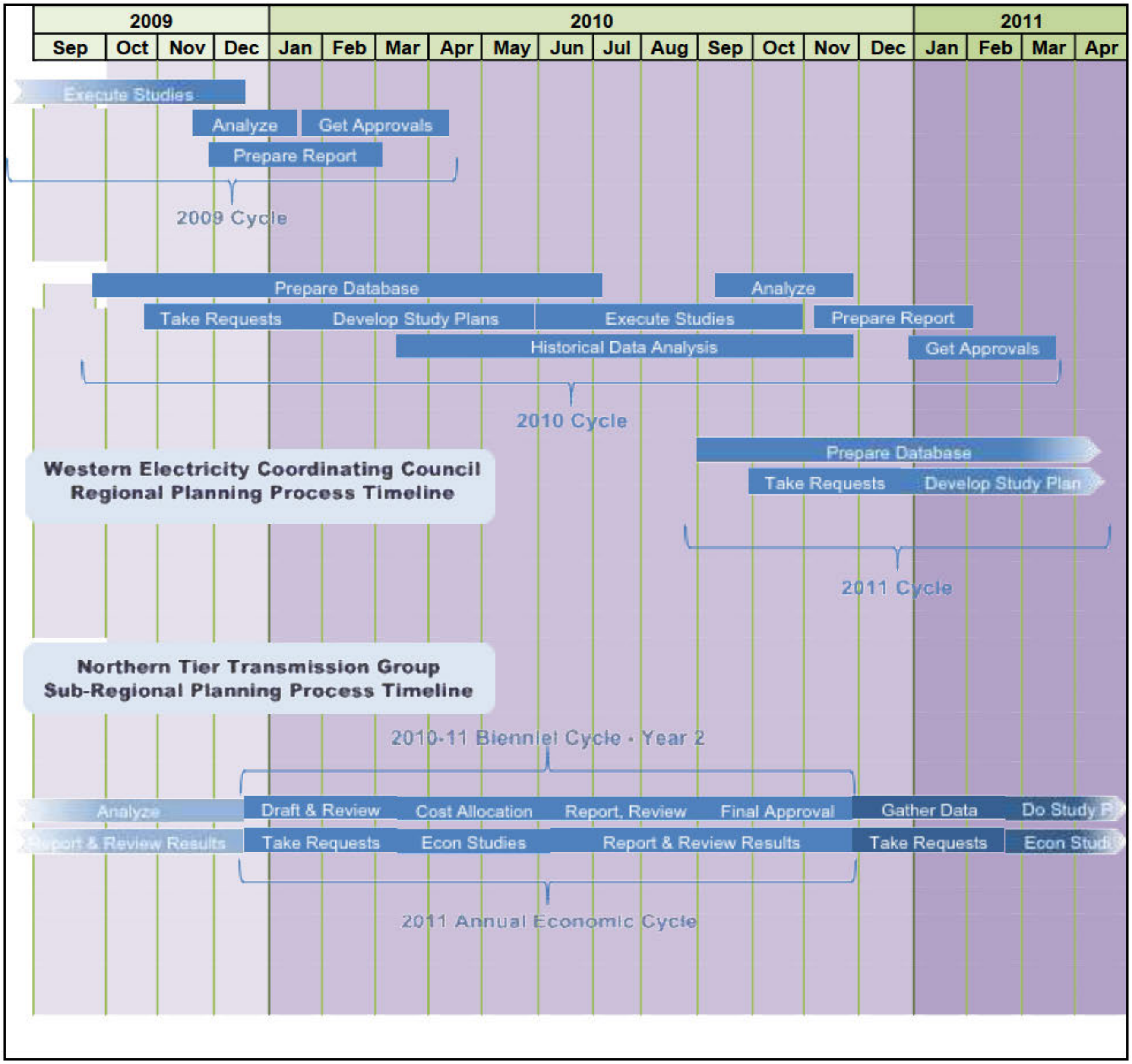


The transmission providers each develop and maintain an Open Access Transmission Tariff process, which receives and acts on requests for transmission service in accordance with a well-defined procedure. The transmission providers also assess future load and resource developments to plan the evolution of an efficient transmission system, and undertake reliability analysis and improvements.

Planning and analysis of improvements are coordinated at the subregional level when service requests and other identified needs call for the development of transmission that involves participation of multiple transmission providers within a subregional transmission group's footprint.

At the regional level, the WECC TEPPC provides a forum for coordination on regional issues and completes the three-level framework that addresses regional, subregional and local issues.

Figure 1-3 - Timelines for Regional & Subregional Planning



The Northern Tier Transmission Group's planning timelines are designed to coordinate with those of WECC. Those timelines include a two-year cycle for transmission expansion and reliability and a one-year economic study cycle. The economic study process examines preliminary plans during the first year of the biennial cycle and draft plans during the second year of the cycle.

NTTG – Review of 2010-2011 Planning Activities

Stakeholder participation is important to the processes of the Northern Tier Transmission Group. All interested parties are encouraged to attend and contribute to the many stakeholder meetings conducted by the Transmission Use, Planning and Cost Allocation committees, and to help in preparing, developing and analyzing planning studies. A chronology of activities in the 2010-2011 biennial planning cycle is provided in Table 1.1 below.

The Northern Tier Planning Committee conducted open conference calls on a frequent basis during the 2010-2011 biennium. The planning process was developed and managed in these conferences. Participants discussed and reached agreement on assumptions, data and methodologies.

The Planning Committee decided to perform studies using the staff of member transmission providers, taking advantage of their internal expertise and software tools. The committee formed a Technical Work Group ("TWG"), to separate detailed technical and model discussions from the policy-level Planning Committee and to provide proper control of confidential information.

An Economic Studies Team was similarly formed to plan and perform any needed economic studies resulting from NTTG's Economic Study Request solicitation during the biennium.

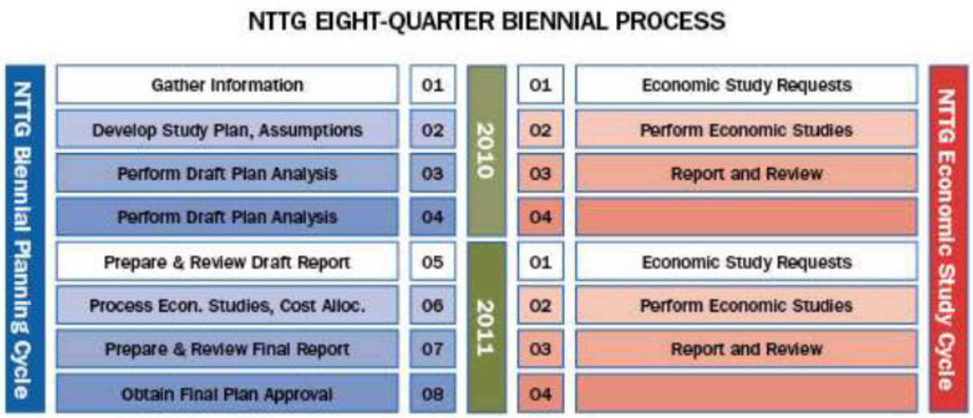
Table 1-1 – Chronology of Northern Tier Activities in 2010 and 2011

2010	Jan	28	2010 Public Semi-Annual Stakeholder Meeting
	Feb	2	2010-11 NTTG Planning Committee Data Request Form Posted
		24	Public Stakeholder Economic Study Request Webinar
	Apr	14	2010 Public Stakeholder Conference Call and Webinar
	May	5	2010 Public Stakeholder Conference Call and Webinar to review NTTG 2010-2011 Study Plan Development and Approach
	Jul	6	NTTG 2010-11 Study Plan Approved and Posted
	Aug	4	2010 Public Semi-Annual Stakeholder Meeting
2011	Jan	28	2010-11 NTTG Planning Committee Data Request Letter Posted
		19	2011 Economic Study Request Webinar
		31	2011 NTTG Stakeholder Conference Call
	Feb	2	2011 NTTG Semi-Annual Public Stakeholder Meeting
	Apr	6	NTTG Public Stakeholder Meeting
	Jul	28	2011 NTTG Semi-Annual Public Stakeholder Meeting
	Sep		Stakeholder input to the Biennial Plan
	Nov		Biennial Plan Approval by NTTG Steering Committee
	Dec		Biennial Plan publication

Details of the Eight-Quarter Northern Tier Planning Process

The overall biennial transmission planning process at Northern Tier is broken down into eight quarters and two tracks. Figure 1.4 diagrams this process for the current 2010-2011 cycle. The overall planning process runs across all eight quarters and is described in further detail in the Northern Tier Transmission Group's Planning Committee Charter.

Figure 1-4 – NTTG Eight-Quarter Biennial Process



The cycle began in January 2010 with a three-month window of opportunity for stakeholders to submit data for loads, resources and transmission projects to be studied, and to submit requests for economic congestion studies.

Based on the data collected, the second quarter was dedicated to developing a study plan and the appropriate study assumptions. Additionally, development of economic studies ensued during this quarter. The Planning Committee decided to approach the planning process by generating the study cases though production cost simulation. The technical work identified the hours of significance and exported the production cost data to the power flow simulation tool. These processes will be described in more detail later in this report.

The Economic Studies Team presented its economic congestion study results for the biennium in the third quarter of 2010.

The TWG devoted the third and fourth quarters of 2010 and the first quarter of 2011 to the export of the production cost cases to the power flow simulation program. There were significant modeling differences to overcome in order to generate acceptable power flow cases.

Work in 2011 (the second half of the biennial cycle) began with preparation and review of the draft transmission report and with conduct of the second economic study request. During the second quarter of 2011, the power flow cases were subjected to N-1 contingency analyses, with the N-1 contingency list provided by participating transmission engineers for their respective companies. Any resulting departures from NERC Standard and WECC Standard requirements were examined. All thermal overloads and voltage excursions were verified. The Planning Committee deemed the resulting power flow studies acceptable.

The biennial planning process concluded with the preparation, review and acceptance of this report. In January 2012, the third biennial planning cycle will begin, with data, models and processes enhanced by the experiences and results of the first two cycles. Additionally, FERC Order 1000, issued in July 2011, will have further implications for Northern Tier's planning and cost allocation practices. NTTG's 2012-2013 Biennial Report will reflect these modified practices in accordance with Order 1000.

Chapter 2 - NTTG Economic Studies

Objective of the Studies

NTTG transmission providers are obligated through their transmission tariffs, in compliance with FERC Order 890, to perform economic planning studies. The requirement for these studies is based on FERC's finding that transmission planning involves both reliability and economic considerations. In the transmission planning process, each transmission provider provides stakeholders with the right to request economic planning studies. These studies evaluate transmission upgrades to reduce congestion or integrate new resources and loads. One portion of this process provides for the transmission provider to determine whether the request is of a local, subregional or regional scope. Economic Study Requests that are found to be subregional or regional are forwarded to NTTG. NTTG performs up to two high-priority subregional studies, as determined by the Transmission Use Committee, each year of the two-year transmission planning process. Additional economic planning studies may be requested and funded by a stakeholder. Additionally, economic study requests may be merged if the requests are similar in scope. Studies deemed by NTTG to be regional in scope are forwarded to the regional transmission planning body.

Economic Study Requests

NTTG transmission providers forwarded subregional and regional study requests to NTTG in the first quarter of 2010 and again in 2011. The NTTG Planning Committee evaluated each request to determine the appropriate organization to perform the study, i.e., WECC TEPPC, NTTG or return to the local transmission provider. In 2010, NTTG received 21 regional, three subregional and one local economic study requests (the local request was returned to the transmission provider). In 2011, 24 requests were received, all regional in scope. There were no economic study requests that required production cost modeling or congestion analysis.

The following tables contain the dispensation of each economic study request received.

Table 2-1 - 2010 Economic Study Requests

Dispensation	2010 Economic Study Request
PPL Montana	
WECC Regional	Colstrip to SE Wyoming CCPG and/or Zephyr
WECC Regional	Colstrip to SE Wyoming CCPG w/o Chinook; hook up with Zephyr
WECC Regional	Broadview - Great Falls - Garrison
WECC Regional	Broadview - Great Falls - Ovando
WECC Regional	Great Falls - Helena - Townsend
WECC Regional	Determine the economic effects of the N-2 common corridor outage criteria
WECC Regional	Create an energy market hub in eastern Wyoming
Northwestern Energy	
NTTG Subregional	MSTI
NWE Local	1500 MW 230 kV radial collector lines into Townsend 500 kV & MSTI

NTTG Subregional	Amps 230 kV upgrade to 401 MW
NTTG Subregional	Colstrip 500 kV system upgrade
TransCanada	
WECC Regional	Northern Lights
WECC Regional	Zephyr
WECC Regional	Chinook
Sea Breeze	
WECC Regional	Juan de Fuca Cable
WECC Regional	West Coast Cable HVDC
WECC Regional	Triton Cable HVDC
WECC Regional	Juan de Fuca Cable II HVDC
Grasslands	
WECC Regional	Add 3000 MW wind in Montana, ND, AB, SK Western Renewable Energy Zones (WREZ); add transmission as needed
WECC Regional	Add 400 MW pumped storage between Broadview & Garrison to GRE1 Case
WECC Regional	Add 6000 MW wind in Montana, ND, AB, SK WREZs; add transmission as needed
WECC Regional	Add 400 MW pumped storage between Broadvu & Garrison to GRE2 Case
TransWest Express	
WECC Regional	600 kV HVDC
WECC Regional	Add 6000 MW of wind in Wyoming WREZs
WECC Regional	Add 12000 MW of wind in Wyoming WREZs

Table 2-2 - 2011 Economic Study Requests

Dispensation	2011 Economic Study Request
TransCanada	
WECC Regional	Zephyr HVDC
WECC Regional	Chinook HVDC 2020
WECC Regional	Chinook HVDC 2030
Wyoming Infrastructure Authority	
WECC Regional	9000 MW renewable and 1800 MW thermal generation in Wyoming
WECC Regional	12000 MW renewable and 2400 MW thermal generation in Wyoming
PacifiCorp	
WECC Regional	Hemingway – Capt. Jack 500 kV
WECC Regional	Sigurd – Las Vegas 500 kV
Grasslands	
WECC Regional	3000 MW in MT
WECC Regional	6000 MW in MT
WECC Regional	Wind Spirit
WECC Regional	Grasslands Northern Plains Intertie
TransWest Express, LLC	
WECC Regional	TransWest Express HVDC
WECC Regional	TransWest Express HVDC
WECC Regional	TransWest Express HVDC
WECC Regional	TransWest Express HVDC
Northwestern Energy	

WECC Regional	MSTI + SWIP
WECC Regional	MT-NW Upgrade (SerCap Upgrade)
WECC Regional	MSTI, MT-NW Upgrade, SWIP Cluster
Riverbank Symbiotics	
WECC Regional	Swan Lake pumped storage
WECC Regional	Parker Knoll
WECC Regional	Parker Knoll + transmission to Glen Canyon
WECC Regional	Parker Knoll + transmission to Intermountain Power Project DC
Tonbridge	
WECC Regional	Greenline
WECC Regional	MATL Upgrade

As shown in the 2010 Economic Study Request Table above, the only requests deemed to be subregional, and thus appropriate for the NTTG Economic Studies Team to take on, were three of the four NorthWestern Energy submissions. The three scenarios were:

1. MSTI 500 kV Line: MSTI is a proposed 500 kV line, approximately 420 miles long, extending from Townsend, MT, to Midpoint, ID. It is series-compensated, and power flow is controlled using a Phase Shifting Transformer. An existing model used by NTTG utilities already exists from the previous Biennial Planning Cycle. MSTI is nearing completion of Phase 2 of the WECC Path Rating Process. The new line would provide 1,500 MW transmission capacity north to south, about 950 MW south to north. The line could provide transmission service for up to 1,500 MW of new renewable resources.
2. Path 18 Upgrade: NorthWestern conducted a Montana to Idaho open season transmission subscription process in 2004. As a result of this subscription process, NorthWestern and the other Path 18 owners are contemplating increasing the capacity of the existing 230 kV AMPS line through the installation of series capacitors and voltage support devices on various Path 18 busses. This upgrade is not in the WECC Path Rating Process yet. The line runs between the Mill Creek 230 kV switchyard and the Antelope 230 kV station. The upgrade may increase path capacity to 401 MW.
3. 500 kV Upgrade: The owners of the Colstrip Transmission System and the Bonneville Power Administration (BPA) are considering increasing the capability of the existing twin 500 kV transmission lines that may start as far east as Colstrip, MT and end as far west as the Mid-Columbia area of Washington. Installation of series capacitors (up to 70% from the current 35%) and appropriate voltage control, and expanding the allowable current-carrying capacity (ampacity) of existing busses on the 500 kV line, may increase the transfer capability by as much as 500 MW to 700 MW. This upgrade is not yet in the WECC Path Rating Process.

The three subregional requests were clustered into one study to assess the impact of the transmission expansion on resource additions in Montana, as described below.

Economic Study Process

The NTTG Economic Studies Team applied Ventyx PROMOD and ABB GridView energy market simulation tools for the economic study, as both were available to the TWG and economic studies teams through

NTTG member companies. PROMOD is the program currently used by WECC staff and others in performing the TEPPC's analyses. GridView is used by a number of entities in the Western Interconnection to perform comparable studies.

Given the limited one-month timeline to run the studies, the team expedited the process by using an existing WECC TEPPC production cost simulation database, the TEPPC 2019 PC1A case. Minor edits were applied to align with NTTG assumptions. Common to all cases, 1,500 MW of wind-powered generation was added at the Townsend bus.

The general outline of the economic study process was to start with the WECC TEPPC 2019 PC1A cases, run three expansion cases and conclude with a sensitivity case. The following three expansion cases were developed:

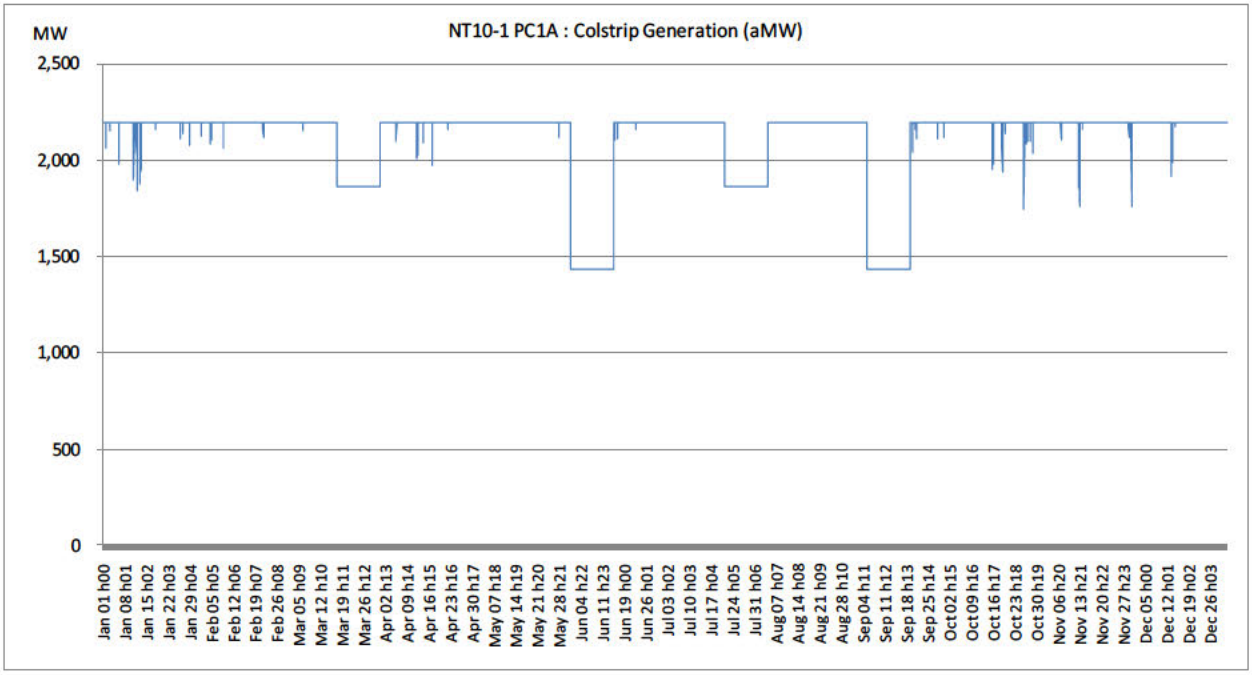
1. Increase capacity of the AMPS line (Path 18) from 337 to 401 MW
2. Increase rating of Montana-Northwest path (Path 8) by 600 MW
3. Add Mountain States Transmission Intertie (MSTI) project

A sensitivity case investigated methods to reduce any "excessive" cycling of coal-fired generators caused by wind-powered generator output variability.

Results and Observations

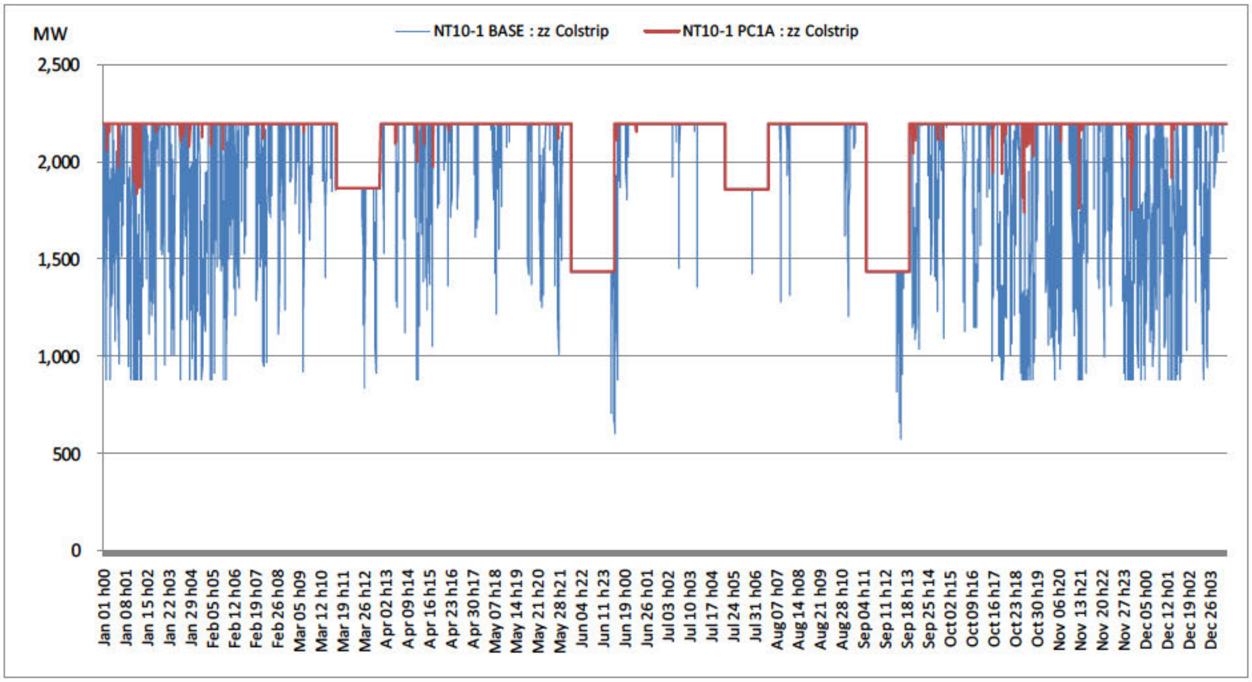
1. The 1,000 MW of new Montana wind resources already modeled in the TEPPC 2019 base case are accommodated with modest coal plant cycling and little wind curtailment as shown Figure 2.1 below.

Figure 2-1 – Colstrip Production in TEPPC 2019 Base Case



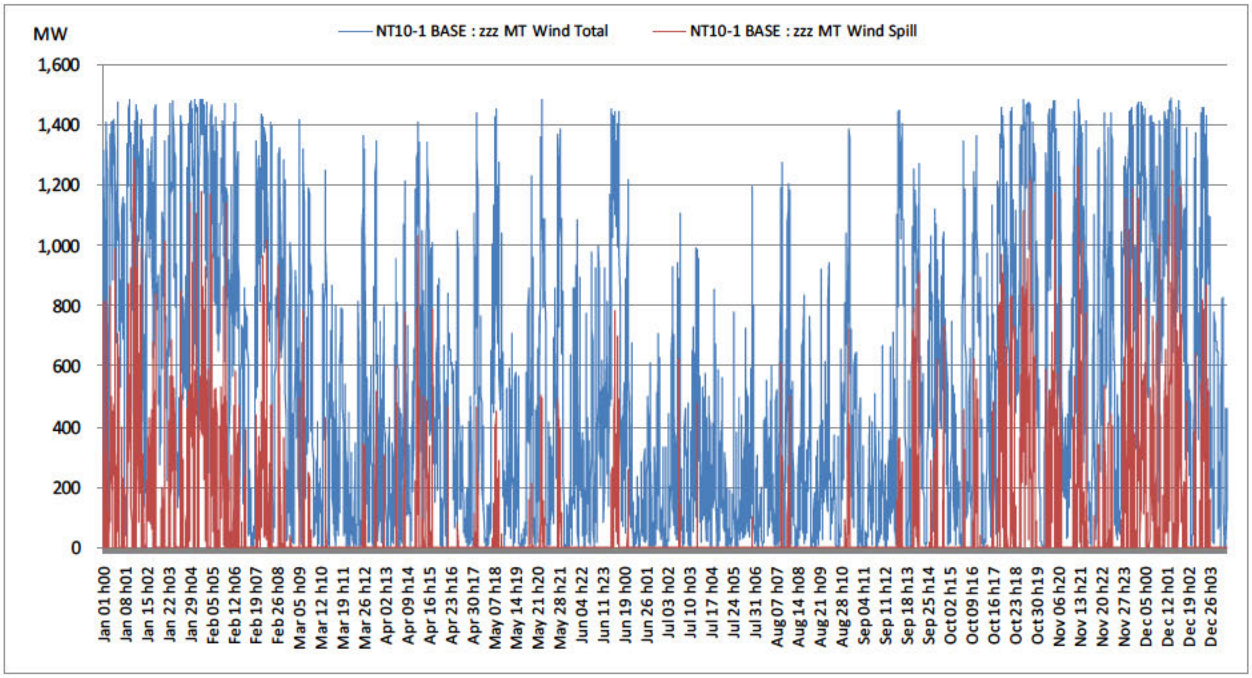
2. The addition of 1,500 MW of wind generation in Montana causes severe cycling of base load coal generation as shown in Figure 2.2 below.

Figure 2-2 – Colstrip Production Impacts from 1,500 MW of Wind Generation



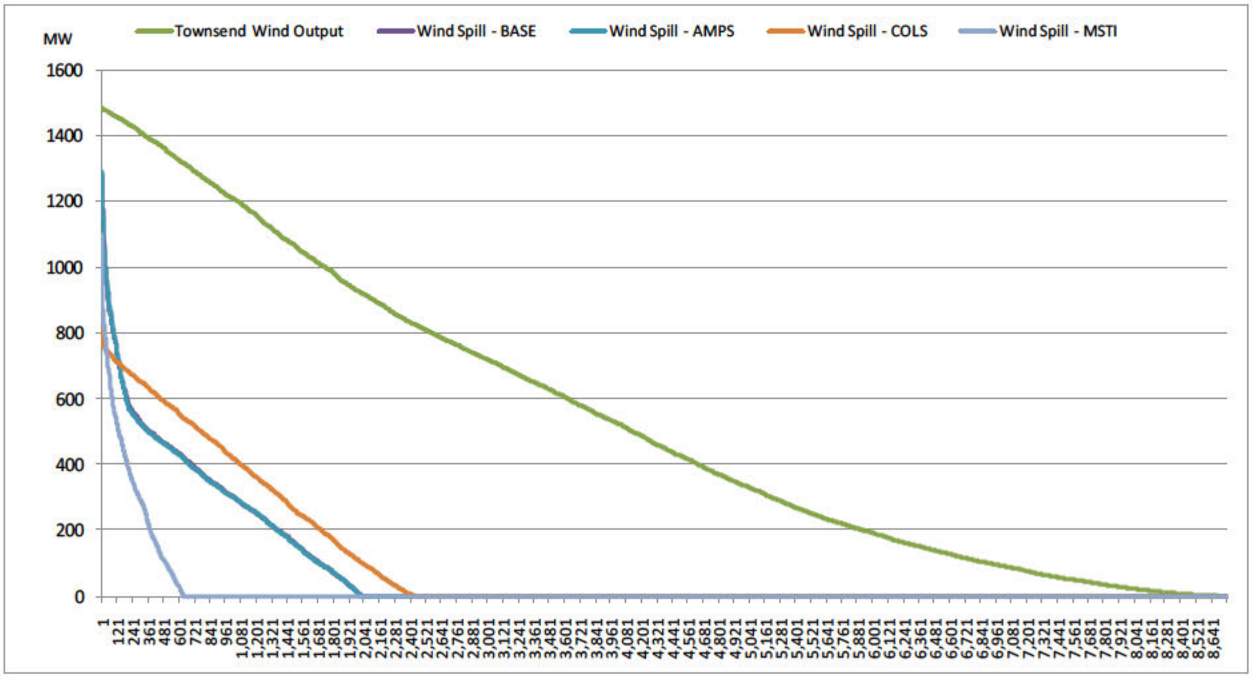
3. Without additional transmission, much of the additional wind energy cannot be accommodated by existing transmission and is curtailed as shown in Figure 2.3 below.

Figure 2-3 – Wind Generation Curtailments Due to Transmission Constraints



4. Upgrading the capacity of Paths 8 and 18 provides some benefit, but a large fraction of the additional wind energy remains unusable. However, the addition of the MSTI project provides the ability to transmit most of the added wind out of Montana to locations that are able to absorb the increased generation with modest re-dispatch of existing resource, as shown in Figure 2.4.

Figure 2-4 – Wind Generation Accommodated by Transmission Projects



5. The Path 8 upgrade and MSTI projects significantly decrease the hours of congestion for the south and west Montana transmission paths. The following table displays the hours of congestion on NTTG-relevant paths for the three expansion cases.

Table 2-3 - Transmission Impact on NTTG Path Congestion

Number of hours in 2019 that flows exceeded the indicated percent of the positive flowgate limit.	**NT10-1 PC1A with 1,500 MW Wind Added in MT**	NT10-1 Base, with Path 18 increased to 401 MW N-S	NT10-1 Base, with Path 8 increased by 600 MW	NT10-1 Base, with MSTI Project added
	75%	75%	75%	75%
Monitored Interface	**NT10-1 BASE**	**NT10-1 AMPS**	**NT10-1 COLS**	**NT10-1 MSTI**
Aeolus - Mona	-	-	-	-
Bonanza West	29	1	4	(12)
Borah West	-	-	-	-
Bridger West	-	-	-	-
Bridger - Populus	-	-	-	-
Brownlee East	19	(2)	(1)	(19)
COI (GridView), COB (Promod)	4,133	(9)	(203)	380
Idaho - Montana	960	(413)	(200)	(960)
Idaho - Northwest	-	-	-	-
Intermountain - Gonder 230 kV	114	-	64	25
IPP DC Line	3,407	(4)	(1,121)	(24)
Midpoint - Summer Lake	1,954	6	554	2,045
Mona - Oquirrh	-	-	-	-
Montana - Northwest	5,664	(53)	(1,601)	(1,020)
Montana - Southeast	1	-	(1)	(1)
Pacific DC Intertie (PDCI)	164	4	22	1
Pavant Intermountain - Gonder	3	(3)	(3)	(3)
TOT 2C	1,082	(18)	(141)	(145)
West of Colstrip	7,399	-	1	-
West of Hatwai	31	2	8	(30)

Chapter 3 - Transmission Study

Objective of the Study

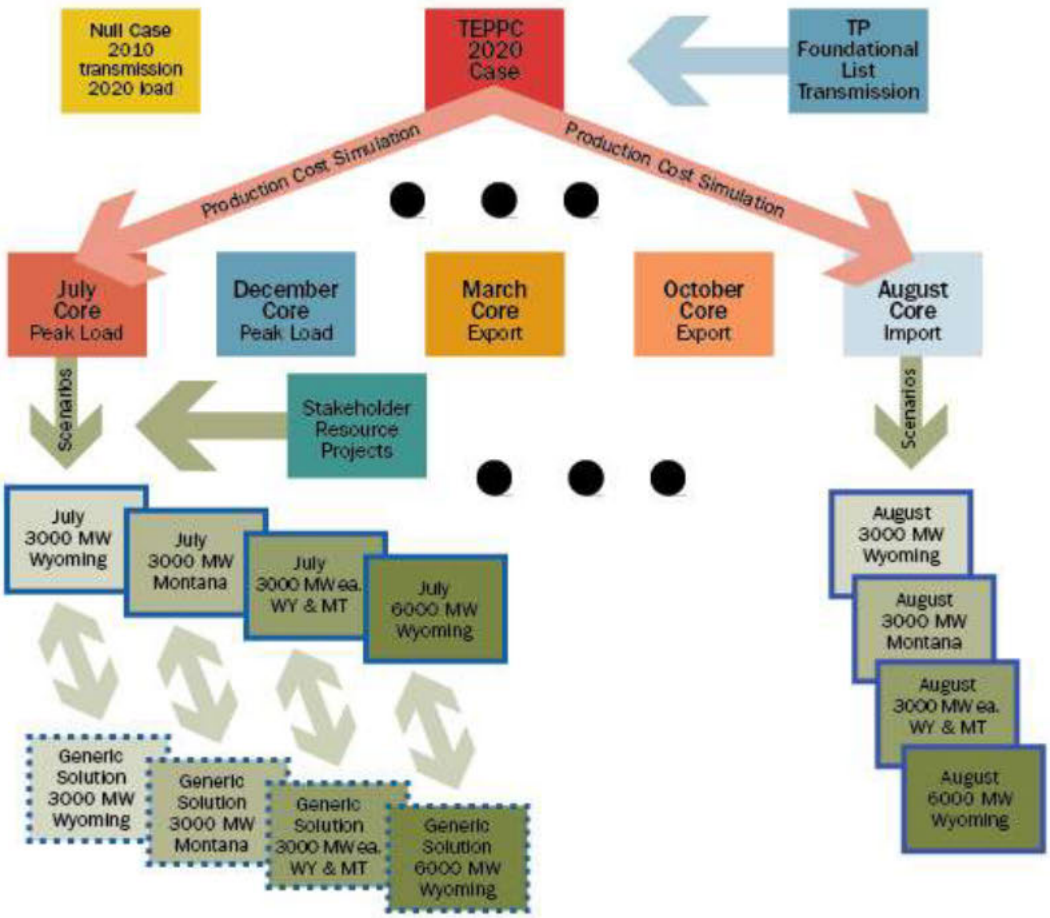
The objective of the 2010-2011 Northern Tier Transmission Plan is to determine what a reliable transmission system could look like in 2020. The plan involved a conceptual study to examine, given a limited number of forecasted and assumed load and resource portfolios, the generic transmission additions required to provide feasible system operation at forecasted stress times, 10 years in the future.

In 2011, high-level analyses were performed to determine the effectiveness of alternative sets of proposed transmission projects, suggested by the conceptual study. These analyses, or scenario cases, formed the basis for the NTTG Transmission Plan. Specifically, the transmission plan objectives were designed to:

1. Identify transmission needs of transmission customers (e.g., retail native load, network and point-to-point), as they are identified by and provided to the transmission provider. The transmission provider shall consolidate this information for their particular system to include in the subregional planning process.
    a. Native load needs will be incorporated by input from the various states' integrated resource planning (IRP) processes, where they exist.
    b. Network transmission customers will be asked to submit information on their projected loads and resources on a comparable basis (e.g., planning horizon and format). The intent will be to plan for all end-use loads on a comparable basis.
    c. Each transmission provider's existing point-to-point customers will be asked to submit any projections they have of a need for service over the planning horizon and at what receipt and delivery points.
2. Identify transmission congestion that is an impediment to the efficient operation of electricity markets. Congestion on the existing and planned system will be reviewed and evaluated.
3. Consider the impacts on congestion of potential new generation facilities or new transmission projects. This will include production simulation studies on a subregional and regional level, and historical use analysis as provided by the Northern Tier Use Committee and TEPPC subcommittees.

To meet the above objectives, the Planning Committee devised a study plan with three major components. Figure 3.1, below, illustrates the framework of the study components comprising a Null Case, Core Cases and Scenario Cases.

Figure 3-1 – Transmission Study Framework



The Study Plan

The 2010-2011 biennial transmission study plan was developed during the second quarter of 2010 and approved by the Planning Committee on June 30, 2010. A copy of this plan is located in Appendix 1 and is available on the NTTG web site.

Null Case

The plan was formulated by the Planning Committee to meet the objective of performing a conceptual study that determines at a high level, given a limited number of load and resource scenarios, what general transmission improvements are required to provide a feasible system operation at times of transmission stress 10 years in the future. For a baseline, the load in the WECC 10hs3bp Base Case was modified to reflect the NTTG area 2019 load forecasts. This baseline, or Null Case, projected how the existing transmission system would perform without the addition of new transmission or energy resources.

Core Cases

In parallel with the development of the Null Case, the Planning Committee created a set of five Core Cases to analyze future system reliability during selected peak load hours and high import and export conditions. Reliability analysis has traditionally been performed on power flow base cases developed by WECC that simulate a specific load pattern, generation dispatch state and transmission topology in the WECC system (e.g., heavy summer peak load conditions or light autumn load conditions). These cases, however, may not adequately stress the NTTG transmission system in ways that may be present during other times of the year. Based on this assessment, the NTTG Planning Committee decided to undertake an alternative approach that combined both the production cost simulation and power flow analysis. The Planning Committee used an integrated one-hour loads and resources analysis to determine transmission system stress that could occur 10 years in the future due to increased load and energy resource additions. The committee chose to run security-constrained generator commitment and dispatch modeling across the 8,760 hours of 2019 to find specific hours when energy flow from resources to loads is most constrained within the NTTG transmission system. The selection of several hours of transmission constraint and peak load formed the basis, or core, of the study.

The TWG later decided to switch from the TEPPC 2019 PC1A to the TEPPC 2020 PC0 case in order to perform the analysis on the most up-to-date system model.

The plan conceived of a model of the 2020 network based on the existing system, with the addition of a minimal set of committed transmission projects. Only those transmission projects deemed to have a high probability of being in service before 2020 and to be primarily for firm load service and reliable system operation were included in this set (i.e., the Foundational Transmission Projects were included).

This transmission network was then tested. The assessment used a commitment and dispatch program and the TEPPC 2020 PC0 core base case. To determine where system stresses existed, the assessment then ran the load and resource scenarios under the hour-by-hour operating conditions across the year 2020 (8,784 hours). To determine times of stress, the TWG decided to use maximum NTTG summer and winter peak loads and times of aggregated maximum imports and exports on eastern NTTG paths. This approach was better able to ascertain congestion rather than the approach outlined in the original study plan. Then, for the most highly stressed hours, the load and resource states were exported to a power flow program for reliability analysis.

Scenario Cases

Finally, the Committee decided to augment the selected Core Cases with four energy resource expansion Scenario Cases. These scenarios were based on data submitted in response to Northern Tier's first quarter request for data. The data indicated that future energy needs will be met, at least in part, by development of renewable resources sited in areas with significant renewable energy potential, such as Wyoming and Montana.

Contingencies

Only N-1 contingencies were run on the core and scenario power flow cases, since this initiative is much closer to a high-level screening study than a rating study, where N-2 contingencies are more relevant. Also, only transmission lines with voltages of 230 kV or higher in the NTTG footprint and in the Northwest (Area 40) were monitored and included in contingency lists.

Generic Transmission Modifications

Both AC and DC generic transmission lines were simulated to resolve contingency violations for the resource addition scenarios.

Chapter 4 - The Null Case

Null Case Introduction

Power flow reliability analysis, as described in this section, was performed on the existing transmission system, the Null Case, to determine if the present system could meet the demands of the forecasted NTTG footprint load level expected in the year 2020.

Null Case Study Assumption and Parameters

The Null Case was developed from the WECC 2010 heavy summer (10hs3bp) base case. In the 2010 heavy summer base case, loads present in the NTTG footprint were increased to the 2020 heavy summer (20hs1ap) base case levels. A total of 3,170 MW (approximately 1.4% compounded annually) of load was increased in the NTTG footprint. Loads outside the NTTG footprint were kept at the 2010 levels. The list of the owners whose loads were increased, along with the area in which the load was present, is shown in Table 4.1. Details regarding the load increase are shown in Appendix 4.

Table 4-1 – Summary of Increased Area Loads

No.	Area (Owner Name)
1.	Area 40 (Portland General Electric)
2.	Area 65 (Pacificorp (East))
3.	Area 60 (Idaho Power Company)
4.	Area 62(NorthWestern Energy)
5.	Area 73 (Black Hill Power Company)
6.	Area 65 (Dixie Generation & Transmission)
7.	Area 63 (WAPA Upper Missouri)
8.	Area 73 (WAPA Lower Missouri)
9.	Area 65 (Utah Associated Municipal Power Systems)
10.	Area 65 (Deseret Power Electric Cooperative)

The transmission topology was not changed from the 10hs3bp base case. Transmission upgrades present in the 20hs1ap base case and new generation resources were not included in the Null Case study. NTTG footprint resources existing in the 10hs3bp base case and 10hs3bp base case resources in other areas were increased, if possible, to meet the load increase. No generation resource was increased beyond its maximum generating capability. Resources that were increased are shown in Table 4.2.

Table 4-2 - Null Case Generation Resources Adjustments

Generator Bus Number & Name	10HS Original Base Case	10 HS Base Case With Increased Load	Delta MW	% Change in Generation
40291 [COULEE19 15.000]	606.7	700	93.3	15.4
40293 [COULEE20 15.000]	0	700	700	999.9
40296 [COULEE22 15.000]	196.1	679.5	483.4	246.5
40298 [COULEE24 15.000]	0	600	600	999.9
60096 [BRWNL 1 13.800]	0	120	120	999.9
60097 [BRWNL 2 13.800]	100	120	20	20
60098 [BRWNL 3 13.800]	100	120	20	20
60099 [BRWNL 4 13.800]	100	120	20	20
60100 [BRWNL 5 13.800]	176.2	225.5	49.3	28
60151 [HELSCYN1 14.400]	130	145	15	11.5
60152 [HELSCYN2 14.400]	130	145	15	11.5
60153 [HELSCYN3 14.400]	0	145	145	999.9
60196 [L MALAD 6.9000]	12	14	2	16.7
60201 [L SAMN 1 13.800]	0	15	15	999.9
60203 [L SAMN 3 13.800]	0	15	15	999.9
60276 [OXBOW1-2 13.800]	80	100	20	25
60277 [OXBOW3-4 13.800]	80	100	20	25
60321 [STRIKE 1 13.800]	0	30	30	999.9
60322 [STRIKE 2 13.800]	20	30	10	50
60323 [STRIKE 3 13.800]	20	30	10	50
60352 [TWINFALS 6.9000]	0	8	8	999.9
60353 [TWINFALS 13.800]	20	40	20	100
60397 [BTMT CT1 18.000]	170	190	20	11.8
62048 [COLSTP 3 26.000]	606.5	815.5	209	34.5
63005 [FT PECK1 13.800]	54.8	34.9	-19	36.2
66055 [NAUGT G1 18.000]	129.2	222.3	93.1	72
73129 [MBPP-1 24.000]	586.9	719.7	132.8	22.6

Null Case Study Methodology

Power flow analysis was performed on the Null Case to determine if any voltage or thermal overload issues existed with all lines in service (i.e., N-0 condition) and with one transmission element out-of-service (i.e., N-1 condition), including auto transformer outages. All N-1 outages for transmission elements above 200 kV were studied for the NTTG footprint[3]. The N-1 power flow study was performed using the PSS/e "ACCC" function software. No N-2 (or higher) outages were taken. Special protection schemes were not implemented in this power flow analysis, which if implemented may have reduced the number of overload problems identified in this study. Also, the amount of regulating resources was not increased to accommodate the increased load. Neither transient stability analysis nor PVQV analysis was performed for this study.

Power Flow Analysis Results

The N-0 power flow analysis on the Null Case identified 24 (15 lines and nine auto transformers) thermal overloads on certain transmission elements with all transmission system elements in service. These overloads were not present in the 2010 heavy summer base case. A high-level summary of overloads and voltage issues on major transmission elements under N-0 conditions is shown in Table 4.3 below. The detailed results regarding thermal overloads under N-0 conditions are shown in Appendix 4. Busses with voltage below 0.90 per unit under N-0 conditions with the loads increased to the 20hs1ap base case level are shown in Appendix 4. There were several 500 kV busses and other busses with voltage above 1.05 per unit under N-0 conditions. They are also shown in Appendix 4.

Table 4-3 - Summary of Null Case N-0 violations

Area #	Number of transmission elements branches on which thermal overload(>100%) was observed due to increased load (Also includes overloads on autotransformers as well)	Highest overload observed (%)	Number of Busses with Voltage less than 0.90 p.u. due to increased load	Lowest Voltage observed (PU)
Area 40	17	131.7	9	0.8271
Area 60	2	115.4	0	N/A
Area 62	0	N/A	3 (Local Area Problem)	0.8674
Area 65	5**	118.1	4	0.826
**Over and above the 5 transmission overload, loading was increased on several 138/12.5 kV auto transformers that serves load in Area 65. This banks already had high loading and due to increase in the load the flows through the transformers had increased.				

Next, the Null Case was studied with single element outages. First, the N-1 contingencies were run with the taps on the auto transformers, switched shunts, phase-shifting transformers and tie lines enabled (allowed to move or adjust). Several contingencies reached maximum iterations without solving, and certain contingencies failed to solve, making the system unstable. The summary of results is shown in

[3] Area 40(Northwest), 60(Idaho), 62(Montana), 63(WAPA UW), 65(Pacificorp), 73 (WAPA RM)

Table 4.4 below. Then all the N-1 contingencies were run with the taps on the auto transformers, switched shunts, phase-shifting transformers and tie lines disabled (not allowed to move or adjust). This resulted in fewer contingencies reaching maximum iterations, as well as contingencies that failed to solve, making the system unstable. The summary of these results is shown in the second row of Table 4.4 below. Detailed results showing which contingency reached maximum iterations and which contingency failed to solve is shown in Appendix 4.

Table 4-4 - Summary of Null Case N-1 Contingency Solutions

	Number of contingencies that reached maximum iterations	Number of contingencies that failed to solve
Taps on auto-transformers, switched shunts, phase shifters, tie lines enabled (allowed to move or adjust)	72	12
Taps on auto-transformers, switched shunts, phase shifters, tie lines disabled or locked (not allowed to move or adjust)	5	5

The N-1 outage analysis showed overloads on several transmission elements. Summary of contingencies with overloads greater than 125% under outage conditions is shown in Table 4.5. The overloads were based on normal summer rating. Detailed results of transmission elements that observed overloads greater than 125% is shown in Appendix 4. Emergency ratings were not taken into account for this study. Fifty-five different thermal overloads (>100%) were observed in the Northwest area, nine different overloads (> 100%) were observed in Idaho area and two different overloads (>100%) were observed in the WAPA Rocky Mountain area. These overloads were based on normal summer rating. Voltage at some busses went below 0.90 per unit under certain outage conditions. The summary of these low voltages is also shown in Table 4.5 below.

Detailed description of the thermal overloads and voltage issues observed for different outage conditions are shown in Appendix 4.

Table 4-5 - Summary of Null Case N-1 Contingency Violations

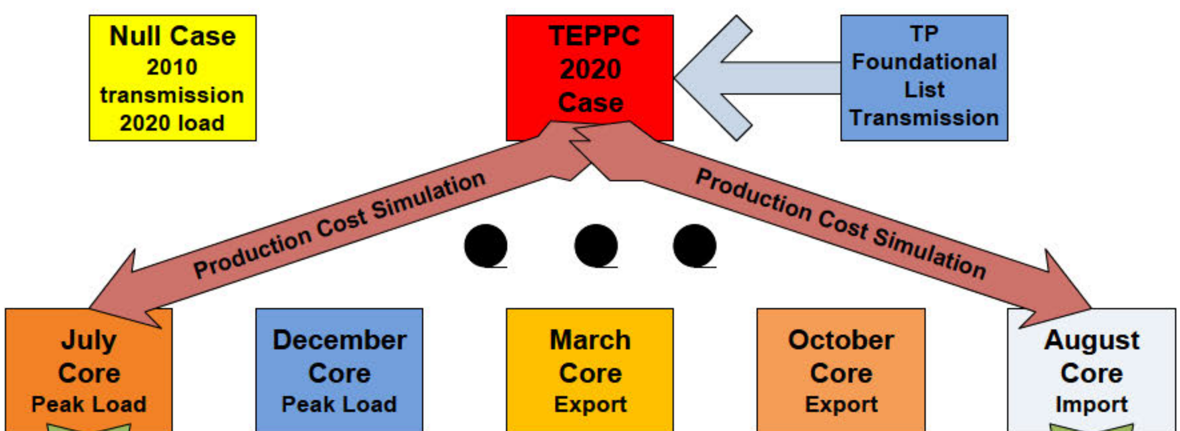
Area #	Number of transmission elements branches on which thermal overload(>100%) was observed due to increased load (Also includes overloads on autotransformers as well)	Highest overload observed (%)	Number of Busses with Voltage less than 0.90 p.u. due to increased load	Lowest Voltage observed (PU)
Area 40	18	163.1	1	0.89298
Area 60	0	N/A	1	0.89587
Area 65	0	N/A	5	0.80647

Conclusion

The Null Case power flow analysis discovered overloads on transmission elements under system normal operating and single element outage conditions. Voltage issues were also observed on several 500 kV busses and at other voltage levels under certain N-1 outage conditions. The results of the Null Case study found that the overloads on the transmission system increases beyond acceptable levels when compared to the NERC and WECC planning criteria.

The conclusion is that the existing transmission topology is not adequate in the year 2020 transmission to reliably serve the estimated 2020 load. Additional transmission capacity is necessary to meet NERC and WECC planning criteria. Additional transmission is necessary in order to reliably meet the future loads. These upgrades (the Foundational Transmission Projects) are defined by the transmission providers and used in the development of the Core and Scenario cases.

Chapter 5 - The Core Cases



Developing the System Model

During the NTTG 2008-09 planning cycle, NTTG used multiple WECC base cases to perform a reliability analysis within its footprint. Each base case had its own topology representation. This approach caused multiple issues for both the reliability studies and the economic studies. Project topology modifications and system contingency files had to be developed for each base case, and it was difficult to compare results between each base case.

Because of these overall inefficiencies, NTTG decided to discontinue using multi-season base cases after the 2008-09 planning cycle. Instead, NTTG chose to pursue exporting economic dispatch data from a production cost model (also called economic dispatch model or economic model) into the power flow programs for running reliability analysis. Using this method, a consistent network topology was assured, allowing network changes and system contingency files to be applied across all study cases.

But using economic dispatch models to develop reliability cases was a new concept. So NTTG judged it prudent to further develop the export capabilities for both PROMOD and GridView, the two economic dispatch models available to NTTG. This assured that at least one of the export methods would achieve the desired result. NTTG developed a Positive Sequence Load Flow (PSLF) macro to process PROMOD exports, while NTTG hired the ABB engineering and consulting group to automate the exporting of hourly data from GridView. At the conclusion of the study, NTTG was able to successfully export economic dispatch results into the GE PSLF power flow program.

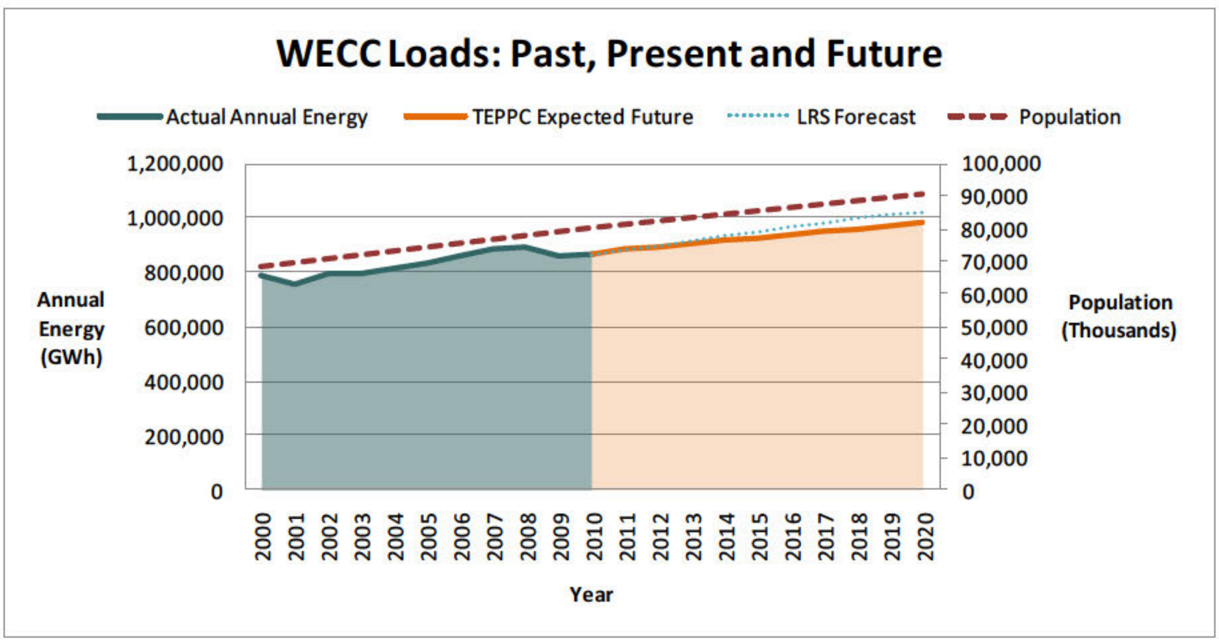
The TEPPC 2020 PC0 Base Case

NTTG turned to WECC for economic dispatch study input data, as the WECC TEPPC already provides this data. The WECC TEPPC develops an economic dataset that uses non-proprietary data. NTTG chose to use the most recent 2020 PC0 TEPPC production cost case for its studies. PC0, the reference case developed as a part of the 2010-11 TEPPC study program, offers expected future assumptions, including loads, generation, transmission and other study-related parameters.

Loads

The 2020 PC0 TEPPC production cost case shows that loads are forecasted to grow to 1 million GWh annually.

Figure 5-1 – WECC Loads: Past, Present and Future



Generation

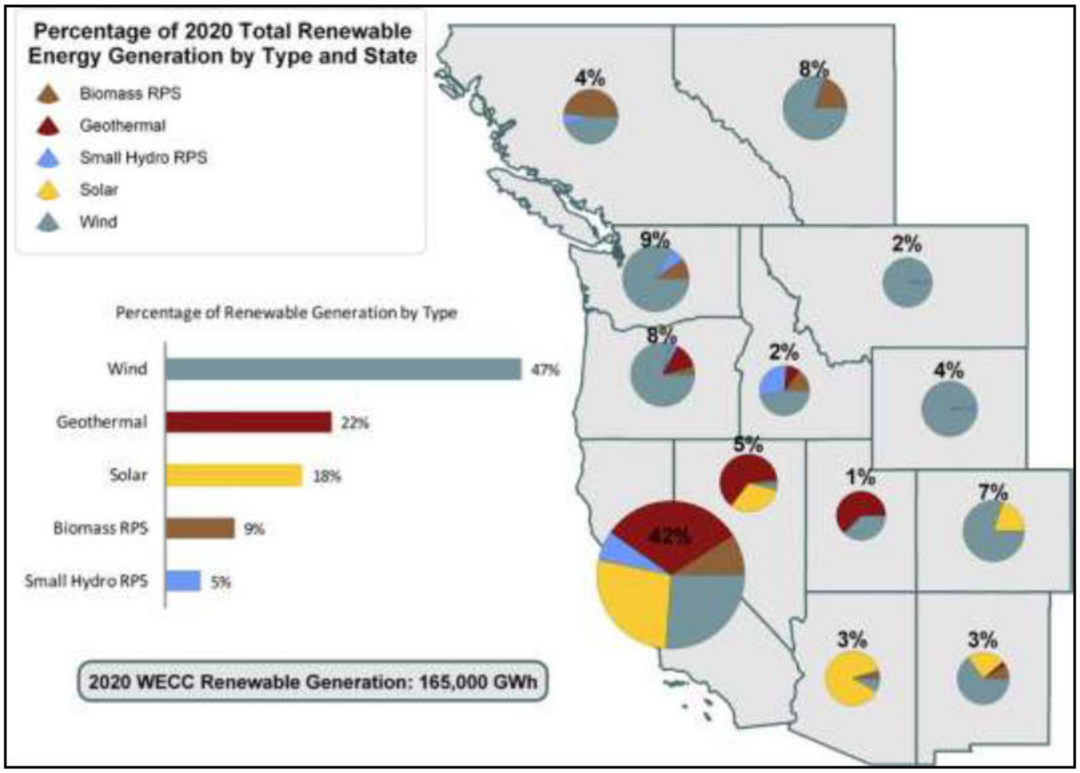
Incremental generation additions were designed to meet load growth through 2020 and the state Renewable Portfolio Standard targets listed below. Other Western states, Canadian provinces and regions with existing and planned renewable generation portfolios include Idaho, Wyoming, Alberta, British Columbia and portions of Mexico (CFE) .

Table 5-1 – Renewable Portfolio Standard by State (% of generation)

	AZ	CA	CO	MT	NV	NM	OR	TX	UT	WA
RPS % IOUs	10.0	33.0	30.0	15.0	22.0	20.0	20.0	5.0	13.3	15.0
RPS % Others	10.0	33.0	10.0	-	-	10.0	6.7	-	13.3	see[4]

The generation additions included almost 35,000 MW of renewable resources. The resulting renewable energy by type and state/province from the PC0 solution is shown below.

Figure 5-2 - Percentage of 2020 Total Renewable Energy Generation by Type and State



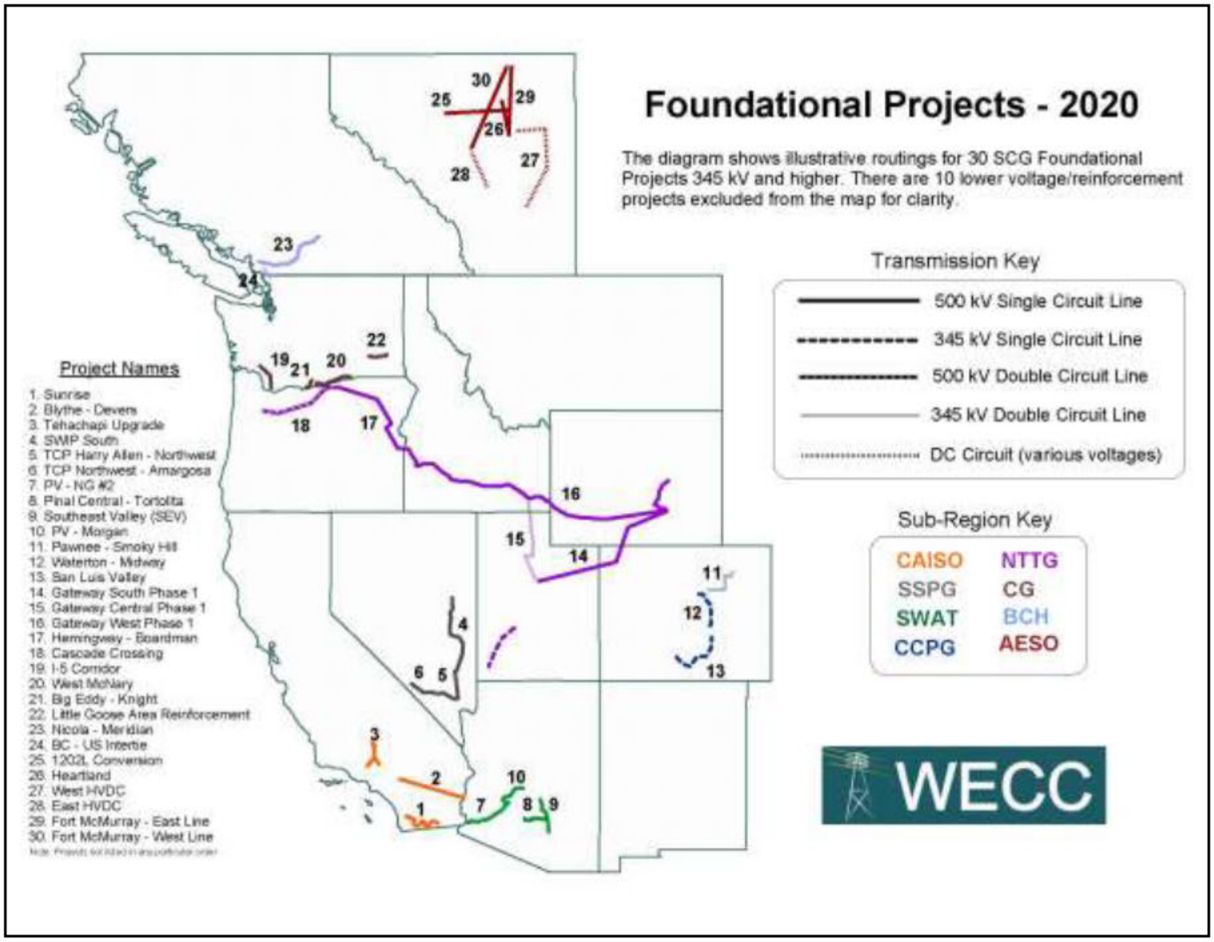
Matching Network Topologies

The 2020 PC0 TEPPC production cost case originated from the WECC 2020hs1a power flow base case. Since WECC staff had made some changes to the transmission topology after importing the power flow case into the production cost environment, NTTG confirmed and, as needed, modified the 2020hs1a case to assure alignment with the PC0 case.

4 In Washington state, the 15% standard applies to all "large" utilities having more than 25,000 customers, including PUDs and municipal utilities.

Changes applied to the WECC 2020hs1a powerflow case by TEPPC were taken from the Subregional Coordination Group's (SCG) Foundational Transmission Projects List Report.

Figure 5-3 – Foundational Transmission Projects - 2020



Aligning Generators

Significant differences in the number of generators exist between the production cost and the power flow models. More than 1,900 generators modeled in the power flow data do not appear in the production cost data. Conversely, there are generators in the production cost model that are not modeled in the power flow data. There can be good reasons for these discrepancies; prime examples include conceptual resources and modeling differences for combined cycle units.

NTTG used a Microsoft Excel spreadsheet to compare generator lists from the power flow and production cost datasets. A large number of generator unit identification numbers needed to be updated, as well as bus name changes. Additionally, many generators lack ID numbers in the production cost model. Those generators were added to the power flow representation. NTTG created a PROMOD database scenario change deck to improve the mapping between the two models. This change deck was shared with WECC and has been incorporated in ongoing WECC studies.

Using Production Cost Model to Simulate All Hours of 2020

NTTG used PROMOD and GridView to simulate an 8,784 hour/year (leap year) dispatch for 2020. Results from that run were exported to a Microsoft Excel spreadsheet to select hours of interest against the criteria of identifying the highest load, export and import hours. The results included line flows, as well as load and generation levels for each hour.

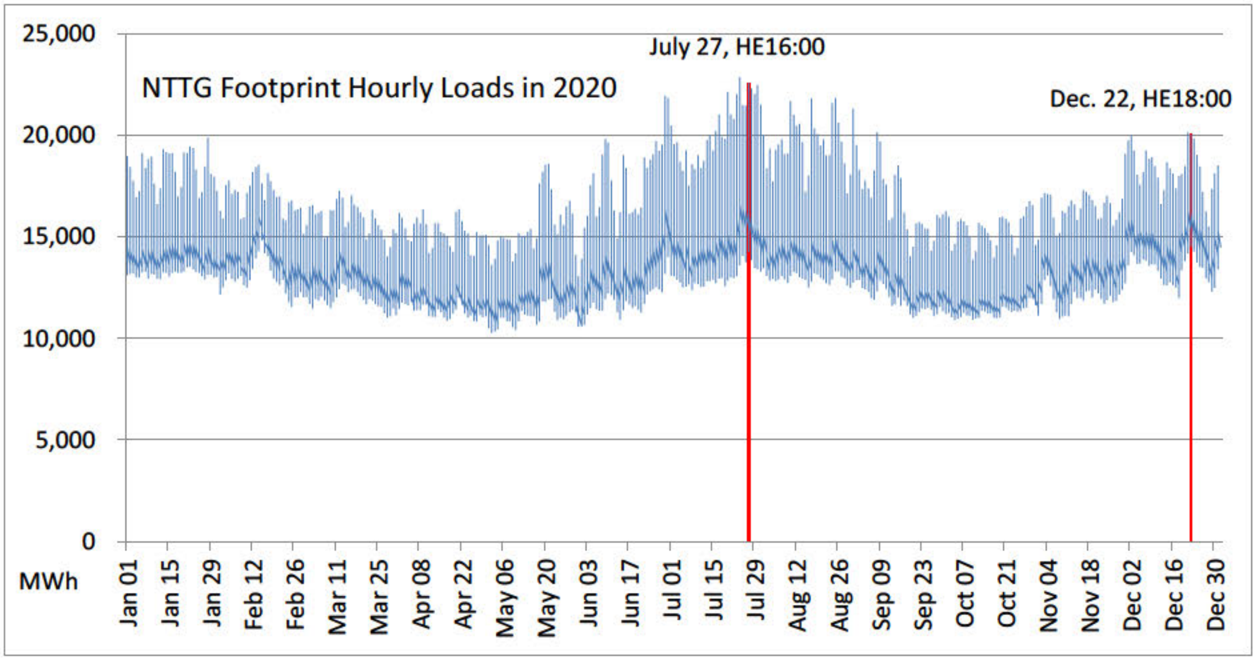
Selecting Hours for Power Flow Analysis

The NTTG TWG examined the hourly production-cost-model reference-case dispatch, for all monitored interfaces in the NTTG footprint, and considered flows at the periphery of the NTTG footprint. The group decided to focus on the eastern portion of the footprint. This approach was consistent with the transmission project study requests received during the second quarter stakeholder data submittal process. And it allowed looking at the total flow on export paths to the west, to the southwest and into Colorado.

Examining hourly flows on 12 WECC paths, the TWG reached consensus to study transmission congestion that would likely to occur during peak loads and high transfer hours. These hours represented times when local load serving transmission could be stressed and when transmission used to export out of or import into NTTG footprint could be stressed. High transfer hours were selected representing hours with maximum flows resulting in paths at or near their limits. Another reason to study high transfer times was that remote development of renewable resources that could meet renewable portfolio standards in the Southwest may lead to high flows to those loads. The peak and high transfer hours studied included:

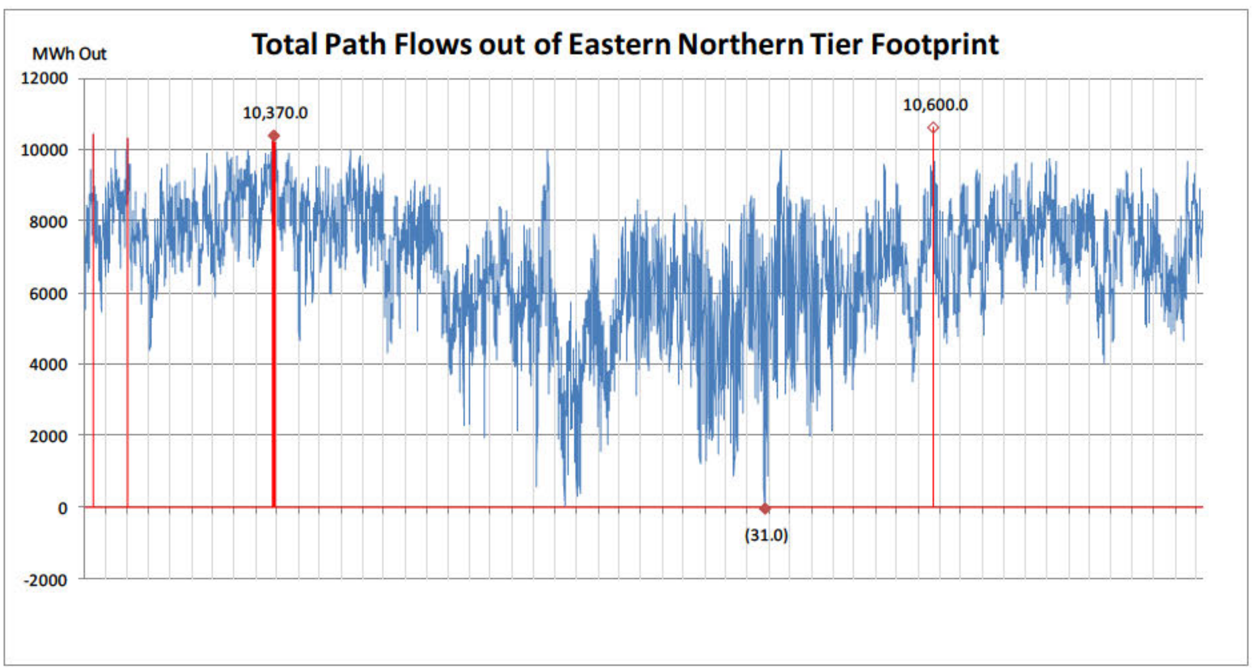
1. Peak load hours	<u>Representing</u>
a. July 27, Hour Ending 16:00	Summer peak
b. December 22, Hour Ending 18:00	Winter peak

Figure 5-4 – NTTG Peak Load Hours Selection



2. High transfer hours	Representing
a. March 2, Hour Ending 21:00	Highest spring exports
b. October 4, Hour Ending 21:00	Highest fall exports
c. August 10, Hour Ending 13:00	Highest annual import

Figure 5-5 – NTTG Export Hours Selection



These five selected hours as exported from the economic model are referred to as the "Core Cases." These contain the 2020 loads and generation as modeled in the TEPPC economic data, including the added generation resources, before any NTTG generation scenarios applied to them.

Transferring Load and Resource Data, and Solving Cases

Once these hours of interest were selected, the generation dispatch and NTTG load patterns were defined for each of the five hours selected by rerunning the economic model and exporting the data for those specific hours to the power flow program. Numerous data issues arose, resulting in specific network elements prohibiting a solution. Each issue was addressed until a successful solution was achieved.

With each additional study-hour simulation and conversion to the power flow case, resolving data modeling incompatibilities to obtain a solvable the power flow became easier. Due to high transfers in the Alberta area, the Alberta area was extracted and solved after first balancing the remaining system. In future studies collaboration between NTTG and the WECC TEPPC should reduce the production cost to power flow model conversion because WECC has adopted the same study process of exporting production cost simulations to power flows for reliability analysis. WECC's adoption of NTTG's process should result in improved alignment of the system model between production cost and power flow program databases.

The Core Cases

The following tabulation shows each Core Case path flow for select paths. Note that a path generally consists of several lines and not just a single line. Flows shown in red text indicate an overload on the path.

Table 5-2 – Core Cases N-0 Path Flows

CORE CASE	ID-NW (3800MW)[1]	MT-NW (2200MW)	COI (4800MW)	PDCI (3100MW)	NORTH OF JOHN DAY (7900MW)	BORAH WEST (4450MW)	BRIDGER WEST (3800MW)	TOT2[2] (A,B,C) (2070MW)	PATH C (1400MW)
JUL27H16	-123	635	3049	2600	5473	502	1593	316	-190
DEC22H18	649	1214	1122	2600	3848	722	1040	587	317
MAR02H21	961	1607	4990	2600	2737	778	1095	1416	215
OCT04H21	3208	1933	1640	2600	1318	3078	2713	1005	1408
AUG10H13	-754	166	-1146	2600	3577	-46	1683	695	-605

Notes:

(1) MW value shown below path name represents the transfer limit of the path.

(2) TOT2 values shown as the sum of the magnitude of the TOT2A, TOT2B and TOT2C flows. TOT2 overloads are identified as an overload on any one segment (A, B or C).

The Western Interconnection can be represented by balancing areas (e.g., areas where a transmission provider or several transmission providers balance the generation to the load) that are connected by paths. The flows across these paths (or interchange flows) between balancing areas for each Core Case are shown in Figures 5.4 through 5.8. MW values for the total area generation, total area load and total area interchange are shown on each diagram. Area losses can be determined from the diagram by taking the sum of the area total interchange and area total generation, then subtracting the total area load.

Figure 5-6 – Interface Flows for JUL27H16 Core Case

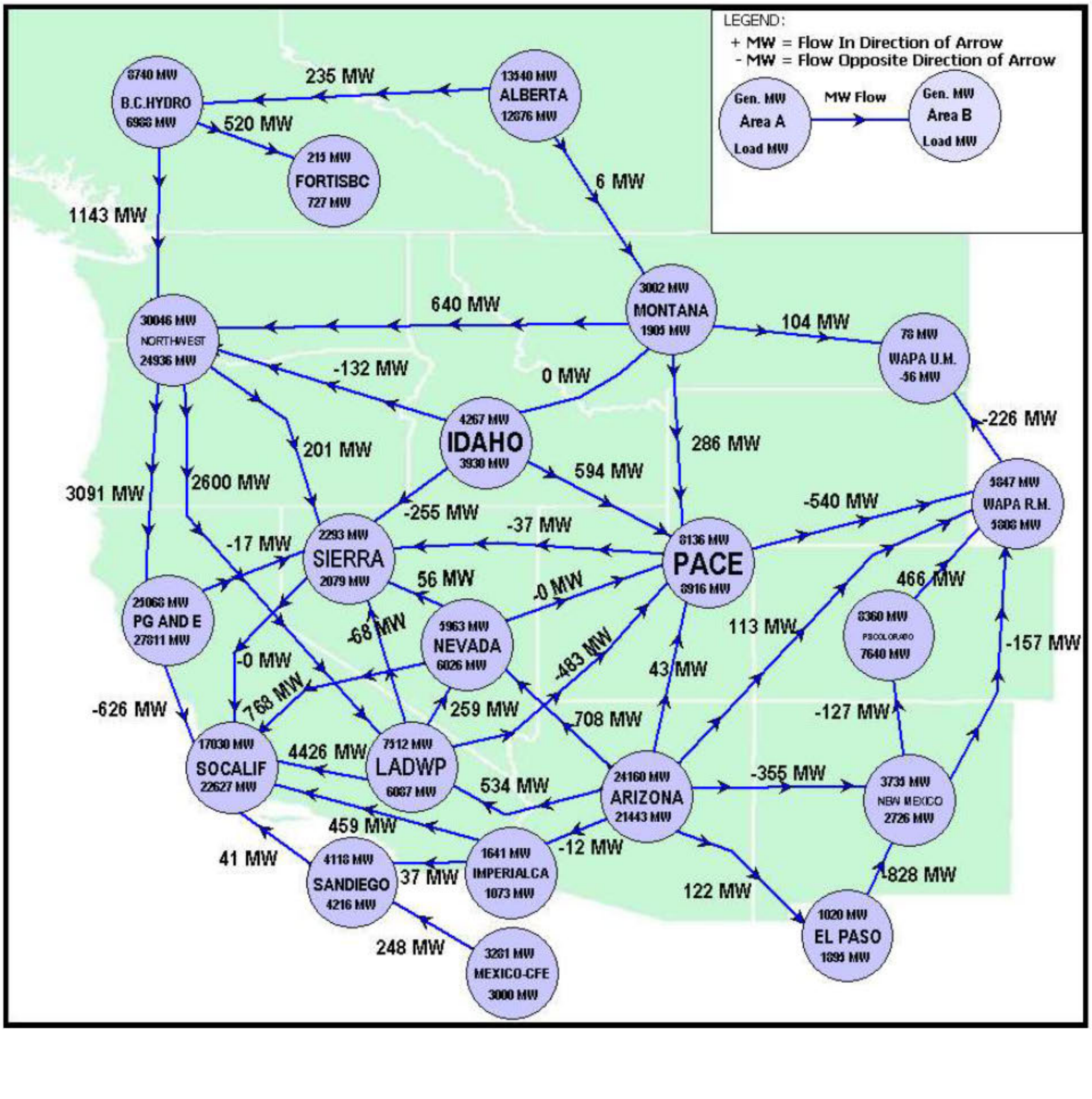


Figure 5-7 – Interface Flows for DEC22H18 Core Case

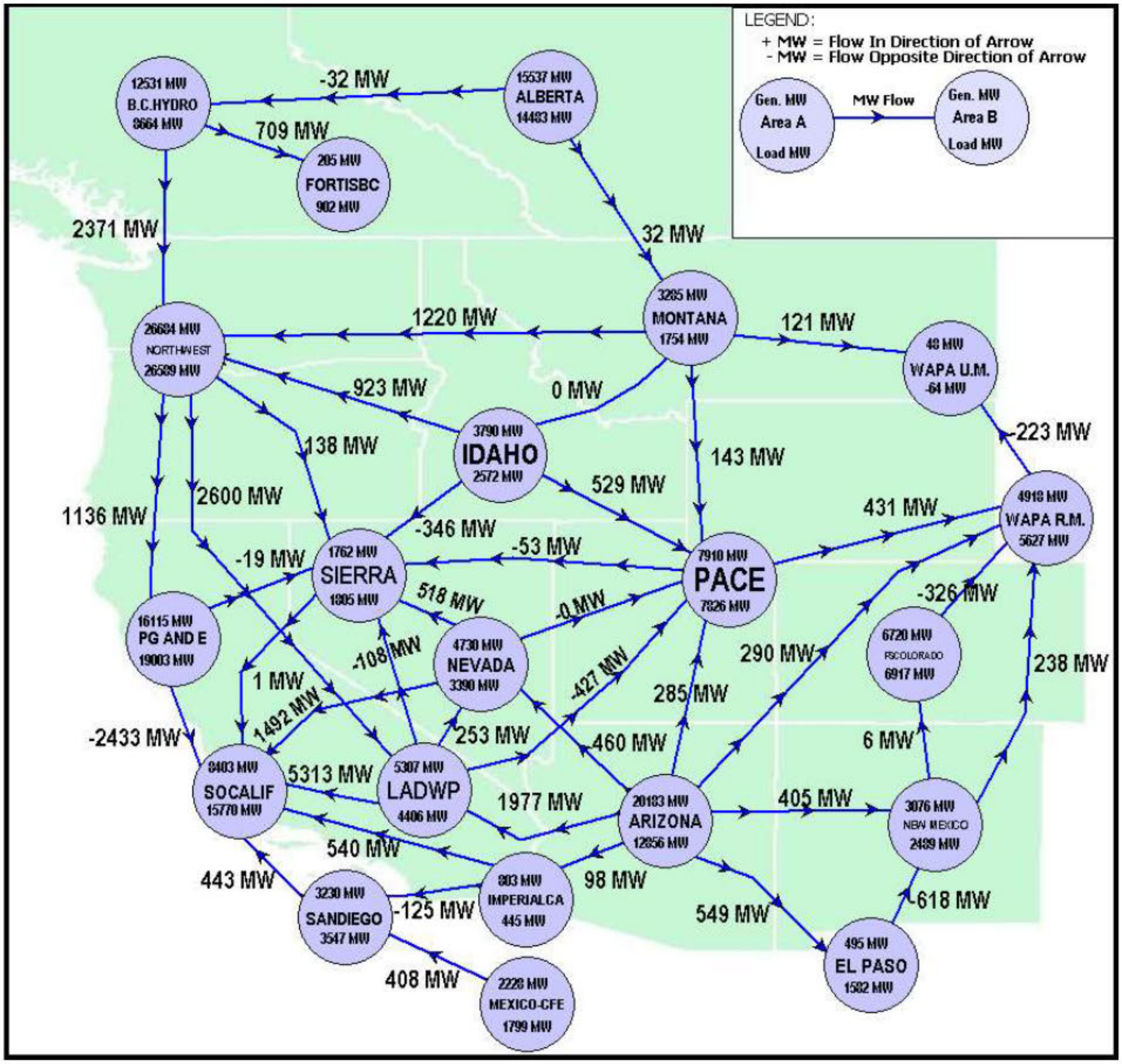


Figure 5-8 – Interface Flows for MAR02H21 Core Case

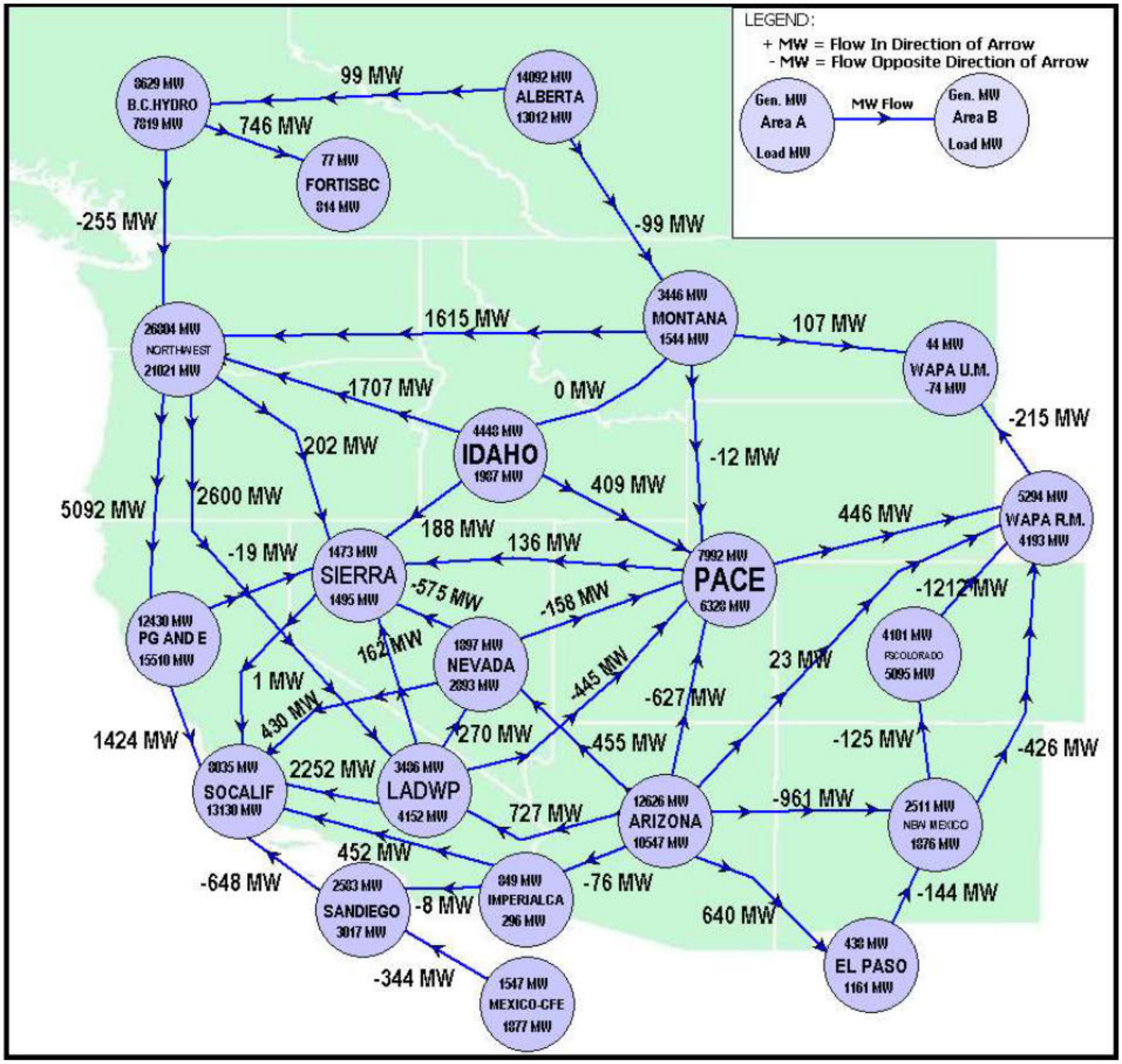


Figure 5-9 – Interface Flows for OCT04H21 Core Case

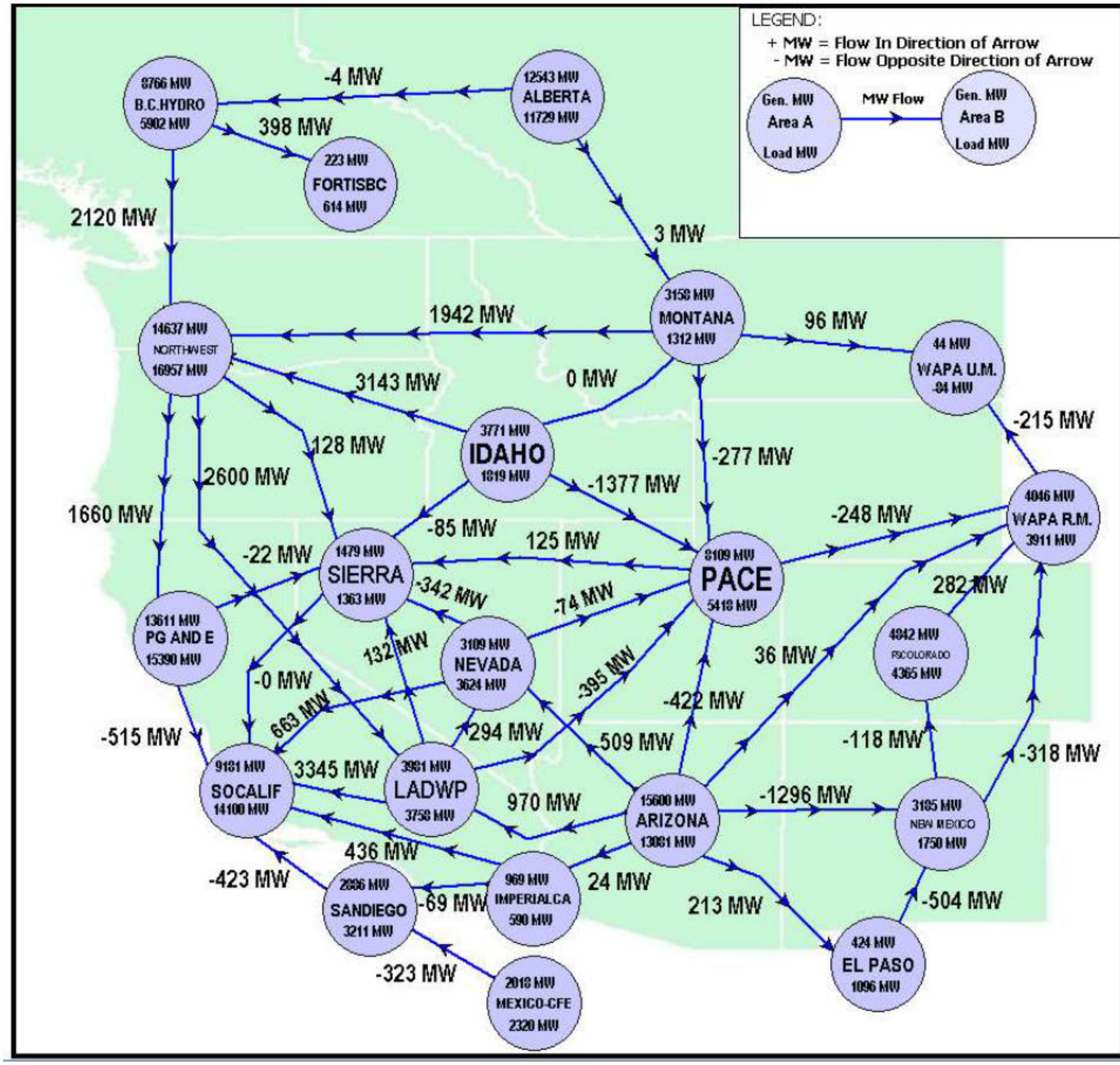
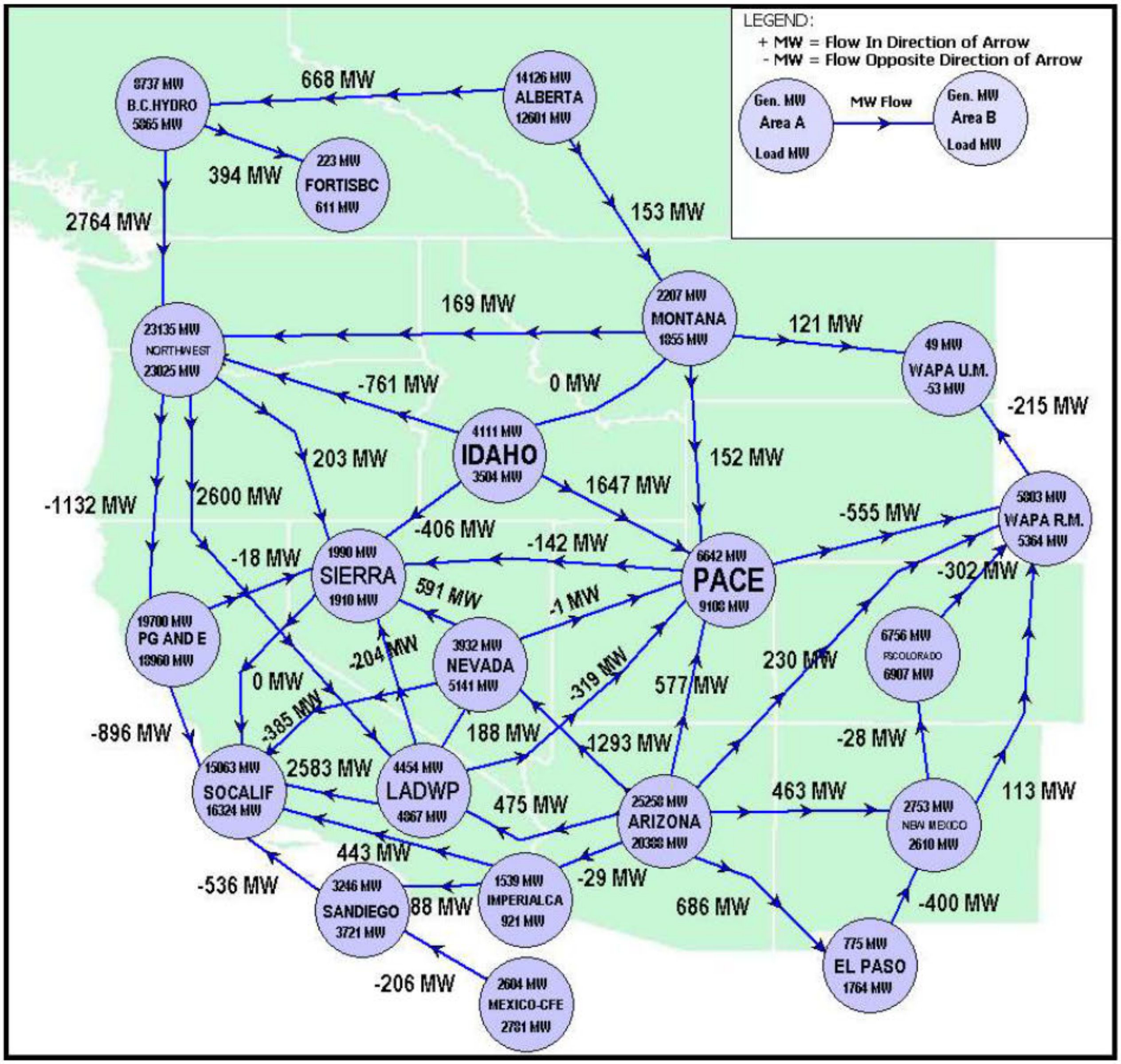


Figure 5-10– Interface Flows for AUG10H13 Core Case



Contingency Analysis

A power systems simulation application, PowerWorld Simulator, was used to analyze a comprehensive set of single element outages (N-1) on all 230 kV and greater lines and transformers, including NTTG and external Foundational Transmission Projects. This resulted in over 400 single-element outages that were simulated to determine the robustness of the proposed system and its ability to serve the projected loads and resources for year 2020.

Any overloads found in the pre-disturbance Core Cases (i.e., N-0) indicate three possible culprits. One explanation is a need to reinforce the Foundation Transmission Projects to reduce expected overloads. A second possibility is a lack of detailed network upgrades at the local transmission level that might not have been represented in the case. The third is a modeling error that is not related to actual system performance and can be corrected in the model. Overloads in the N-0 analysis would be exacerbated for particular outages and would again show either the need to strengthen a specific section of the transmission system (possibly through reinforcements to the Foundational Transmission Projects) or the need for new network upgrades to address specific issues brought about by the outages in question.

The Core Cases N-0 and N-1 violation tables for all five study hours are located Appendix 6.

Study Hour – July 27 H16

This hour represents a summer peak load condition for the NTTG footprint. The pre-disturbance (N-0) overload screening for this hour in the Core Case showed 14 overloaded elements, primarily transformers. This is most likely due to the projected load increase for the 2020 year and the stresses it places on the local system. A total of 21 voltage violations (outside the 0.9 – 1.1 per unit acceptable voltage range) were observed in the areas of interest. Other than a high voltage on the 230 kV busses, most of the other reported violations were either on "dummy" busses (e.g., on the line side of series capacitors, where these voltage levels would be acceptable) or slightly higher-than-normal voltages on some 500 kV busses. These could probably have been reduced by appropriate switching of reactive devices.

There were 10 N-1 thermal overload violations in addition to the 14 pre-disturbance overloads. One of the significant overloads (~137%) was due to the loss of the Dave Johnston – Windstar 230 kV circuit #2, which overloaded the corresponding parallel circuit. This element is one of the Foundational Transmission Projects and will likely be equipped with generation tripping to prevent this overload. The largest overload (143%) was seen on the Ben Lomond 345/138 transformer due to the loss of another source to the 138 kV load through the Syracuse 345/138 transformer.

A total of 28 voltage violations were identified for N-1 conditions – 27 violations for high bus voltage and one violation for low bus voltage. A large portion of the reported overvoltage violations related to 500 kV busses. Overvoltage in the 1.1 to 1.15 per unit ("p.u.") range are not considered a severe violation, especially if the overvoltage occurs on a dummy buss. The listed under voltage on a 230 kV bus was related to a local area problem.

The 14 transformer overloads reported for N-0 conditions were also reported as violations for N-1 conditions. These overloads were excluded from the N-1 violation tables.

Study Hour – December 22 H18

This hour represents a winter peak load condition for the NTTG footprint. The pre-disturbance overload screening for this hour in the Core Case showed 8 branch elements overloaded, primarily transformers. This is most likely due to the projected load increase for the 2020 year and the unresolved stresses it places on the local system.

A total of 57 high bus voltage violations (outside the 0.9 – 1.1 p.u. voltage range) were identified for N-0 conditions. Other than a high voltage on the 230 kV busses, most of the other reported violations were either on dummy busses or slightly higher-than-normal voltages on some 500 kV busses. The voltages were barely over the upper limit of the range. These probably could have been further reduced by appropriate switching of reactive devices.

For N-1 conditions, the results indicated three thermal overload violations, with all three voltages near or below the 115% emergency rating. These are considered minor overloads. One of the overloads barely exceeded the emergency limit of the Ben Lomond 345/138 kV transformer due to the loss of another source to the 138 kV load through the Syracuse 345/138 kV transformer.

N-1 contingency analysis indicated 28 voltage violations – 27 high voltage violations and one low voltage violation. Most of the reported overvoltage violations related to 500 kV busses. Overvoltage in the 1.1 to 1.15 p.u. range are not considered severe violations, in particular if these occur in dummy busses. The increase in voltage was minor and probably would not have resulted in reported violations had the initial voltages been tuned to fall inside the range. The listed under voltage on a 230 kV bus was related to a local area problem.

The transformer overloads reported on radial connected loads listed in the N-0 violation tables were excluded from the N-1 violation tables in order to reduce duplication of the report violations. These violations also occurred during N-1 system conditions.

Study Hour – March 02 H21

This hour represents a heavy spring export load condition for the NTTG footprint. A total of 12 thermal overload violations were identified for N-0 conditions. Most of these violations were overloads on transformers located in the neighborhood of new wind projects. It is very likely these overloads were related to failure to increase the associated transformer ratings when the new resources were added. These types of overloads are mainly a local issue as the majority of the transformers are rated for 34.5/230 kV operation. The Pavant, Intermount-Gonder 230 kV path was also overloaded in the case at 122% for N-0 conditions.

A total of 15 voltage violations were recorded for N-0 conditions – 14 high bus voltage violations and one low bus voltage violation. Other than a high voltage on the 230 kV busses, most of the other reported violations were either on dummy busses or slightly higher-than-normal voltages on some 500 kV busses. These probably could have been adjusted by appropriate switching of reactive devices. Notice also that the one reported low voltage, on the 500 kV level, occurred on a dummy bus on the line side of a series capacitor under light flow conditions.

A set of more than 400 N-1 contingencies were run on this March Core Case because as the study on the Core Cases was progressing it was determined that the March case represented the critical case for study. The study results indicated 10 thermal overload violations and 47 voltage violations. A large portion of the reported overvoltage violations related to 500 kV busses. Overvoltage in the 1.1 to 1.15 p.u. range are not considered a severe violation, in particular if these occur in dummy busses.

The transformer overloads reported on radial connected loads listed in the N-0 violation tables were excluded from the N-1 violation tables in order to reduce duplication of the report violations. These violations also occurred during N-1 system conditions.

Study Hour – October 04 H21

This hour represents a heavy autumn export load condition for the NTTG footprint. The pre-disturbance overload screening for this hour in the Core Case showed several transformers overloaded. Eight branch element overloads were recorded. These overloads appear to be data related, since they were associated with dedicated transformers for specific generation projects. There were three interface violations reported for N-0 conditions: Midpoint-Summer Lake at 107%, Pavant, Intermountain-Gonder at 105% and Path C at 101%.

A total of 53 bus voltage violations were recorded for N-0 conditions. Other than a high voltage on two 230 kV busses, most of the other reported violations were either on dummy busses or slightly higher-than-normal voltages on some 500 kV busses. The voltages were barely over their upper limit of the p.u. voltage range. These overvoltages could have been further reduced by appropriate switching of reactive devices.

The N-1 contingency results indicated 20 thermal overload violations. The most severe overloads (~140%) on the 500 kV system were related to the loss of the Hemingway to Boardman 500 kV line. This being a heavy export (from the NTTG footprint) case, loss of the Hemingway-Boardman 500 kV line resulted in overloading the parallel branch, the Hemingway-Summer Lake 500 kV line. Initiating unit tripping on the eastern side of the system, or increasing the rating of the limiting element (a series capacitor at Burns), are potential solutions to mitigate overloads for loss of the Hemingway to Boardman 500 kV line. Other overloads on the 230 kV system constituted a local area problem due to the projected increase in load/generation in the studied case.

A total of 63 voltage violations were recorded for N-1 conditions. Most of the reported overvoltage violations related to 500 kV busses. Overvoltages in the 1.1 to 1.15 p.u. range are not considered a severe violation. The increase in voltage was minor and probably would not have resulted in reported violations had the initial voltages been tuned to fall inside the range. The largest overvoltage (1.31 p.u.) on a 230 kV bus was related to large flow redistribution following the loss of a 230 kV tie near a source of wind generation. This was considered a local area problem.

The transformer overloads reported on radial connected loads listed in the N-0 violation tables were excluded from the N-1 violation tables in order to reduce duplication of the report violations. These violations also occurred during N-1 system conditions.

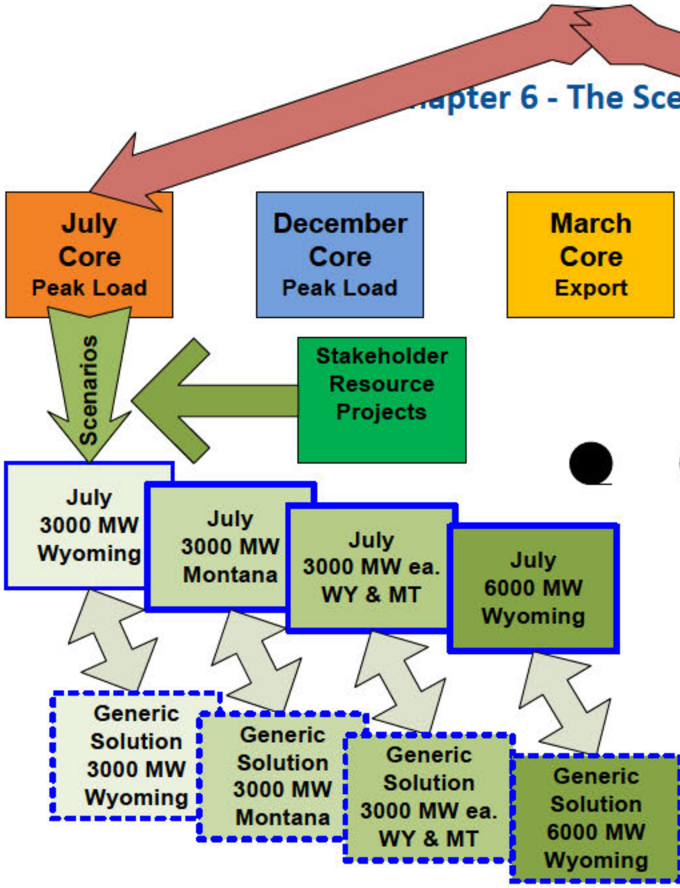
Study Hour – August 10 H13

This hour represents a maximum import load condition for the NTTG footprint. The pre-disturbance overload screening for this hour in the Core Case shows 10 transformer overloads. The reported extreme thermal overload was 150% of the continuous rating. These overloads are most likely due to the projected load increase for the 2020 year and the unresolved stresses it places on the local system. For N-0 conditions, 68 bus voltage violations were recorded outside the 0.9 – 1.1 p.u. voltage range in the areas of interest. Other than a high voltage on the 230 kV busses, most of the other reported violations were either on dummy busses or slightly higher than normal voltages on some 500 kV busses. These overvoltages could probably have been reduced by appropriate switching of reactive devices. This study hour is an import (to the NTTG footprint) case with south-to-north flows on California-Oregon Intertie (COI). Most of the 500 kV voltage violations were along the COI system, highlighting the relatively light flows and the need for additional reactor switching.

A total of 12 overloaded elements were recorded for N-1 conditions. One significant overload (~134%) was due to loss of the Dave Johnston – Windstar 230 kV circuit #2. This line loss overloaded the corresponding parallel circuit. This element is one of the Foundational Transmission Projects and will likely be equipped with generation tripping to prevent this overload. The largest overload (140%) was seen on the Ben Lomond 345/138 transformer due to the loss of another source to the 138 kV load through the Syracuse 345/138 transformer. The Bridger-Rock Springs circuit 1 was overloaded just below the emergency rating (115%) for loss of the parallel circuit 230 kV #2.

A total of 28 bus voltage violations were recorded for N-1 conditions – 27 high bus voltage violations and one low bus voltage violation. A large portion of the reported overvoltage violations related to 500 kV busses. Overvoltages in the 1.1 to 1.15 p.u. range are not considered a severe violation, in particular if these occur in dummy busses (line side terminals of series capacitors). The number of elements that experienced overvoltages increased for outages that result in the loss of large generation in the NTTG footprint (i.e., Colstrip #4) or unloading the 500 kV system by impeding the flow (opening a 500/230 kV transformer) from the 500 kV system to the lower voltage (load serving) system. The listed undervoltage violation on a 230 kV bus was related to a local area problem.

The transformer overloads reported on radial connected loads listed in the N-0 violation tables were excluded from the N-1 violation tables in order to reduce duplication of the report violations. These violations also occurred during N-1 system conditions.



The Scenario Cases

Four scenario cases were developed from the Core Cases to represent four different resource scenarios.

The four scenario cases are shown below:

1. 6,000 MW in Wyoming
2. 3,000 MW in Wyoming, 3,000 MW in Montana
3. 3,000 MW in Montana
4. 3,000 MW in Wyoming

Within each of the four scenarios, five study hours were selected. The five study hours are shown below:

1.	Summer Peak	July 27, Hour 16
2.	Winter Peak	December 22, Hour 18
3.	Heavy Spring Export	March 2, Hour 21
4.	Heavy Autumn Export	October 4, Hour 21
5.	Maximum Import	August 10, Hour 13

Each study hour within a scenario was evaluated using load flow analysis to identify the minimum amount of transmission improvements required to reduce path flows to acceptable levels on the overloaded path or on the path experiencing voltage problems. Single element (N-1) contingency analysis was performed on all five study hours for each scenario to evaluate the performance of the system.

The contingency analysis performance criterion is shown below:

- N-1 contingencies of 230 kV and above elements within the NTTG footprint (420 total)
- Report violations for elements at 230 kV and above
- Violation if the increase in flows on a monitored element was greater than 2% above the 100% rating of the element
- Violation if the voltage change on a monitored element was greater than 1%, outside a range of 90%-110%

1.0: Scenario 1 – 6,000 MW in Wyoming

This scenario intends to represent the effect of an additional 6,000 MW of alternative generation in Wyoming (assumed to be distributed among the Anticline, Dave Johnston, Windstar and Aeolus busses).

6,000 MW in Wyoming – Case Development

Case development for Scenario 1 began with the Core Case from each study hour. Generation resources were added to the Core Case for each study hour to develop five power flow cases for Scenario 1. Table 6.1 shows the generation resources added to the Core Case used to develop the five study hour cases for Scenario 1.

Table 6-1 – Scenario 1 Generation Resource Additions

Area Name	Bus Name	Generation Addition
PACE	DAVEJOHN	500 MW
	AEOLUS	2000 MW
	ANTICLINE	2000 MW
	WINDSTAR	1500 MW
	Total	**6000 MW**

A sink was created for each of the five study hours by removing generation resources in order to offset the 6,000 MW resource addition. Table 6.2 shows the generation resources removed from the Core Case used to develop the five study hour cases for Scenario 1. The values shown represent the total generation MW reduction in each of the areas listed. A more detailed table identifying the specific busses with generation reductions is provided in Appendix 7.

Table 6-2 - Scenario 1 Generation Resource Reductions

Area Name	Generation Reduction (MW) July 27 Hour 16	Generation Reduction (MW) December 22 Hour 18	Generation Reduction (MW) March 2 Hour 21	Generation Reduction (MW) October 4 Hour 21	Generation Reduction (MW) August 10 Hour 13
SOCALIF	2065	1000	2246	760	2954
SANDEIGO		178		70	272
NORTHWEST	8	12		107	
NEWMEXICO				270	
ARIZONA	1180	845	1947	1263	660
PG&E	2500	2240	2240	2463	436
SIERRA		47			
ALBERTA	129	1019		898	776
NEVADA	118				120
WAPA RM				60	
PACE		102		129	
	6000 MW	**5443 MW**	**6433 MW**	**6020 MW**	**5218 MW**

Once the generation additions and reductions were completed, the power flow case was solved. The study team identified overloads of transmission elements before the addition of generic transmission improvements. Table 6.3 shows the N-0 path flows for Scenario 1 before the addition of generic transmission improvements for each study hour analyzed in Scenario 1.

Items shown in red text indicate that path elements are overloaded above the existing rating due the addition of 6,000 MW of generation resources in Wyoming. The path ratings are shown in parentheses below the path name. TOT2 flows are shown as the sum of TOT2A, TOT2B and TOT2C. An overload on any element of TOT2 (A, B, C) is considered a path overload; so overloads on TOT2 could be listed at values less than the 2,070 MW value.

Table 6-3 - Scenario 1 N-0 Path Flows (Pre-Generic Transmission Improvements)

SCENARIO 1	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3800) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW
JUL27H16	2111	988	**5275**	2600	5815	3207	**4673**	**1963**	317
DEC22H18	3304	1486	2814	2600	3585	**5273**	**4704**	981	1191
MAR02H21	2135	**4018**	**7660**	1904	5181	1911	3088	**2705**	-96
OCT04H21	**5933**	2041	3358	2600	982	**6264**	**6049**	**2546**	**2174**
AUG10H13	1435	396	673	2600	3430	2447	**4242**	722	-10

Transmission improvements, in the form of new 500 kV transmission lines (AC solution option), were added to each of the five study hours to supplement the Foundational Transmission Projects. The locations of the 500 kV transmission improvements are shown in Figure 6.1.

Transmission improvements using DC transmission lines (DC solution option) were tested on the March study hour (maximum spring export). Figure 6.2 shows the location of the DC transmission improvements tested on the March study hour.

Both the AC solution option and DC solution option appeared as adequate solutions for relieving overloads.

Figure 6-1 – Scenario 1 Generic Transmission Improvements (AC Solution Option)

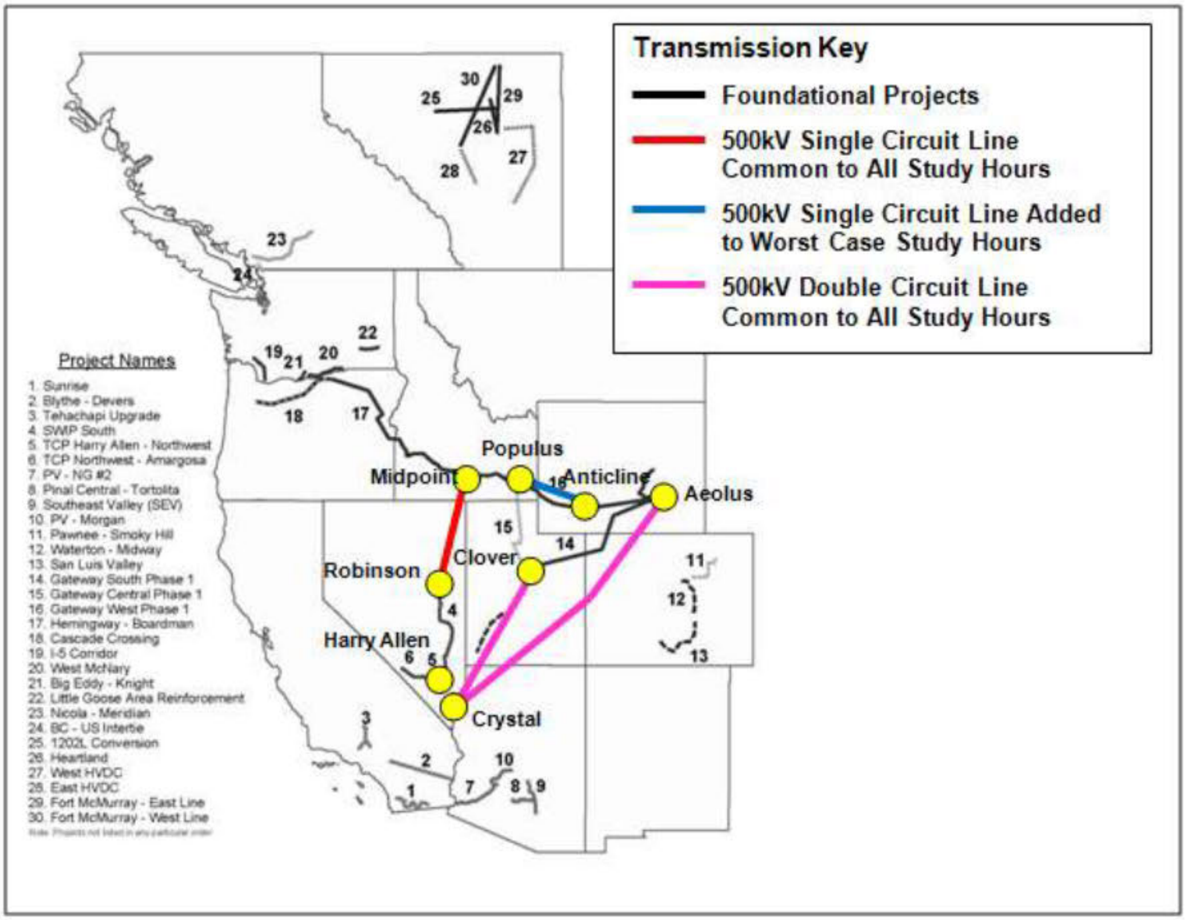
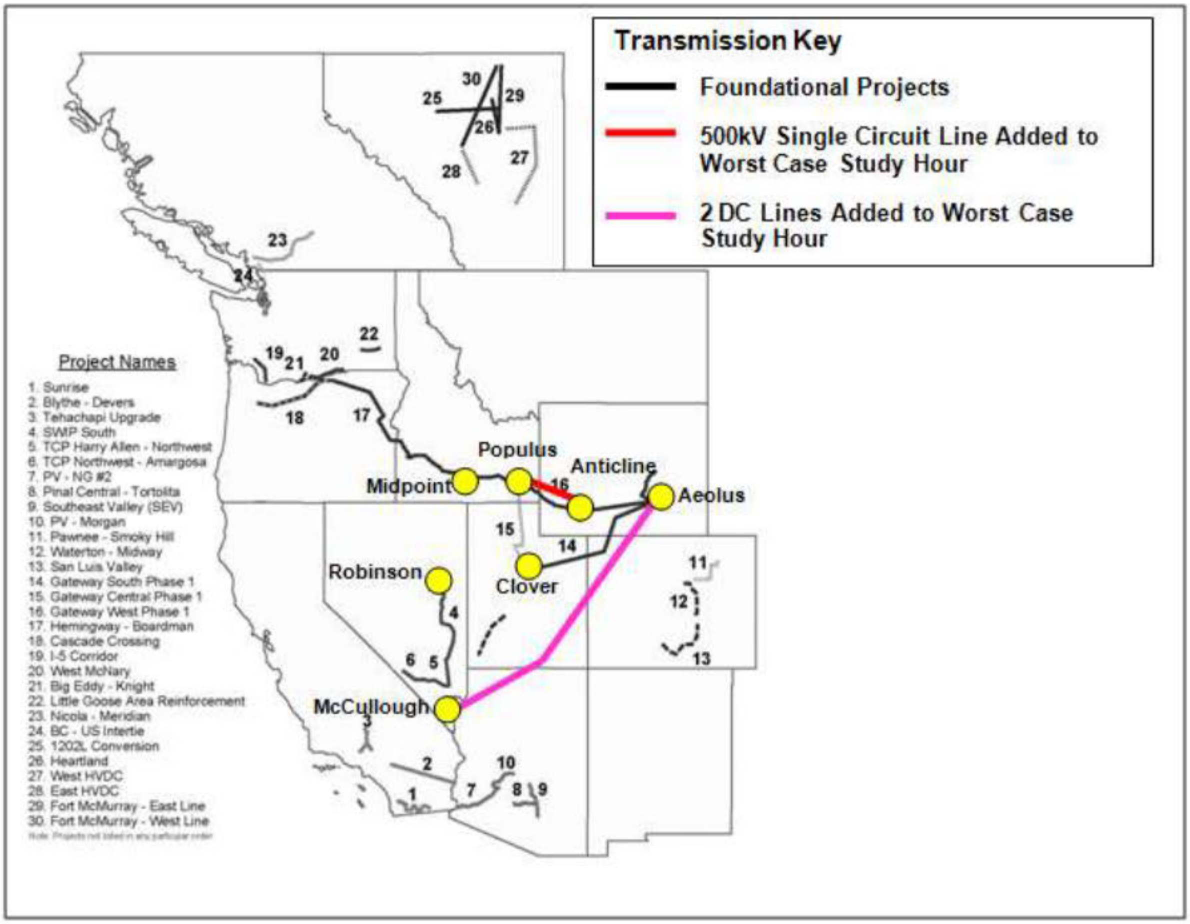


Figure 6-2 – Scenario 1 Generic Transmission Improvements (DC Solution Option)



6,000 MW in Wyoming – Study Results

The study results indicated that the addition of 6,000 MW of generation in Wyoming resulted in overloaded paths as shown in Table 6.3. Overloaded paths for Scenario 1 common between study hours were overloads on COI, Bridger West, Borah West and TOT2 (A,B,C). The overloaded elements identify the need for transmission improvements.

The transmission improvements common to all five study hours were: 1.) a double circuit 500 kV transmission line between the Aeolus and Crystal busses, 2.) a double circuit 500 kV transmission line between the Clover and Crystal busses, and 3.) a 500 kV transmission line between the Midpoint and Robinson busses. Load flow analysis was performed on each study to test if the proposed transmission improvements were adequate in reducing the overloads.

Post-improvement N-0 path flows are shown in Table 6.4. The study results indicate that the proposed transmission improvements relieved the majority of the overloads shown in Table 6.3.

For the March and August study hours, an additional 500 kV transmission line was added between Anticline and Populus to relieve overloads on the Bridger West Path. This transmission line was added in parallel with the Gateway West Phase 1 line, a Foundational Transmission Project.

One post-improvement N-0 overload common to the December and October study hours were overloads on Bridger West of 103.5% and 116.3% (respectively) on a 3,800 MW rating. The common overload on the Bridger West Path for the December and October study hours suggests than an additional transmission improvement between Anticline and Populus is one solution to resolve the identified overloads. The addition of a second 500 kV transmission element from Anticline to Populus in the March and August study hours relieved overloads on the Bridger West Path for Scenario 1.

A DC solution option was also tested on the March study hour. Two DC lines between Aeolus-McCullough were added to the case. The DC solution option also included a second 500 kV circuit between Anticline and Populus, however, this circuit is most likely not needed. The study results indicate that the DC solution option appears as an adequate solution alternative. One post-improvement overload on COI (105%) was identified with the DC solution option. This overload may be mitigated by adjusting the flow on the PDCI.

Even though this study did not include a combination of AC and DC transmission line improvements, several of the AC and DC improvements described above could be combined to create another solution option to resolve the transmission overloads identified in this Scenario.

N-1 contingency analysis for each study hour in Scenario 1 indicated that the majority of the 420 contingencies solved for each study hour. There were two study hours that had unsolved contingencies. The BOARDT2-DALREED contingency was unsolved in the March and October study hours.

N-0 and N-1 violations discussed in this report are violations on elements 200 kV and above within the NTTG footprint. N-0 and N-1 violation tables for each study hour within this scenario are provided in Appendix 8.

The sum of the N-1 violations for all the study hours in Scenario 1 was 371 violations. The majority of overloaded elements for all the study hours were transformer overloads for N-1 conditions. The most common N-1 violation for all study hours was high bus voltage. Most of the high bus voltage violations were reported at dummy busses near 500 kV series capacitors. The number of violations in the March study hour was similar for both the AC and DC solution options.

Table 6-4 – Scenario 1 N-0 Path Flows (Post-Generic Transmission Improvements)

SCENARIO 1	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW	DBL CKT 500kV Aeolus-Crystal (3000) MW	DBL CKT 500kV Clover-Crystal (3000) MW	SGL CKT 500kV Midpoint-Robinson (1500) MW	500kV CKT #2 Anticline-Populus (1500) MW	2 DC Lines Aeolus-McCullough (6000) MW
JUL27H16	695	881	3841	2599	5523	1952	3621	700	-199	1928	1148	437	NA	NA
DEC22H18	2817	1414	2331	2600	3482	3997	3932	239	764	1722	625	-366	NA	NA
MAR02H21 (AC Option)	1948	1680	4791	2769	2811	2693	4213	1459	-40	2912	1661	1496	1184	NA
MAR02H21 (DC Option)	2261	1688	5060	2760	2853	1690	2732	1640	145	NA	NA	NA	490	6000
OCT04H21	3480	1899	984	2600	622	3924	4420	888	984	2314	2163	315	NA	NA
AUG10H13	1310	378	529	2600	3384	2452	4674	646	-388	1000	207	117	1481	NA

Notes:

(1) Second 500 kV circuit between Anticline-Populus was added to the March and August study hours to relieve overloads on Bridger West. Interface rating was increased from 3,700 MW to 5,200 MW.

(2) Path rating shown in parentheses below the path name.

(3) Path overloads are identified in red text. TOT2 is reported as the sum on TOT2A, TOT2B and TOT2C. On overload on any TOT2 segment represents an overload on the path.

1.1: 6,000 MW in Wyoming – Summer Peak – July 27, Hour 16

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 21 overloaded branch elements – all transformers – ranging from 100.3% to 160% of the nominal rating. These transformer overloads were found to be located on radial-connected loads and are considered a local problem. There were 27 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency. The majority of the high bus voltage violations are on dummy busses located on the line side of series capacitors, where slightly higher-than-nominal voltage would be expected.

A set of 420 N-1 contingencies was run on this study hour, causing 53 violations with zero unsolved contingencies. Violations were observed on 11 elements overloaded above the 100% rating. Ten elements were overloaded at less than 115% of the 100% rating. One element produced an overload of 137% of the continuous rating. The remaining 42 violations resulted from elements with a bus voltage greater than 1.1 p.u.

Area interchange diagrams are provided in Figures 6.3-6.6. MW values shown on the difference diagram represent a MW change as referenced to the study hour Core Case.

Figure 6-3 – Scenario 1 Core Case Flows: JUL27H16

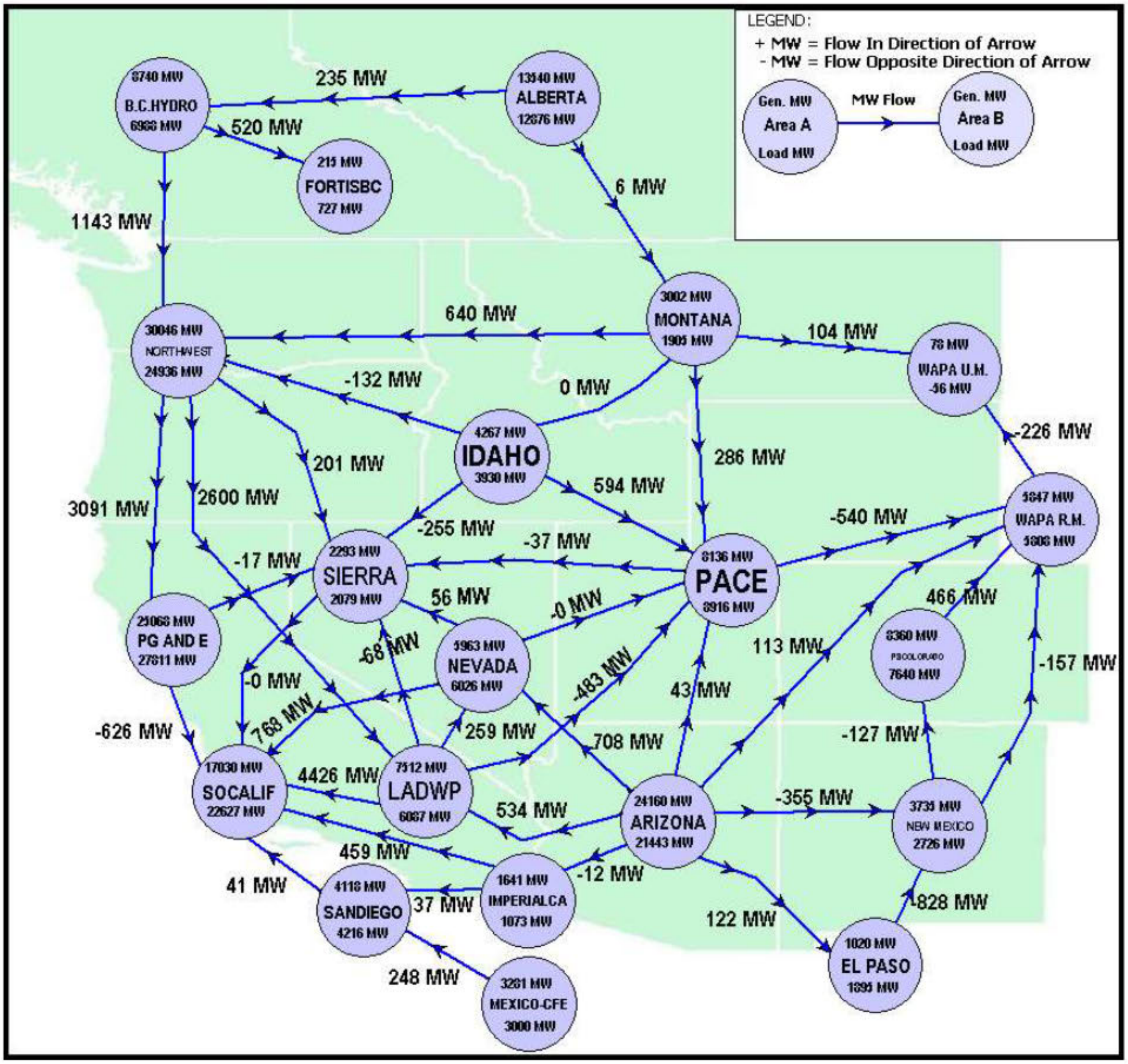


Figure 6-4 – Scenario 1 N-0 Flows (Pre-Transmission Improvements): JUL27H16

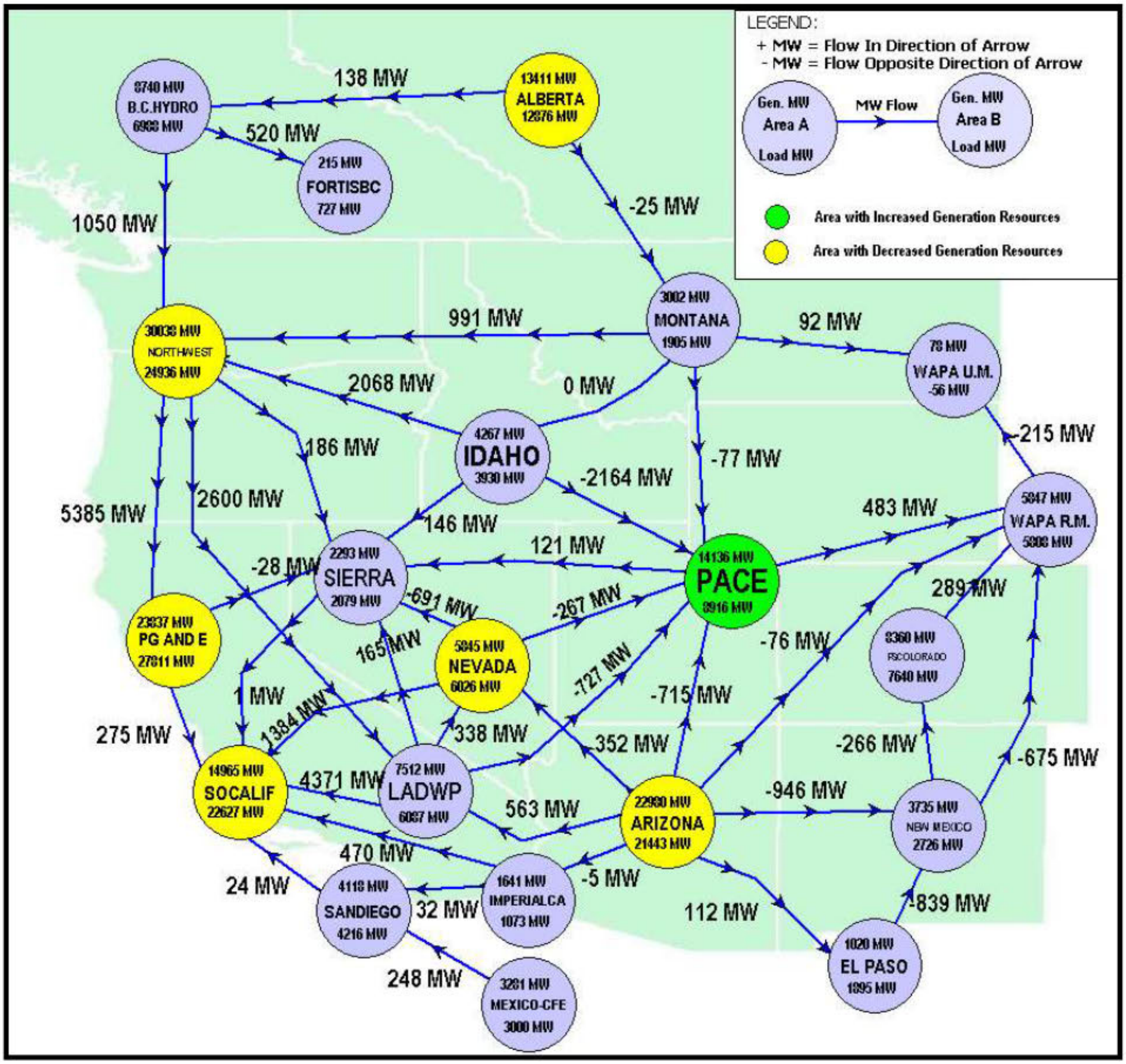


Figure 6-5 – Scenario 1 N-O Flows (Post-Transmission Improvements) JUL27H16

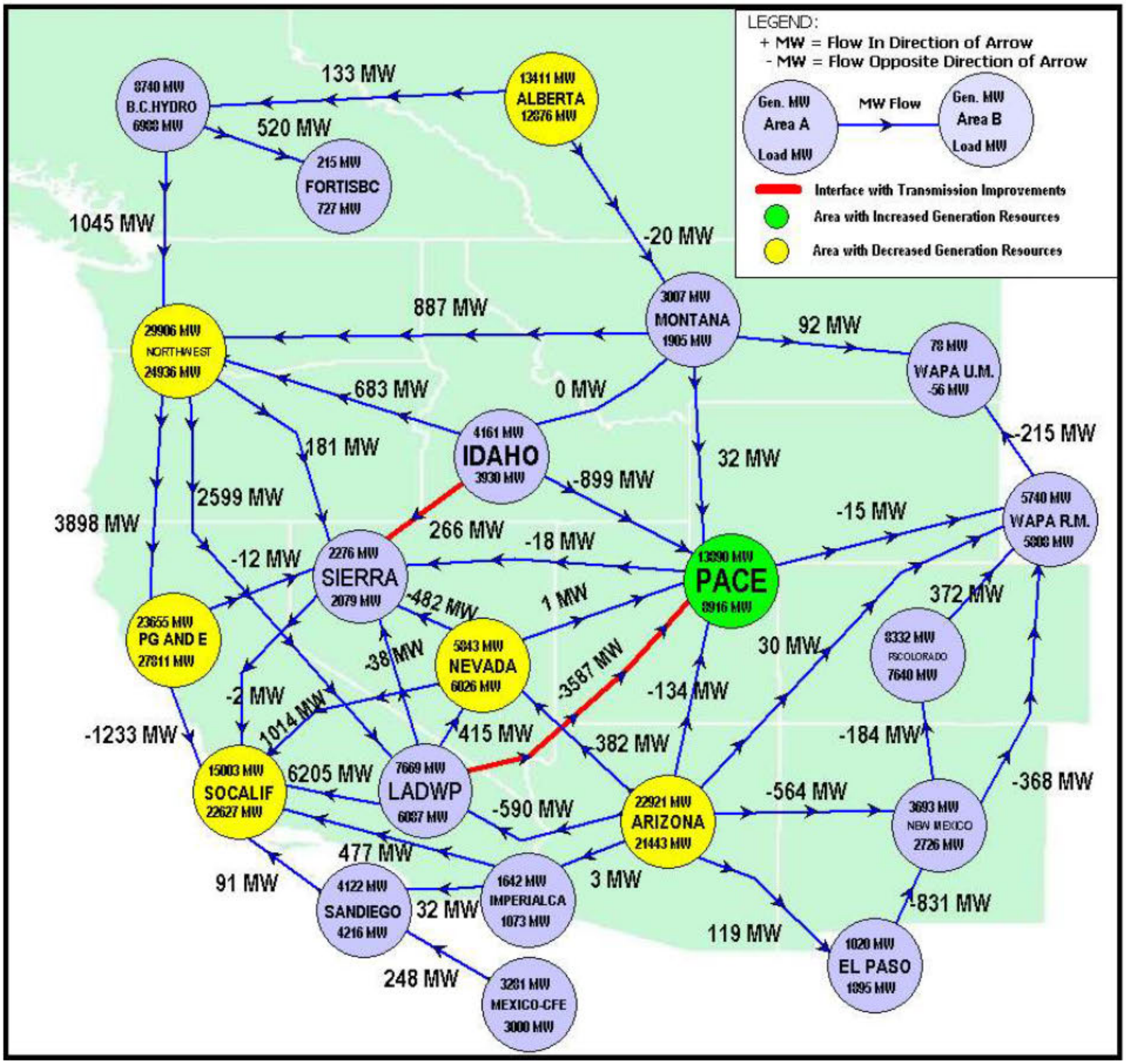
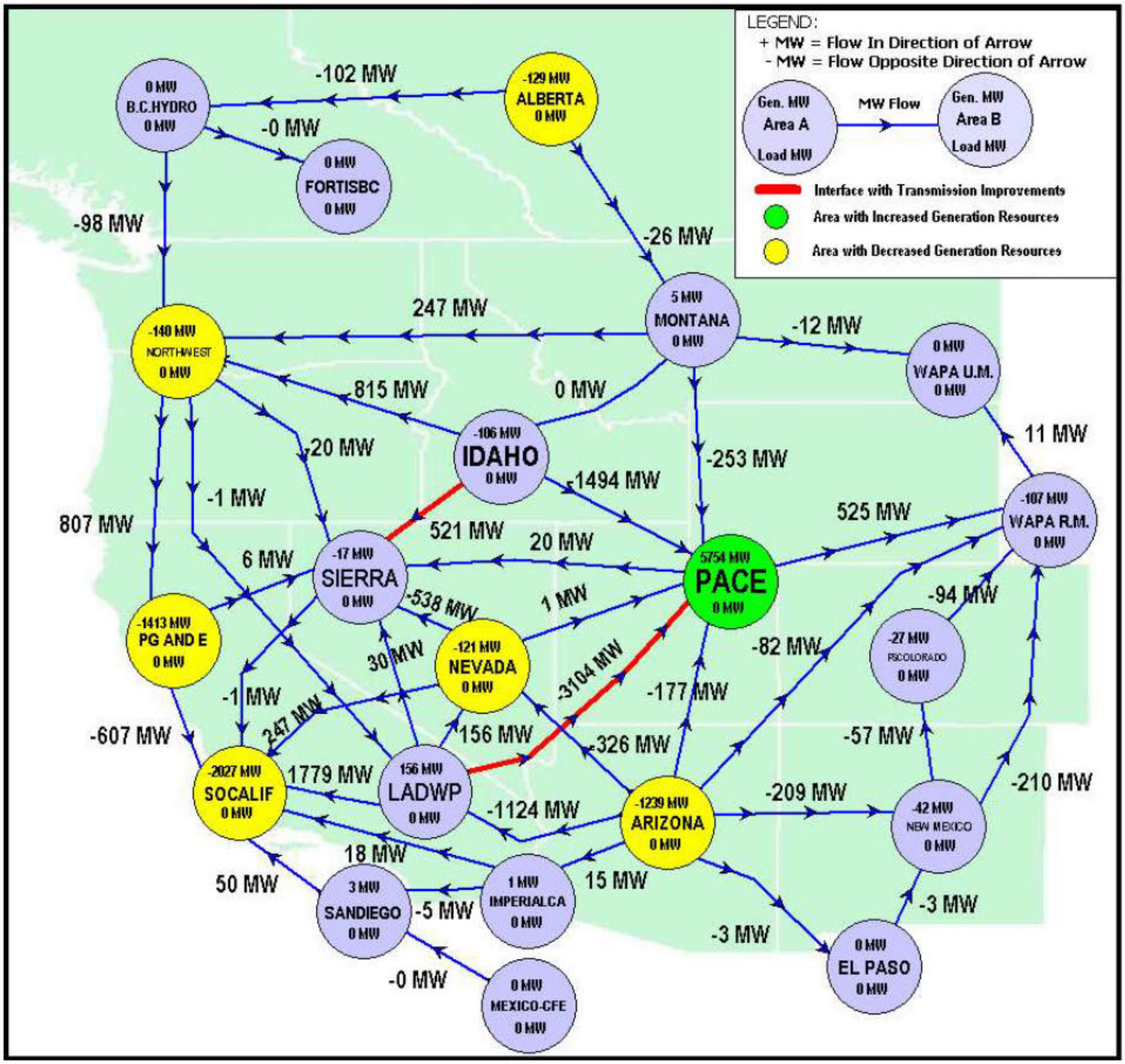


Figure 6-6 – Scenario 1 Difference Flows (Core Case vs. Post-Improvement Case) JUL27H16


LEGEND:
+ MW = Flow In Direction of Arrow
- MW = Flow Opposite Direction of Arrow
Gen. MW
Area A
Load MW
MW Flow
Gen. MW
Area B
Load MW
Interface with Transmission Improvements
Area with Increased Generation Resources
Area with Decreased Generation Resources
0 MW B.C.HYDRO 0 MW
-129 MW ALBERTA 0 MW
0 MW FORTISBC 0 MW
-140 MW NORTHWEST 0 MW
5 MW MONTANA 0 MW
0 MW WAPA U.M. 0 MW
-106 MW IDAHO 0 MW
-107 MW WAPA R.M. 0 MW
-17 MW SIERRA 0 MW
5754 MW PACE 0 MW
-1413 MW PG AND E 0 MW
-121 MW NEVADA 0 MW
-27 MW PSCOLORADO 0 MW
-2027 MW SOCALIF 0 MW
156 MW LADWP 0 MW
-1239 MW ARIZONA 0 MW
-42 MW NEW MEXICO 0 MW
3 MW SANDIEGO 0 MW
1 MW IMPERIALCA 0 MW
0 MW EL PASO 0 MW
0 MW MEXICO-CFE 0 MW
-102 MW
-0 MW
-98 MW
-26 MW
247 MW
-12 MW
815 MW
0 MW
20 MW
11 MW
-1 MW
1494 MW
-253 MW
807 MW
521 MW
20 MW
525 MW
6 MW
-538 MW
1 MW
-94 MW
30 MW
3104 MW
-82 MW
-1 MW
247 MW
-177 MW
-607 MW
156 MW
326 MW
-57 MW
1779 MW
-209 MW
-210 MW
-1124 MW
18 MW
50 MW
15 MW
-5 MW
-3 MW
-3 MW
-0 MW

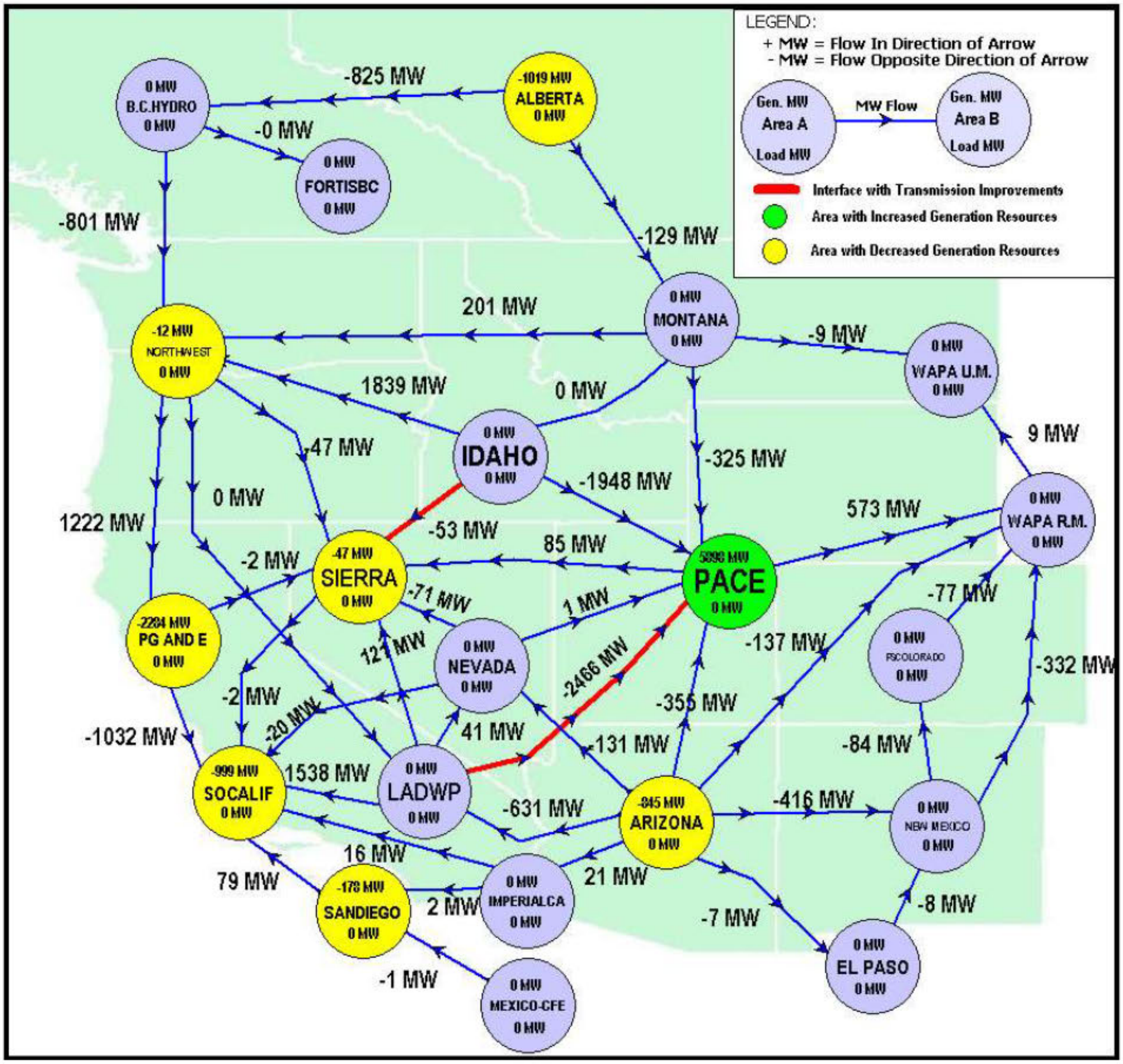
1.2: 6,000 MW in Wyoming – Winter Peak – December 22, Hour 18

After the addition of the generic transmission improvements, two N-0 interface violations were found within the NTTG footprint: Bridger West at 106% and Midpoint-Summer Lake at 104%. Pre-contingency, this study hour was found to have 17 overloaded branch elements ranging from 100.3% to 145% of the nominal rating. Most of these were transformers; two of the 17 elements were series capacitors. There were 25 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 87 violations with zero unsolved contingencies. Of the 87 violations, 18 violations were for overloaded elements. The range of overloads for the 18 violations was from 101% to 129%. There were four violations for low bus voltage and 65 violations for high bus voltage.

A difference flow diagram is shown in Figure 6.7. MW values shown on the difference diagram represent the MW change as referenced to the study hour Core Case. Additional area interchange diagrams are located in Appendix 5.

Figure 6-7 – Scenario 1 Difference Flows: DEC22H18



1.3: 6,000 MW in Wyoming – Heavy Spring Export –March 2, Hour 21

After the addition of the generic transmission improvements, one N-0 interface violation was found within the NTTG footprint: Bridger West at 114%. COI was operating at 99.8% capacity in the AC solution option case. Pre-contingency, this study hour was found to have 24 overloaded branch elements ranging from 101.2% to 182% of the nominal rating. The extreme overload of 181.6% was the result of a data error in the transformer rating assigned to the case. Of the 25 overloaded elements, there were five line elements, one series capacitor and 18 transformers. There were 24 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 119 violations with two unsolved contingencies on the AC solution option case. The two unsolved contingencies were BOARDT2-DALREED and JONESCYN-DALREED. Of the 119 violations, 40 violations were elements overloaded above the 100% rating. Of those, 32 were overloaded greater than 115%. The remaining 79 violations resulted from elements with a bus voltage greater than 1.1 p.u.

In the DC solution option case for this study hour, the study found 31 N-0 branch element overloads and three N-0 interface overloads. Overloaded interfaces were Midpoint-Summer Lake at 106%, COI at 105.4% and TOT 2C at 100.2%. Overloads on branch elements ranged from 100.1% to 217%. The majority of the overloaded branch elements were transformers on radial lines connected loads. There were 16 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

N-1 contingency analysis for the DC solution option reported 220 violations with two unsolved contingencies. The two unsolved contingencies were BOARDT2-DALREED and JONESCYN-DALREED. Of the 220 violations, 117 were elements overloaded above the 100% rating. The remaining 103 violations resulted from elements with a bus voltage greater than the 1.1 p.u. Of the 117 violations for overloads, 56 of the violations were overloaded greater than 115%.

A difference flow diagram for the AC solution option as referenced to the Core Case is shown in Figure 6.8. MW values shown on the difference diagram represent the MW change between the two power flow cases. The difference diagram for the DC solution as referenced to the Core Case is shown in Figure 6.9. Figure 6.10 is a comparison plot of the DC solution option referenced to the AC solution option. Additional area interchange diagrams are located in Appendix 5.

Figure 6-8 – Scenario 1 Difference Flows: MAR04H21 (AC Solution)

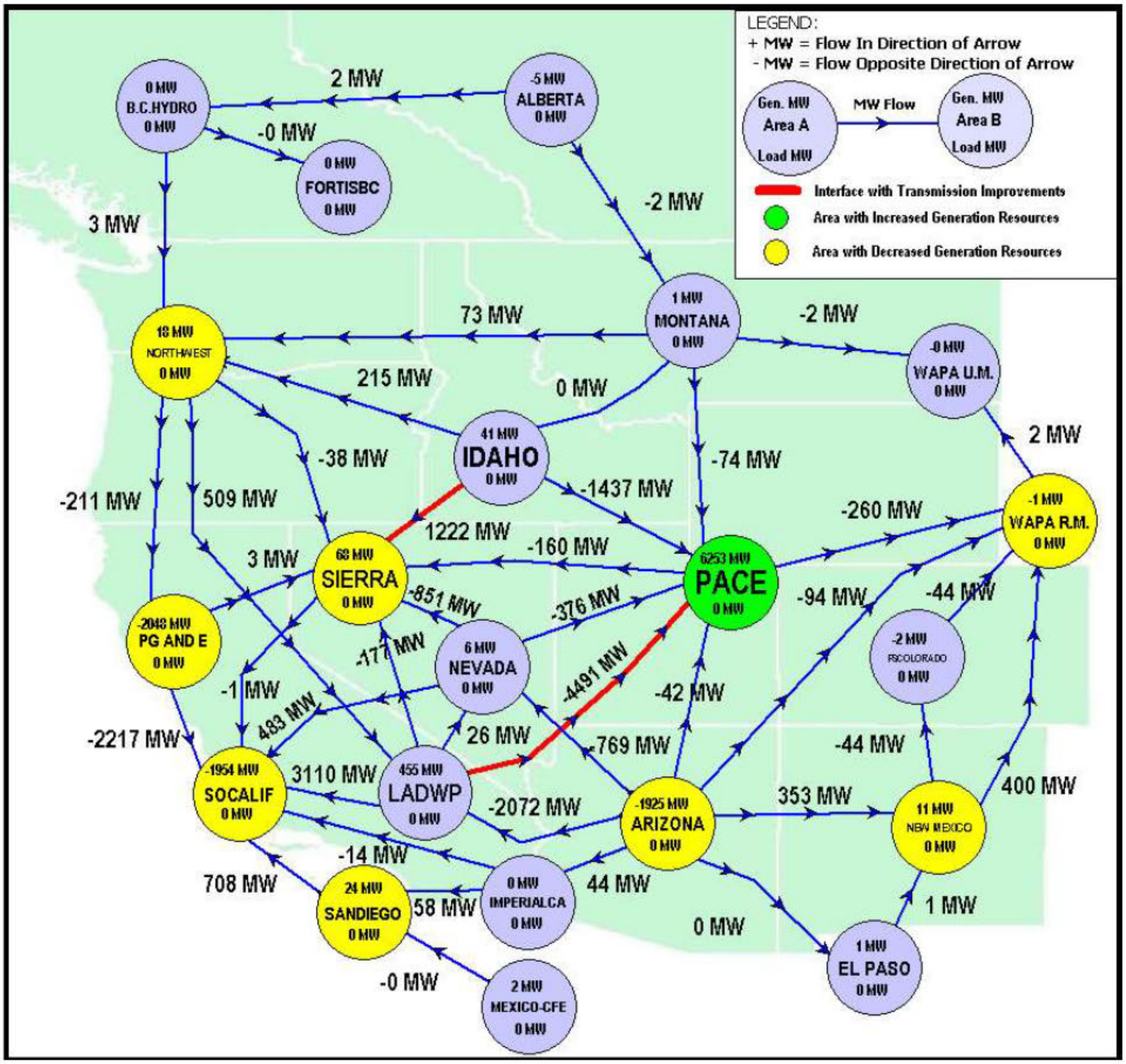


Figure 6-9 – Scenario 1 Difference Flows: MAR04H21 (DC Solution)

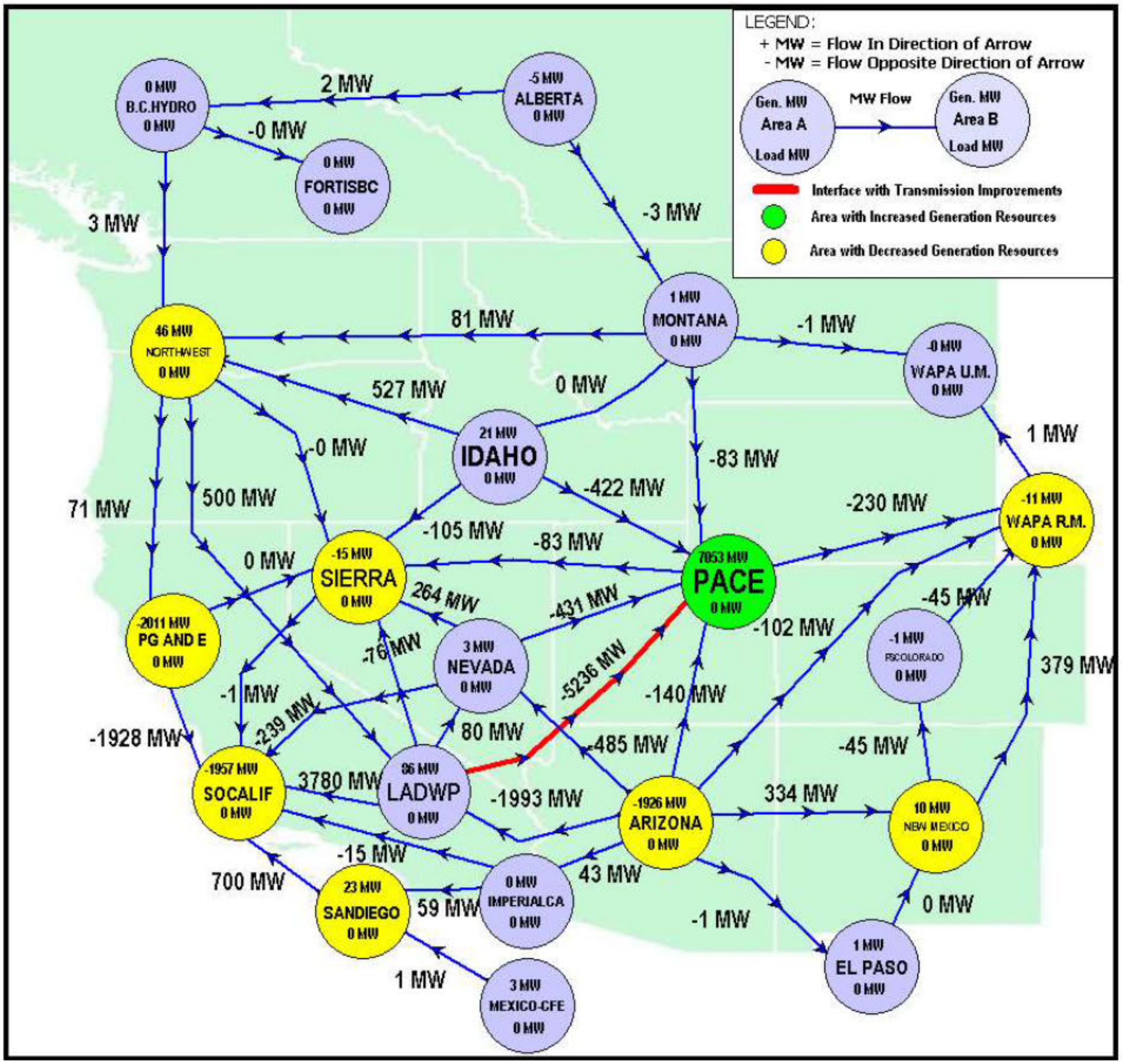
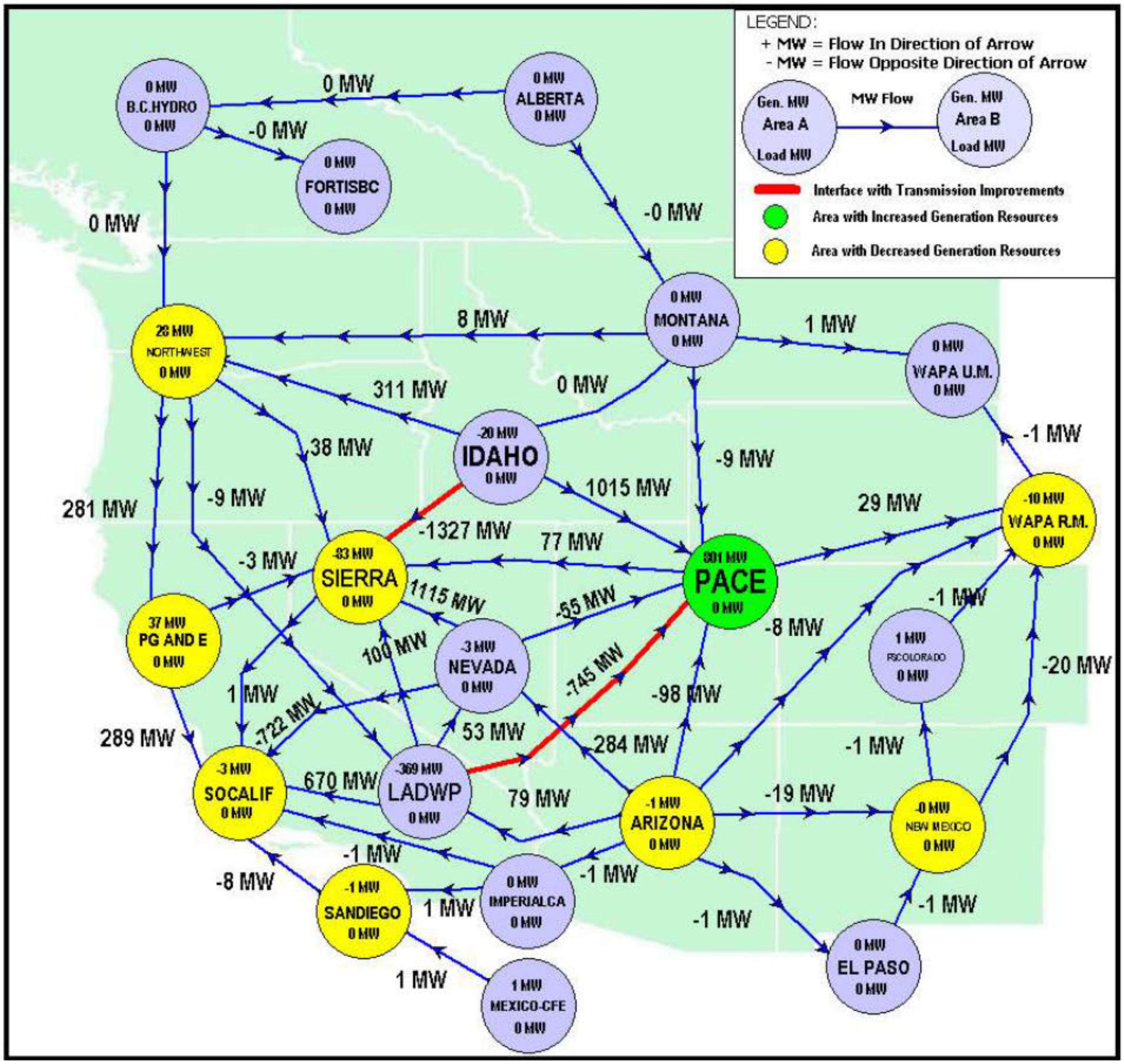


Figure 6-10 – Scenario 1 Difference Flows: MAR04H21 (AC Solution vs. DC Solution)



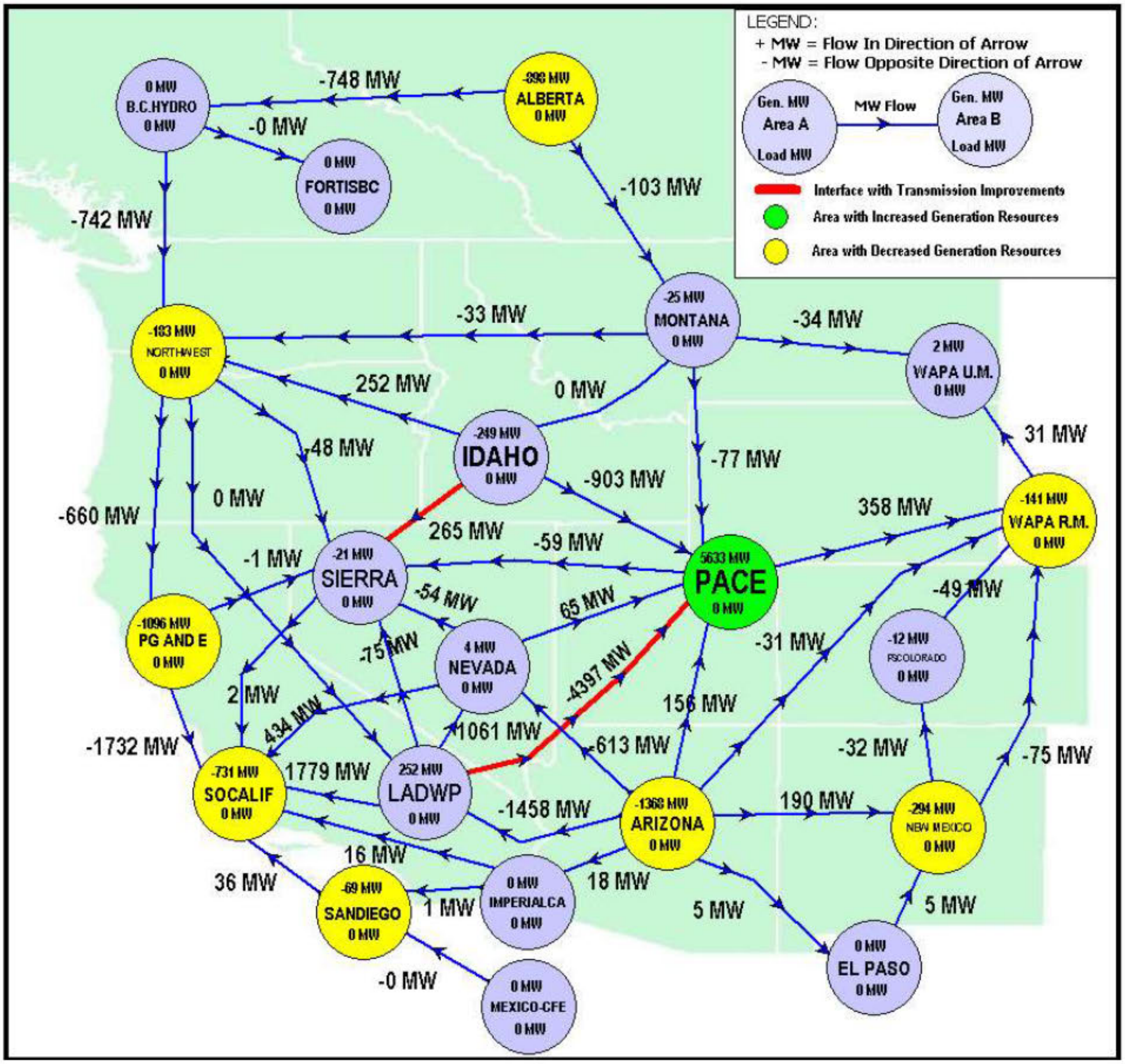
1.4: 6,000 MW in Wyoming – Heavy Autumn Export – October 4, Hour 21

After the addition of the generic transmission improvements, two N-0 interface violations were found within the NTTG footprint: Bridger West at 120% and Midpoint-Summer Lake at 111%. Pre-contingency, this study hour produced 20 overloaded branch elements ranging from 100.1% to 127% of the nominal rating. The N-0 overload elements consisted of one line, three series capacitors and 16 transformers. There were 10 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 64 violations with one unsolved contingency. The one unsolved contingency was BOARDT2-DALREED. Thirty of the 64 violations were overloaded elements. Fourteen of those overloaded elements were overloaded 115% above the continuous rating. The remaining 34 violations resulted from elements with a bus voltage greater than 1.1 p.u.

A difference flow diagram is shown in Figure 6.11. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-11 – Scenario 1 Difference Flows: OCT04H21



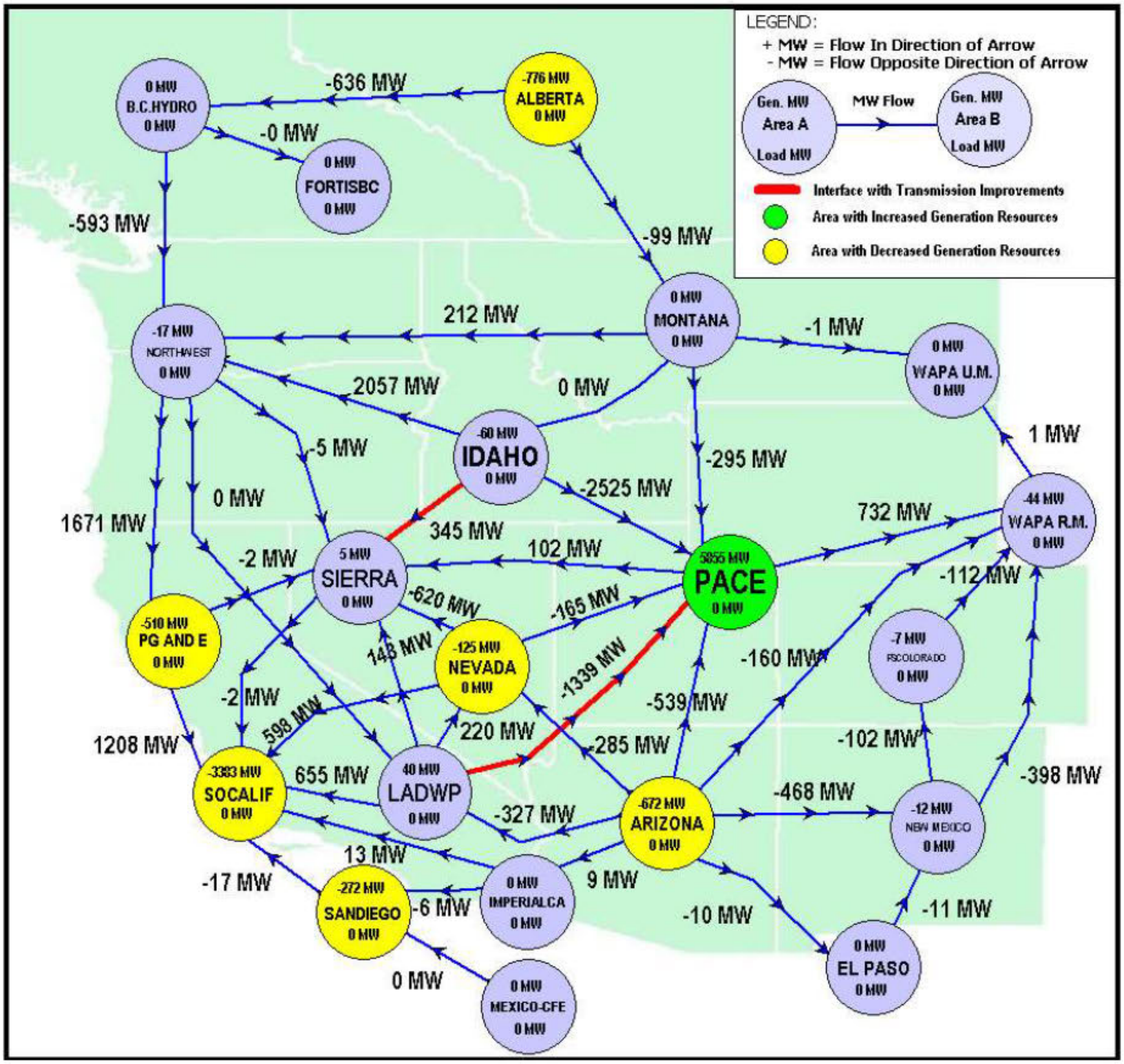
1.5: 6,000 MW in Wyoming – Maximum Import – August 10, Hour 13

After the addition of the generic transmission improvements, one N-0 interface violation was found within the NTTG footprint: Bridger West at 126%. Pre-contingency, this study hour was found to have 17 overloaded branch elements ranging from 100.4% to 149% of the nominal rating, all of which were transformers. There were 27 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 48 violations with zero unsolved contingencies. Of the 48 violations, 10 were overloaded elements, two of which were overloaded 115% above the continuous rating. Of the remaining 38 violations, 36 were elements with a bus voltage greater than 1.1 p.u., and two were elements with a bus voltage less than 0.9 p.u.

A difference flow diagram is shown in Figure 6.12. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-12 – Scenario 1 Difference Flows: AUG10H13



2.0: Scenario 2 – 3,000 MW in Wyoming, 3,000 MW in Montana

This scenario represents the effect of a combined additional 3,000 MW of alternative generation in Wyoming (equally distributed among the Anticline, Aeolus and Windstar busses) and 3,000 MW of alternative generation in Montana, located at the Townsend bus (between Broadview and Garrison busses).

3,000 MW in Wyoming, 3,000 MW in Montana – Case Development

Case development for Scenario 2 began with the Core Case from each study hour. Generation resources were added to the Core Case for each study hour to develop five power flow cases for Scenario 2. Table 6.5 shows the generation resources added to the Core Case used to develop the five study hour cases for Scenario 2.

Table 6-5 – Scenario 2 Generation Resource Additions

Area Name	Bus Name	Generation Addition
MONTANA	TOWNSEND	3000 MW
PACE	WINDSTAR	1000 MW
	AEOLUS	1000 MW
	ANTICLINE	1000 MW
	Total	**3000 MW WY** **3000 MW MT**

A sink was also created for each of the five study hours by removing generation resources in order to offset the total resource addition of 3,000 MW in Wyoming and 3,000 MW in Montana. Table 6.6 shows the generation resources removed from the Core Case used to develop the five study hour cases for Scenario 2. A more detailed table showing the bus locations with changes in generation is provided in Appendix 7.

Table 6-6 - Scenario 2 Generation Resource Reductions

Area Name	Generation Reduction (MW) July 27 Hour 16	Generation Reduction (MW) December 22 Hour 18	Generation Reduction (MW) March 2 Hour 21	Generation Reduction (MW) October 4 Hour 21	Generation Reduction (MW) August 10 Hour 13
SOCALIF	2065	1000	2246	760	2954
SANDEIGO		178		70	272
NORTHWEST	8	12		107	
NEWMEXICO				270	
ARIZONA	1180	942	1947	1263	830
PG&E	2500	2240	2240	2463	436
SIERRA		47			
ALBERTA	129	1019		898	776
NEVADA	118				120
WAPA RM				60	
PACE		102		129	
	6000 MW	**5540 MW**	**6433 MW**	**6020 MW**	**5388 MW**

Once the generation additions and reductions were completed, the power flow case was solved. Additionally, overloads of transmission elements before the addition of generic transmission improvements were identified. Table 6.7 shows the N-0 path flows for Scenario 2 prior to the addition of generic transmission improvements for each study hour analyzed in Scenario 2.

Table 6-7 - Scenario 2 N-0 Path Flows (Pre-Generic Transmission Improvements)

SCENARIO 2	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW
JUL27H16	725	3179	5804	2600	7366	1737	3071	1562	-204
DEC22H18	2041	3705	3530	2084	5148	3322	121	578	588
MAR02H21	3351	2880	7647	2011	4332	1421	72	2433	-569
OCT04H21	3882	4455	3576	2600	2655	4122	4028	2326	1328
AUG10H13	-125	2670	1277	2600	5115	830	2568	422	-125

Generic transmission improvements that appeared to be adequate solutions to overloads and that were common to the five study hours for Scenario 2 are shown in Figure 6.13.

Transmission improvements in the form of new 500 kV transmission lines (AC solution option) were added to each of the five study hours. The location of the 500 kV transmission improvements are shown in Figure 6.13.

Transmission improvements using DC transmission lines (DC solution option) were tested on the March study hour (maximum spring export). Figure 6.14 shows the location of the DC transmission improvements tested on the March study hour.

Both the AC solution option and DC solution option proved to be adequate solutions for relieving overloads.

Figure 6-13 – Scenario 2 Generic Transmission Improvements (AC Solution Option)

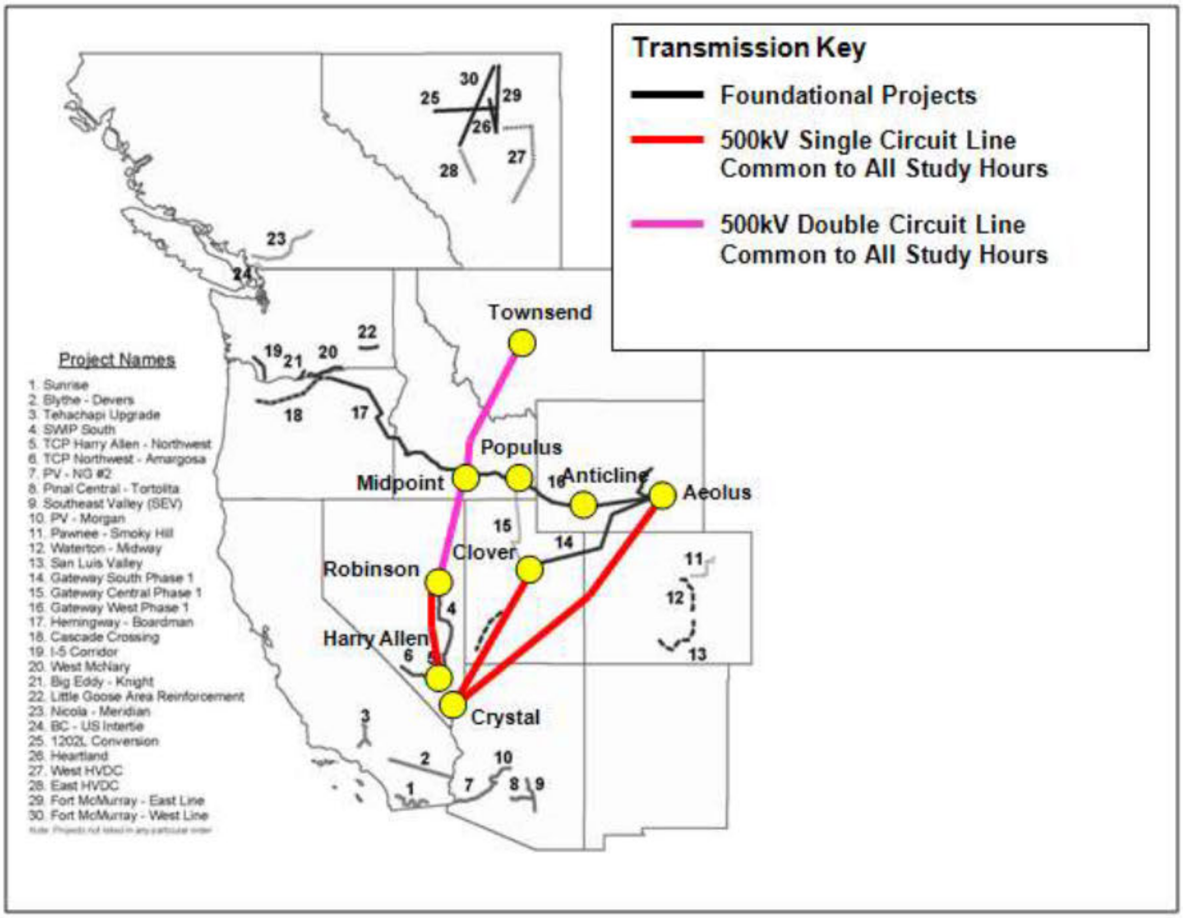
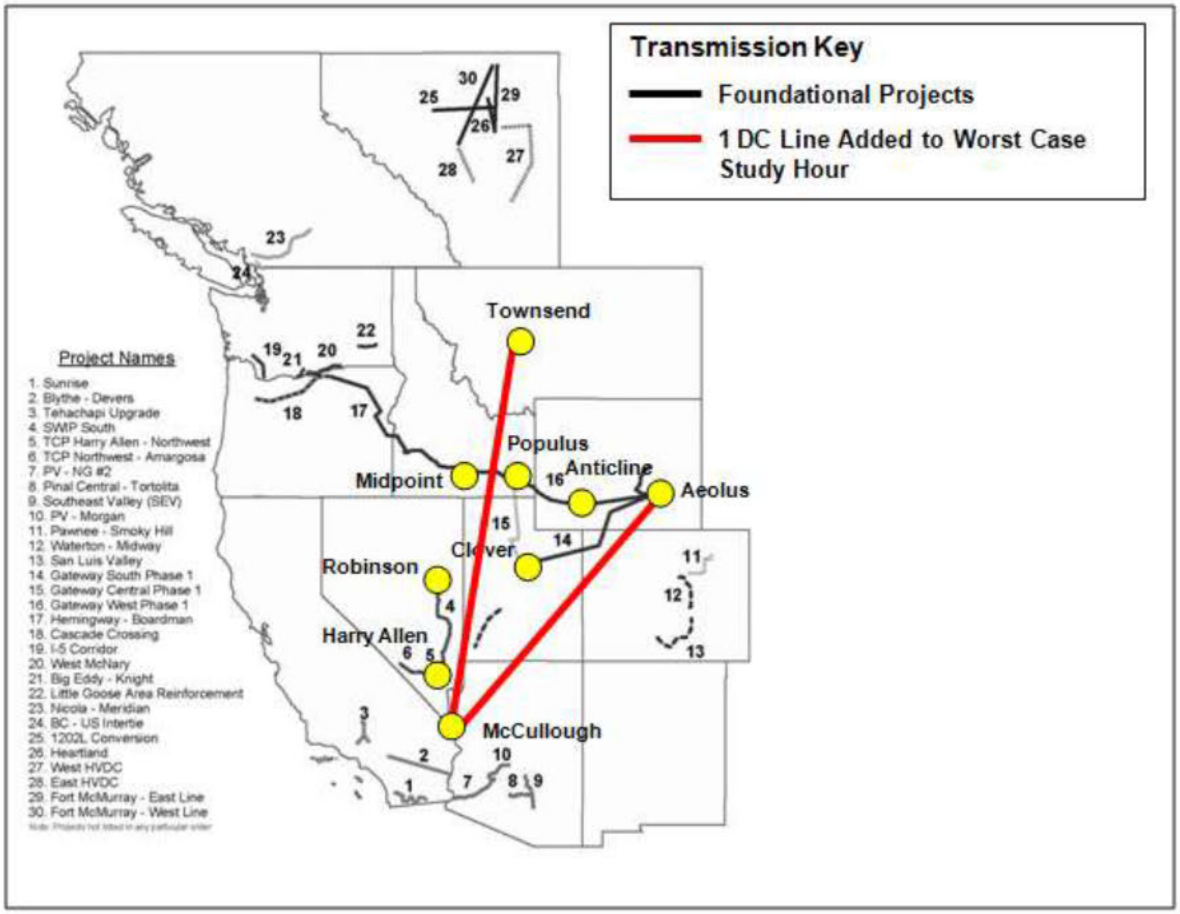


Figure 6-14 – Scenario 2 Generic Transmission Improvements (DC Solution Option)



3,000 MW in Wyoming, 3,000 MW in Montana – Study Results

The study results indicated that the addition of 3,000 MW of generation in Wyoming and 3,000 MW of generation in Montana caused overloaded paths as shown in Table 6.7. Overloaded paths for Scenario 2 that were common between study hours included overloads on Montana-Northwest, COI and TOT2. The overloaded elements identified the need for generic transmission improvements.

The transmission improvements common to all five study hours were: 1.) a double-circuit 500 kV transmission lines between the Townsend and Midpoint and Midpoint-Robinson busses, 2.)a second 500 kV circuit between the Robinson and Harry Allen busses. It should be noted that a 500 kV circuit between the Robinson-Harry Allen busses was already represented in each study hour (based on the

Core Case), 3.) a 500 kV transmission line between the Aeolus and Crystal, and 4.) a 500 kV transmission line between the Clover and Crystal busses.

Post-improvement N-0 path flows are shown in Table 6.8. The study results indicate that the proposed transmission improvements resolved the majority of the overloads shown in Table 6.7. Minor overloads were recorded in the Montana-Northwest path of 101% on a 2,200 MW rating for the December study hour. The March study hour also had a minor overload of 101.6% on a 4,800 MW rating for COI.

N-1 contingency analysis for each study hour in Scenario 2 indicated that the majority of the 420 contingencies solved for each study hour. There were two study hours that had unsolved contingencies: March with four and October with one.

A DC solution option was also tested on the March study hour. DC lines between Aeolus-McCullough and Townsend-McCullough were added to the case. The study results indicate that the DC solution option appears as an adequate solution alternative. One post-improvement overload on COI (105%) was identified with the DC solution option. This overload may be mitigated by adjusting the flow on the PDCI.

In this Scenario, the AC and DC transmission line improvements described above could be combined to create another solution option to resolve the transmission overloads identified. An example would be a DC transmission line from either Montana or Wyoming with the other state having an AC transmission line solution. Such cases were not contemplated during the creation of the study plan and not included during this study cycle.

There were 27 N-0 branch element overloads and one N-0 interface overload (COI at 103.6%) reported in the DC solution option case for the March study hour. Overloads on branch elements ranged from 100.1% to 192%. The majority of the overloaded branch elements were transformers on radial connected loads. There were 10 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

N-1 contingency analysis for the DC solution option reported 102 violations, with three unsolved contingencies. The three unsolved contingencies were BOARDT2-DALREED, JONESCYN-DALREED and HELLSCYN-BROWNLEEC1. Of the 102 violations, 69 were elements overloaded above the 100% rating, with 48 of those overloaded by more than 115%. The remaining 33 violations resulted from voltage violations, with one low bus voltage violation and 32 high bus voltage violations.

The sum of the N-1 violations for all the study hours in Scenario 2 was 275 violations. The majority of overloaded elements for all the study hours were transformer overloads for N-1 conditions. The most common N-1 violation for all study hours was high bus voltage, most commonly reported at dummy busses near 500 kV series capacitors.

N-0 and N-1 violations discussed in this report are violations on elements 200 kV and above within the NTTG footprint. N-0 and N-1 violation tables for each study hour within this scenario are provided in Appendix 8.

Table 6-8 – Scenario 2 N-0 Path Flows (Post-Generic Transmission Improvements)

SCENARIO 2	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW	DBL CKT 500kV Townsend-Midpoint (3000) MW	DBL CKT 500kV Midpoint-Robinson (3000) MW	DBL CKT 500kV Robinson-Harry Allen (3000) MW	SGL CKT 500kV Aeolus-Crystal (1500) MW	SGL CKT 500kV Clover-Crystal (1500) MW	2 DC Lines Townsend-McCullough & Aeolus-McCullough (6000) MW
JUL27H16	1382	727	4030	2600	5169	686	2390	704	-506	3101	1634	1676	907	825	NA
DEC22H18	1904	2223	2903	2251	3909	985	1127	241	308	1980	388	235	428	471	NA
MAR02H21 (AC Option)	1927	1730	4876	2760	2874	1365	534	1835	-291	2909	3175	2848	1453	1427	NA
MAR02H21 (DC Option)	2017	1877	4975	2788	2993	1364	832	1886	-40	NA	NA	54 SGL CKT	NA	NA	6000
OCT04H21	3798	2068	1328	2393	548	2922	3334	983	922	2740	1877	2009	1182	1517	NA
AUG10H13	1213	1028	881	2600	3765	641	2752	392	-702	2184	662	557	597	140	NA

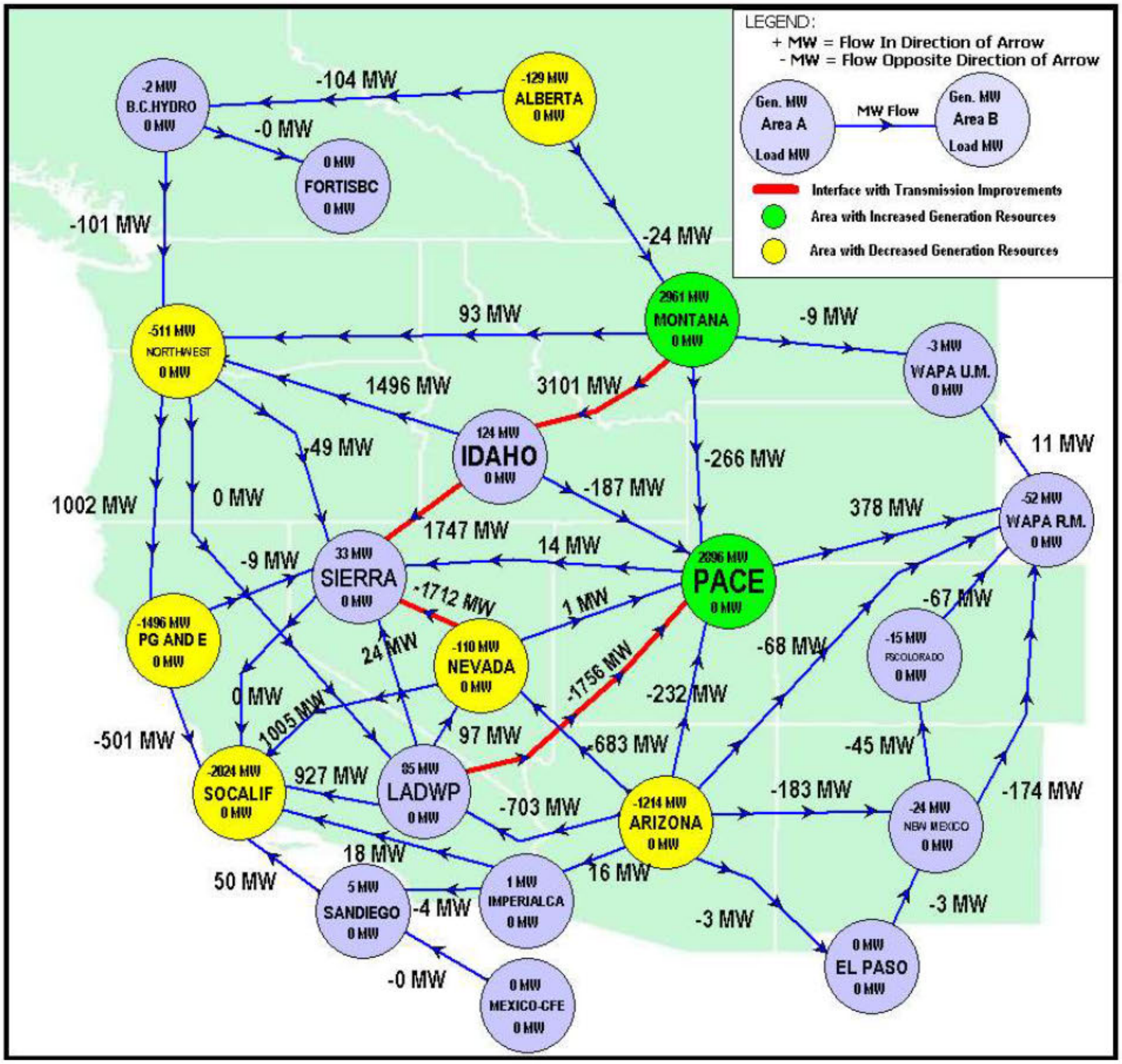
2.1: 3,000 MW in Wyoming, 3,000 MW in Montana – Summer Peak – July 27, Hour 16

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 21 overloaded branch elements, ranging from 102.3% to 160% of the nominal rating, all of which were transformers. There were 12 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 19 violations with zero unsolved contingencies. Of the 19 violations, five were for overloaded elements, with a maximum overload of 137%. There were two violations for low bus voltage and 12 violations for high bus voltage.

A difference flow diagram is shown in Figure 6.15. MW values shown on the difference diagram represent the MW change as referenced to the study hour Core Case. Additional area interchange diagrams are located in Appendix 5.

Figure 6-15 – Scenario 2 Difference Flows: JUL27H16



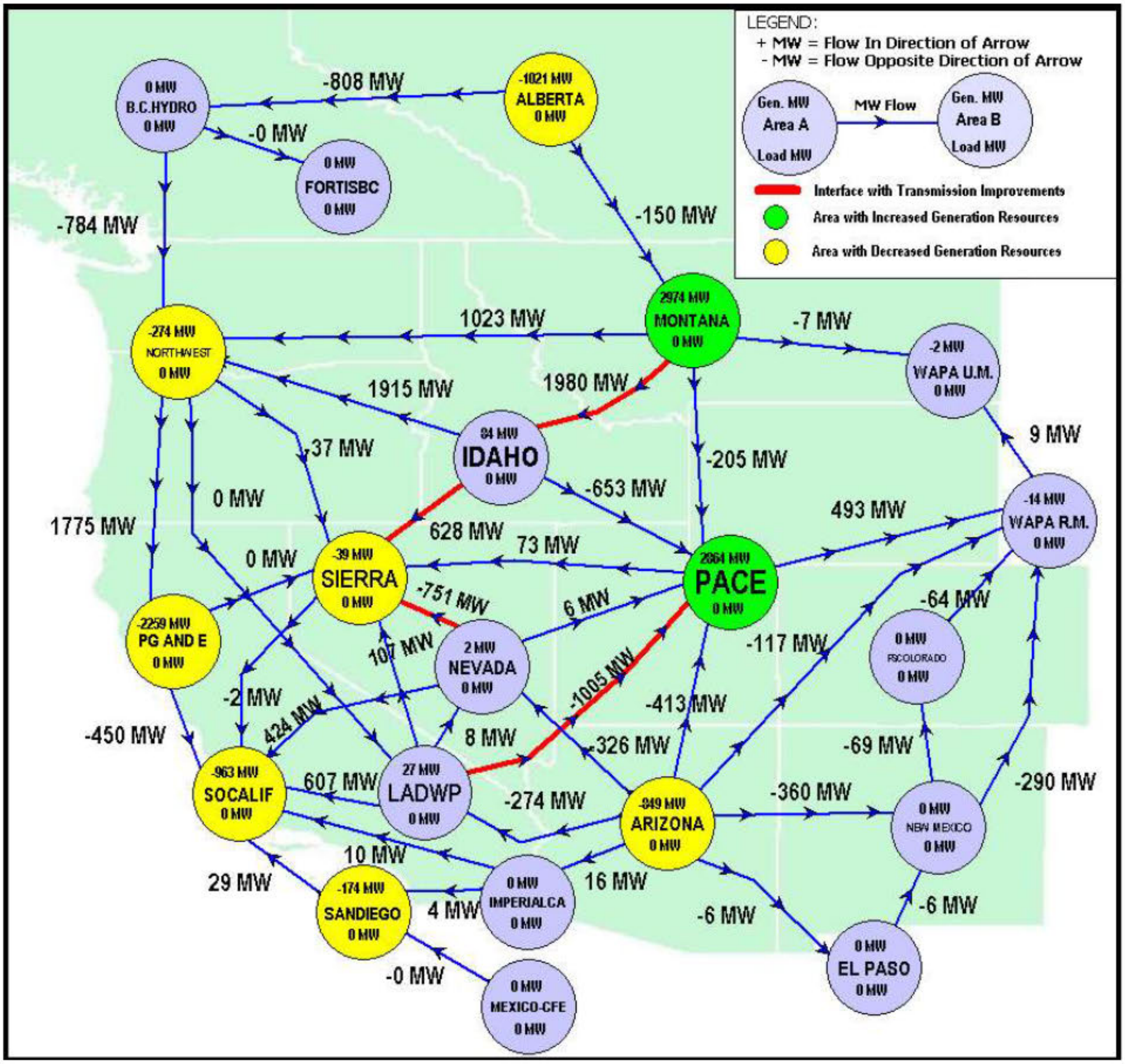
2.2: 3,000 MW in Wyoming, 3,000 MW in Montana – Winter Peak – December 22, Hour 18

After the addition of the generic transmission improvements, two N-0 interface violations were found within the NTTG footprint: Montana-Northwest at 101% and Midpoint-Summer Lake at 110.3%. Pre-contingency, this study hour uncovered 17 overloaded branch elements, ranging from 104.6% to 145% of the nominal rating. Of the 17 overloaded branch elements, 16 were transformers and one was an overloaded series capacitor. There were 18 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 45 violations, with zero unsolved contingencies. Of the 45 violations, 19 were overloaded elements with a range of 100.2% to 143%. There were two violations for low bus voltage and 24 violations for high bus voltage violations.

A difference flow diagram is shown in Figure 6.16. MW values shown on the difference diagram represent the MW change as referenced to the study hour Core Case. Additional area interchange diagrams are located in Appendix 5.

Figure 6-16 – Scenario 2 Difference Flows: DEC22H18



2.3: 3,000 MW in Wyoming, 3,000 MW in Montana – Heavy Spring Export – March 2, Hour 21

After the addition of the generic transmission improvements, one N-0 interface violation was found within the NTTG footprint: COI at 102%. Pre-contingency, this study hour revealed 26 overloaded branch elements ranging from 101.3% to 186% of the nominal rating for the AC solution option study case. The 26 overloaded elements comprised three series capacitors, five lines and 18 transformers. There were 12 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 102 violations with four unsolved contingencies. The four unsolved contingencies were BOARDT2-DALREED, JONESCYN-DALREED, WALAWALLA-WALLULA and HELLSCYN-BROWNLEE. Of the 102 violations, 50 violations were elements overloaded above the 100% rating. The extreme overload value for N-1 conditions was 224%. There were two low bus voltage violations and 50 high bus voltage violations.

For the DC solution option, one N-0 interface violation was found within the NTTG footprint: COI at 103.6%. Pre-contingency, this study hour was found to have 27 overloaded branch elements ranging from 101.3% to 192% of the nominal rating for the DC solution option study case. The extreme value was most likely a data error in the MVA rating of the overloaded element. The majority of the branch overloads were transformers, with a few series capacitors. There were 10 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A difference flow diagram for the AC solution option as referenced to the Core Case is shown in Figure 6.17. MW values shown on the difference diagram represent the MW change between the two power flow cases. The difference diagram for the DC solution as referenced to the Core Case is shown in Figure 6.18. Figure 6.19 is a comparison plot of the DC solution option referenced to the AC solution option. Additional area interchange diagrams are located in Appendix 5.

Figure 6-17 – Scenario 2 Difference Flows: MAR04H21 (AC Solution)

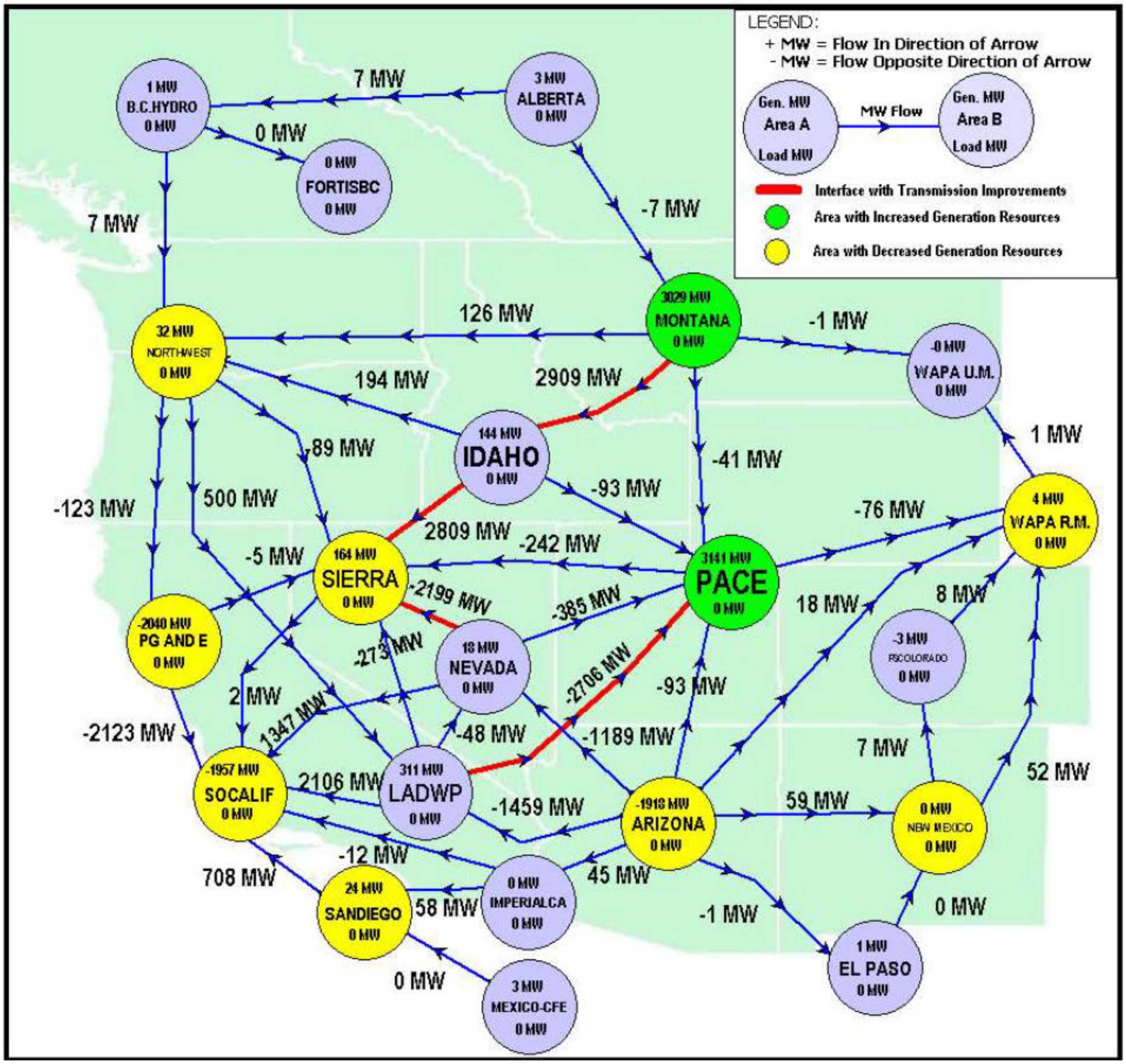

LEGEND:
+ MW = Flow In Direction of Arrow
- MW = Flow Opposite Direction of Arrow
Gen. MW Area A Load MW
MW Flow
Gen. MW Area B Load MW
Interface with Transmission Improvements
Area with Increased Generation Resources
Area with Decreased Generation Resources
1 MW B.C.HYDRO 0 MW
3 MW ALBERTA 0 MW
0 MW FORTISBC 0 MW
32 MW NORTHWEST 0 MW
3029 MW MONTANA 0 MW
-0 MW WAPA U.M. 0 MW
144 MW IDAHO 0 MW
4 MW WAPA R.M. 0 MW
164 MW SIERRA 0 MW
3141 MW PACE 0 MW
-2040 MW PG AND E 0 MW
18 MW NEVADA 0 MW
-3 MW PSCOLORADO 0 MW
-1957 MW SOCALIF 0 MW
311 MW LADWP 0 MW
-1918 MW ARIZONA 0 MW
0 MW NEW MEXICO 0 MW
24 MW SANDIEGO 0 MW
0 MW IMPERIALCA 0 MW
1 MW EL PASO 0 MW
3 MW MEXICO-CFE 0 MW
7 MW
0 MW
7 MW
-7 MW
126 MW
-1 MW
194 MW
2909 MW
89 MW
1 MW
-41 MW
-123 MW
500 MW
-93 MW
-76 MW
2809 MW
-242 MW
-5 MW
-2199 MW
-385 MW
18 MW
8 MW
-273 MW
-2706 MW
-93 MW
2 MW
1347 MW
-2123 MW
-48 MW
-1189 MW
7 MW
52 MW
2106 MW
-1459 MW
59 MW
-12 MW
708 MW
45 MW
58 MW
-1 MW
0 MW
0 MW

Figure 6-18 – Scenario 2 Difference Flows: MAR04H21 (DC Solution)

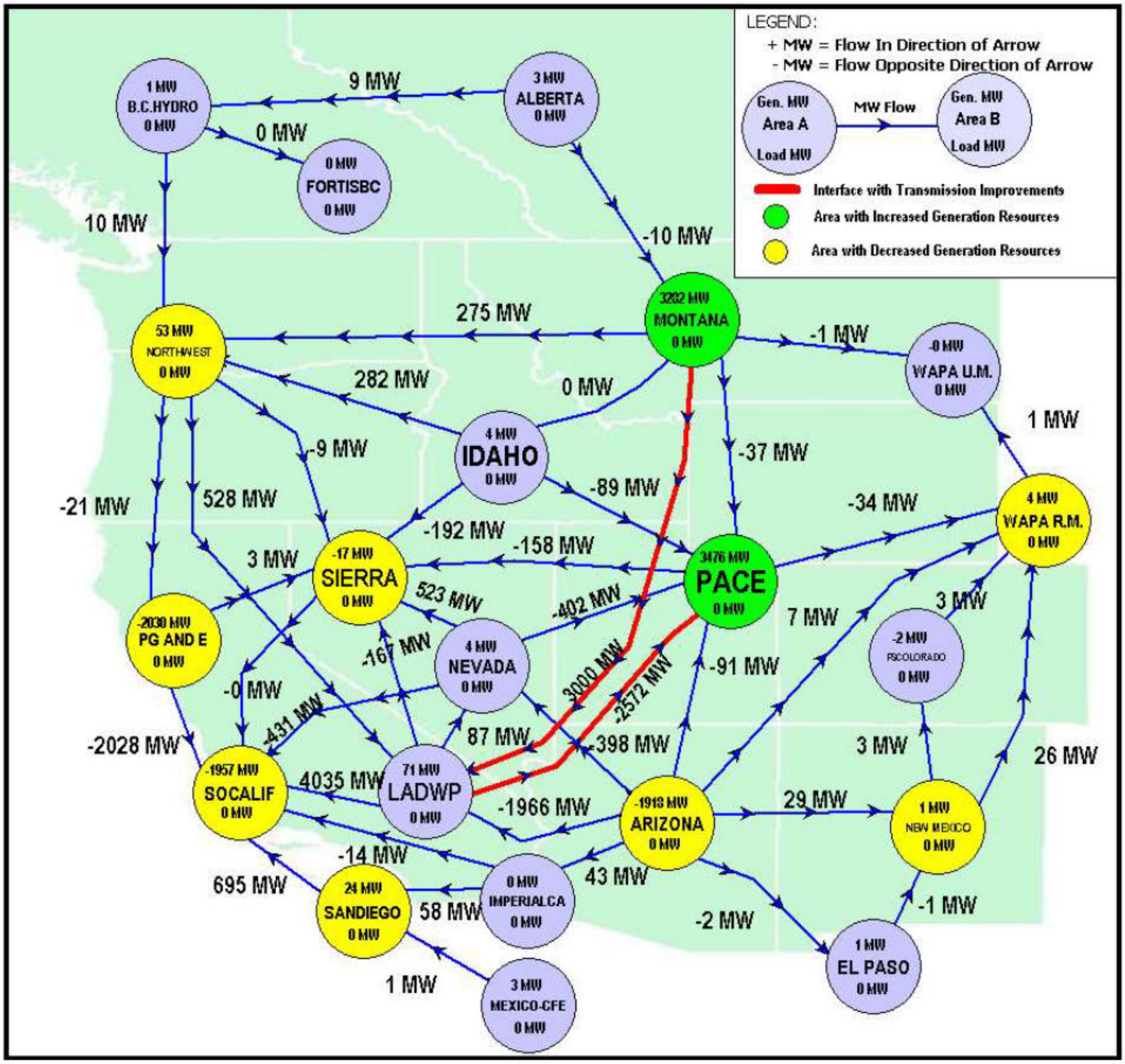
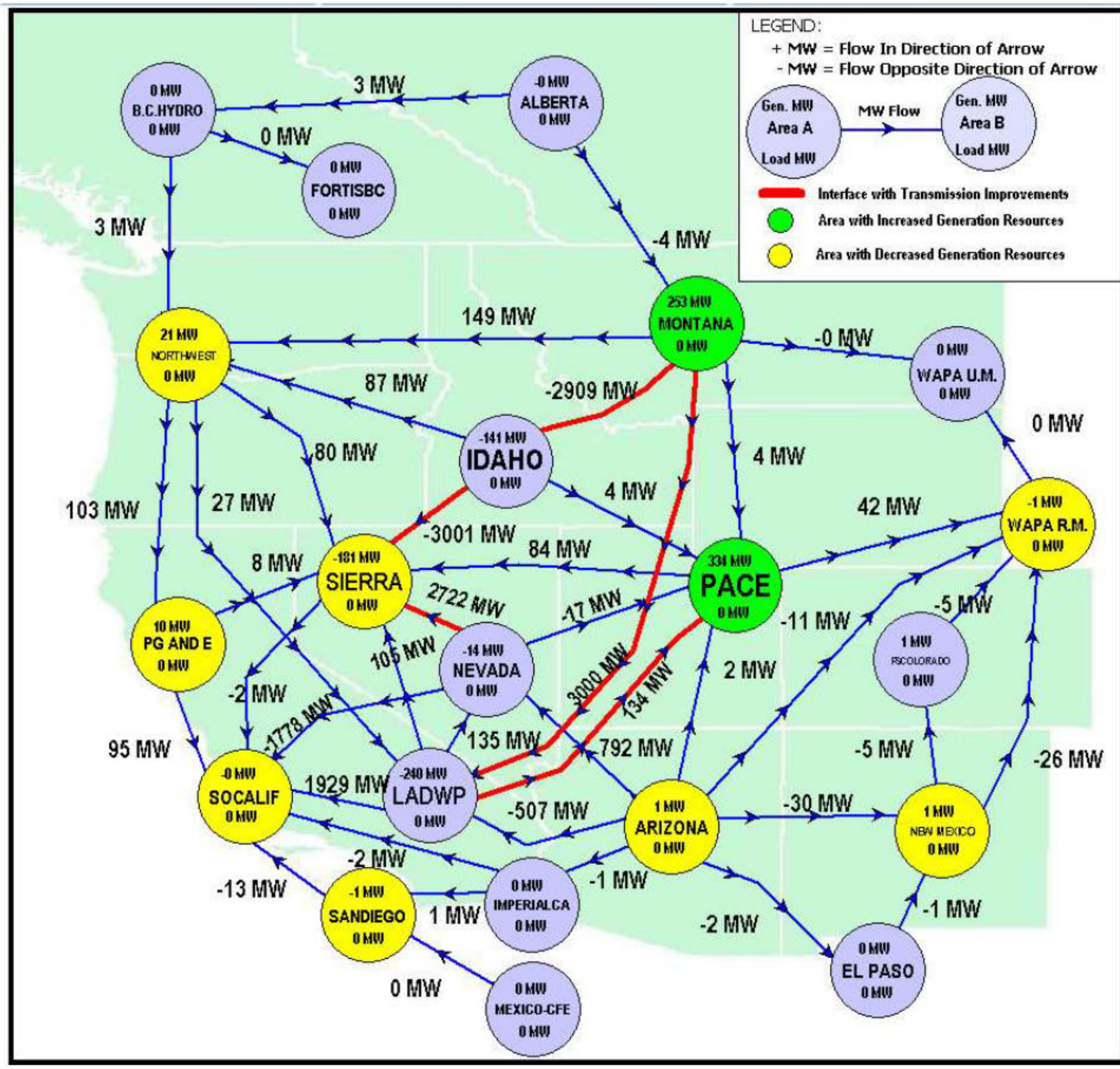


Figure 6-19 – Scenario 2 Difference Flows: MAR04H21 (AC Solution vs. DC Solution)



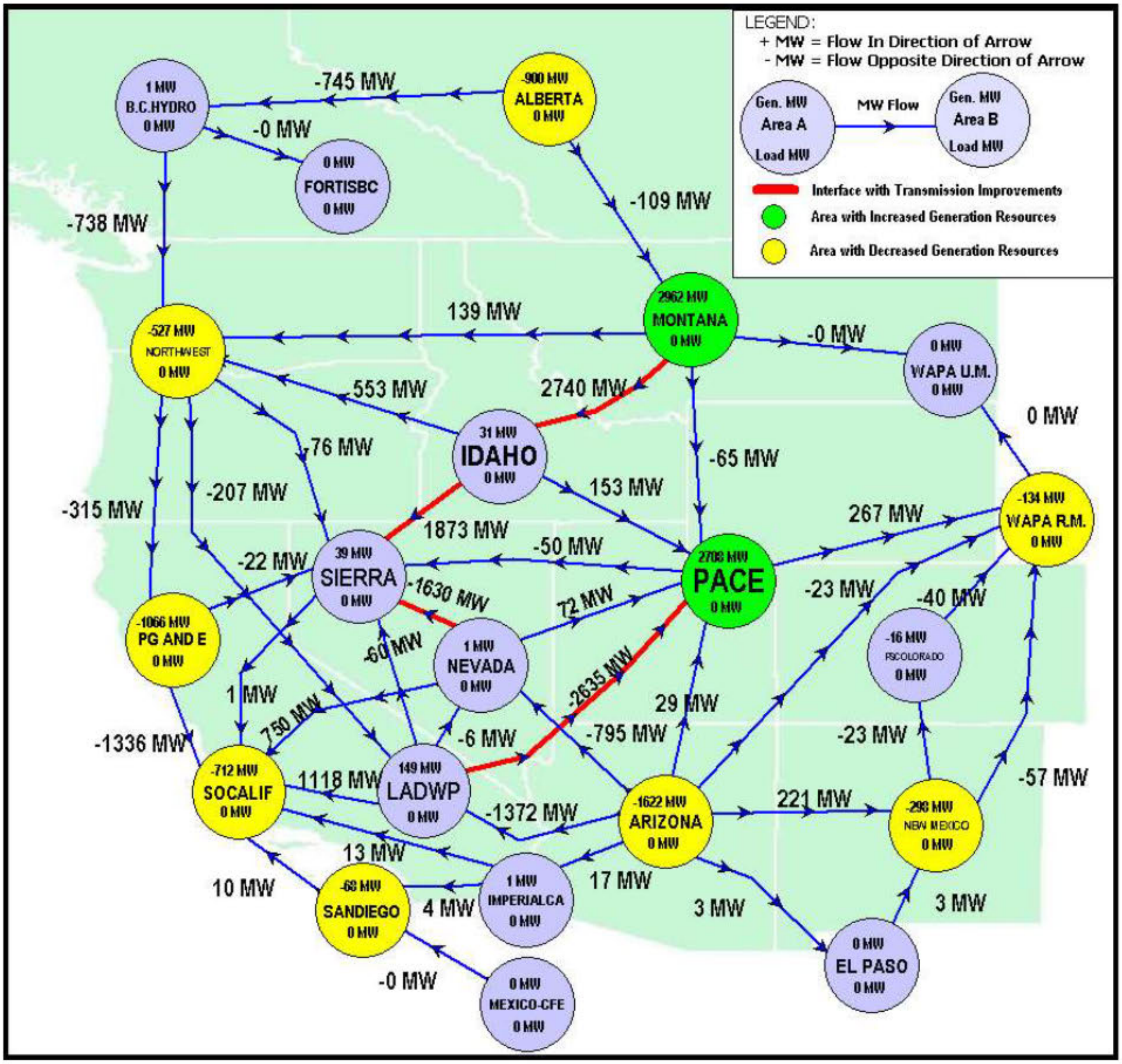
2.4: 3,000 MW in Wyoming, 3,000 MW in Montana – Heavy Autumn Export – October 4, Hour 21

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Idaho-Northwest was operating at 99.95% in the case, with Montana-Northwest at 94%. Pre-contingency, this study hour was found to have 20 overloaded branch elements ranging from 100.4% to 127% of the nominal rating. The 20 overloaded elements comprised one line, one series capacitor and 18 transformers. There were 26 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 80 violations, with one unsolved contingency. The unsolved contingency was BOARDT2-DALREED. Of the 80 violations, 23 resulted in elements overloaded above the 100% rating. The maximum overload was 165% of the continuous rating. The remaining 57 violations resulted from elements with a bus voltage greater than the 1.1 p.u.

A difference flow diagram is shown in Figure 6.20. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-20 – Scenario 2 Difference Flows: OCT04H21



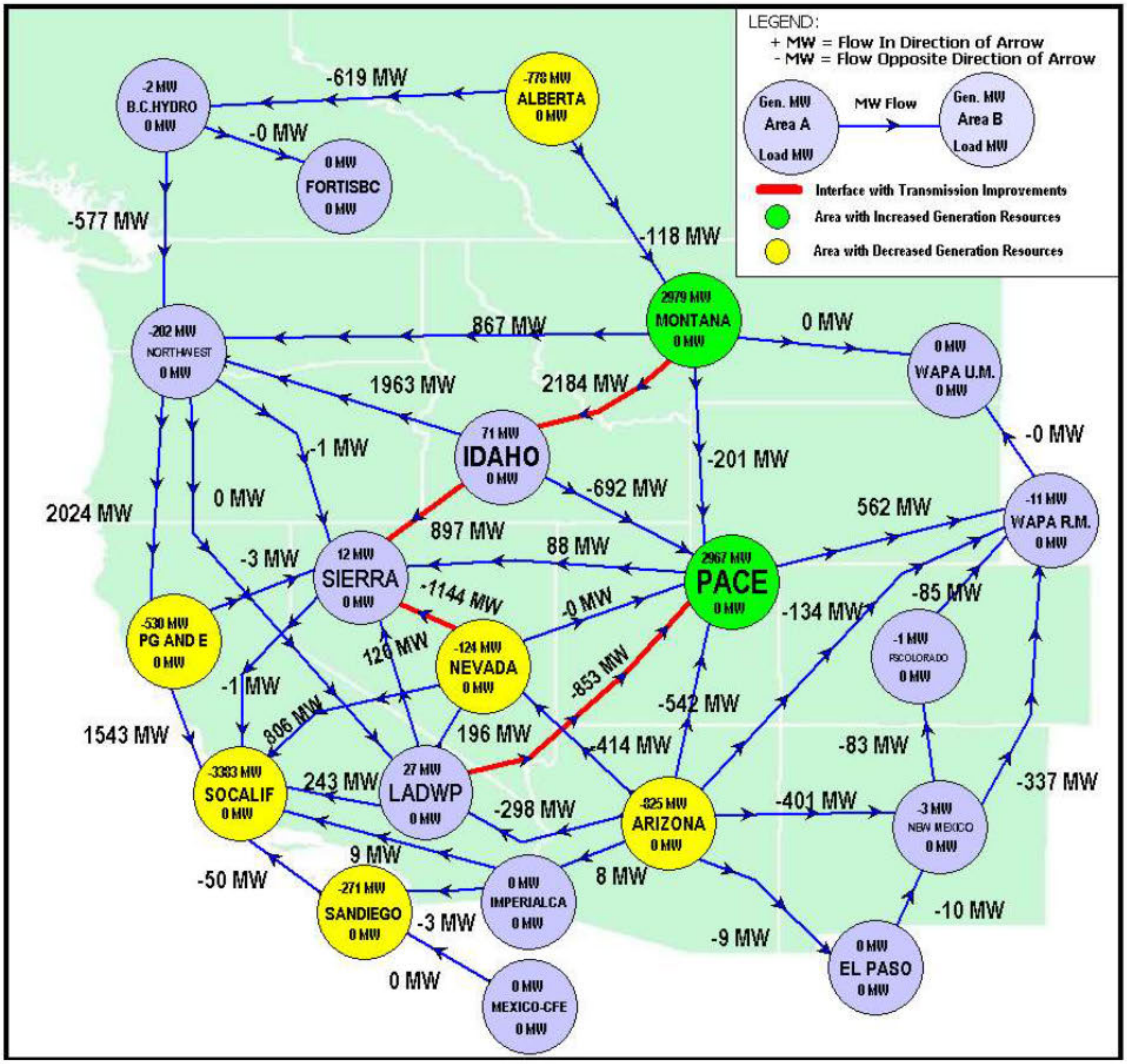
2.5: 3,000 MW in Wyoming, 3,000 MW in Montana – Maximum Import – August 10, Hour 13

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 16 overloaded branch elements ranging from 101.2% to 150% of the nominal rating. All N-0 overloaded elements were transformers. The extreme value of 362% appeared to be a data error in the transformer rating. There were 17 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 29 violations with zero unsolved contingencies. Of the 29 violations, seven were overloaded elements. The maximum overload was 135% of the continuous rating. The remaining violations were 21 high bus voltage violations and one low bus voltage violation.

A difference flow diagram is shown in Figure 6.21. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-21 – Scenario 2 Difference Flows: AUG13H13



3.0: Scenario 3 – 3,000 MW in Montana

The scenario intends to represent the effect of an additional 3,000 MW of alternative generation in Montana, equivalently located at the Townsend bus (between the Broadview and Garrison busses).

3,000 MW in Montana – Case Development

Case development for Scenario 3 began with the Core Case from each study hour. Generation resources were added to the Core Case for each study hour to develop five power flow cases for Scenario 3. Table 6.9 shows the generation resources added to the Core Case used to develop the five study hour cases for Scenario 3.

Table 6-9 – Scenario 3 Generation Resource Additions

Area Name	Bus Name	Generation Addition
MONTANA	TOWNSEND	3000 MW
	Total	**3000 MW**

A sink was also created for each of the five study hours by removing generation resources in order to offset the 3,000 MW resource addition. Table 6.10 shows the generation resources removed from the Core Case used to develop the five study hour cases for Scenario 3.

Table 6-10 – Scenario 3 Generation Resource Reductions

Area Name	Generation Reduction (MW) July 27 Hour 16	Generation Reduction (MW) December 22 Hour 18	Generation Reduction (MW) March 2 Hour 21	Generation Reduction (MW) October 4 Hour 21	Generation Reduction (MW) August 10 Hour 13
SOCALIF	1168	550	914	760	1695
SANDEIGO		178	451	70	
NORTHWEST	8	12	274	107	
NEWMEXICO			289	270	
ARIZONA	520		776	213	295
PG&E	1300	864	248	495	436
SIERRA		47	47		
ALBERTA		1019		898	776
WAPA RM			45	60	
PACE		102	182	129	
BC HYDRO			539		

	2996 MW	2772 MW	3765 MW	3002 MW	3202 MW

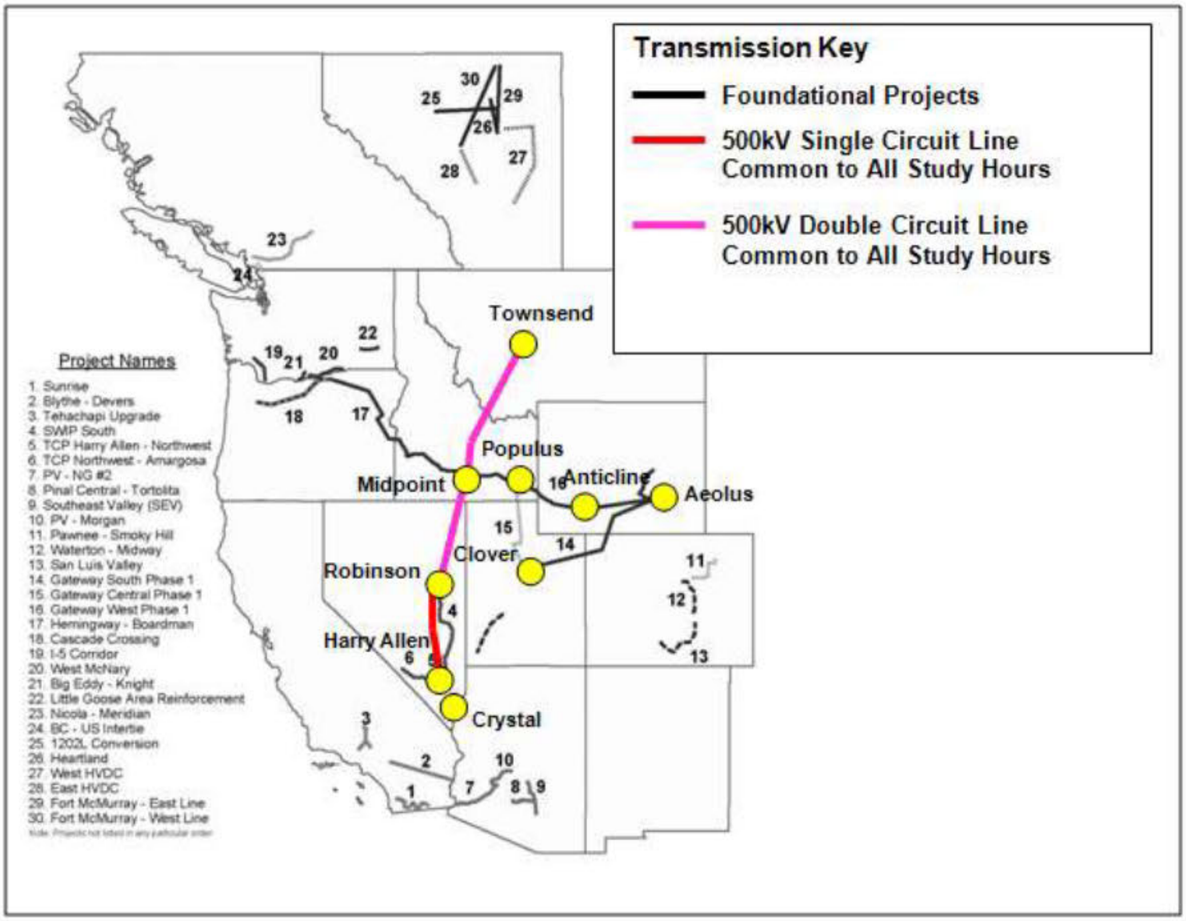
Once the generation additions and reductions were completed, the power flow case was solved. Additionally, the study identified overloads of transmission elements before the addition of generic transmission improvements. Table 6.11 shows the N-0 path flows for Scenario 3 prior to the addition of generic transmission improvements for each study hour analyzed in Scenario 3.

Table 6-11 – Scenario 3 N-0 Path Flows (Pre-Generic Transmission Improvements)

SCENARIO 3	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW
JUL27H16	-458	**2940**	4667	2600	7200	339	1551	691	-408
DEC22H18	824	**3431**	2179	2133	4877	1331	1196	289	322
MAR02H21	1442	**3862**	**6618**	2946	5053	1384	1102	**1981**	-160
OCT04H21	2953	**4300**	2652	2600	2477	2884	2537	1307	1137
AUG10H13	-919	**2458**	300	2600	4903	-86	1681	423	-756

Generic Transmission improvements that proved to be adequate solutions to overloads and that were common to the five study hours for Scenario 3 are shown in Figure 6.22.

Figure 6-22 – Scenario 3 Generic Transmission Improvements



3,000 MW in Montana – Study Results

The study results indicated that the addition of 3,000 MW of generation in Montana resulted in overloaded paths as shown in Table 6.11. Overloaded paths for Scenario 3 common between study hours were overloads on Montana-Northwest. The overloaded elements identified the need for generic transmission improvements.

Double-circuit 500 kV transmission lines were added between the Townsend-Midpoint and Midpoint-Robinson busses. A second 500 kV circuit was added in parallel to the Robinson-Harry Allen transmission line.

The N-0 path flows shown in Table 6.12 indicate that the proposed generic transmission improvements resolved the majority of the overloads shown in Table 6.11. One N-0 overload was recorded for the March study hour on COI, operating at 106.7% on a 4,800 MW rating.

N-1 contingency analysis for each study hour in Scenario 3 indicated that the majority of the 420 contingencies solved for each study hour. There were two study hours with unsolved contingencies; March with two and October with one.

The sum of the N-1 violations for all the study hours in Scenario 3 was 242 violations. The majority of overloaded elements for all the study hours were transformer overloads for N-1 conditions. The most common N-1 violation for all study hours was high bus voltage.

N-0 and N-1 violations discussed in this report are violations on elements 200 kV and above within the NTTG footprint. N-0 and N-1 violation tables for each study hour within this scenario are provided in Appendix 8.

A DC transmission solution originating in Montana as described in Scenarios 1 and 2 above would likely resolve the transmission overloads created by the increased Montana generation in this Scenario.

Table 6-12 – Scenario 3 N-0 Path Flows (Post-Generic Transmission Improvements)

SCENARIO 3	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW	DBL CKT 500kV Townsend-Midpoint (3000) MW	DBL CKT 500kV Midpoint-Robinson (3000) MW	DBL CKT 500kV Robinson-Harry Allen (3000) MW
JUL27H16	1089	522	3763	2600	5158	-66	1377	547	-480	**3178**	1290	1338
DEC22H18	2360	1907	2128	2288	3675	419	1296	169	-8	2102	-193	-417
MAR02H21 (AC Option)	2024	1684	**5125**	2946	3084	2311	989	1002	448	2956	**3606**	**3484**
OCT04H21	3759	2087	1470	2339	655	2787	2594	1097	1282	2722	1961	2176
AUG10H13	737	772	196	2600	3554	-793	1405	367	-1019	2272	179	419

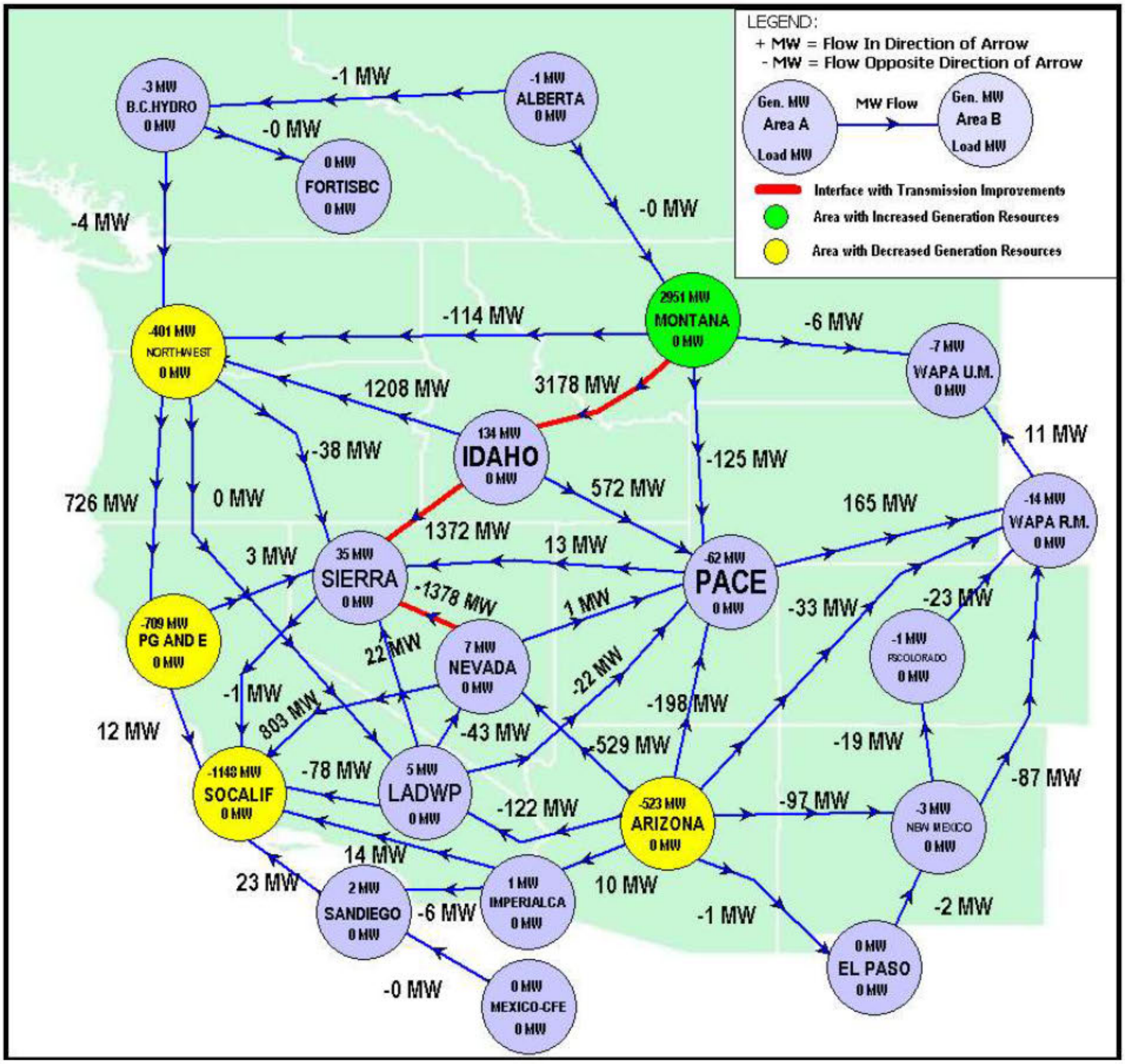
3.1: 3,000 MW in Montana – Summer Peak – July 27, Hour 16

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 18 overloaded branch elements, ranging from 104% to 166% of the nominal rating. All N-0 overloaded branch elements were transformers. There were 16 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 21 violations, with zero unsolved contingencies. Of the 21 violations, 10 were for overloaded elements. The extreme overload was 142% of the continuous rating. The remaining 11 violations resulted from elements with a bus voltage greater than 1.1 p.u.

A difference flow diagram is shown in Figure 6.23. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-23 – Scenario 3 Difference Flows: JUL27H16



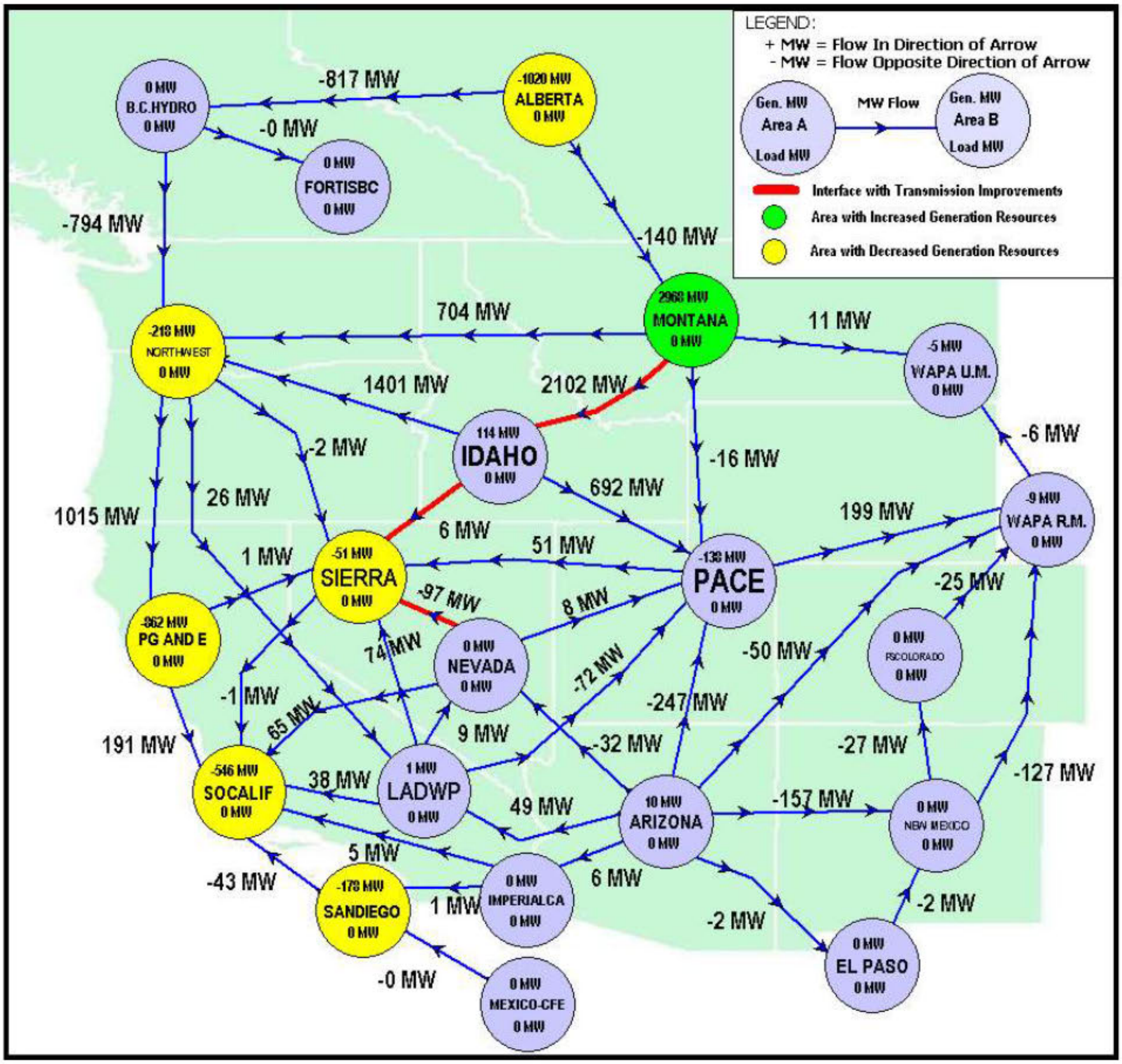
3.2: 3,000 MW in Montana – Winter Peak – December 22, Hour 18

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 15 overloaded branch elements – all transformers – ranging from 107.3% to 145% of the nominal rating. There were 41 busses in the case with a voltage magnitude greater than the 1.1pu pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 28 violations, with zero unsolved contingencies. Of the 28 violations, nine were overloaded elements. The maximum overload was 111% of path rating. There was one low bus voltage violation and 18 high bus voltage violations.

A difference flow diagram is shown in Figure 6.24. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-24 – Scenario 3 Difference Flows: DEC22H18



3.3: 3,000 MW in Montana – Heavy Spring Export – March 2, Hour 21

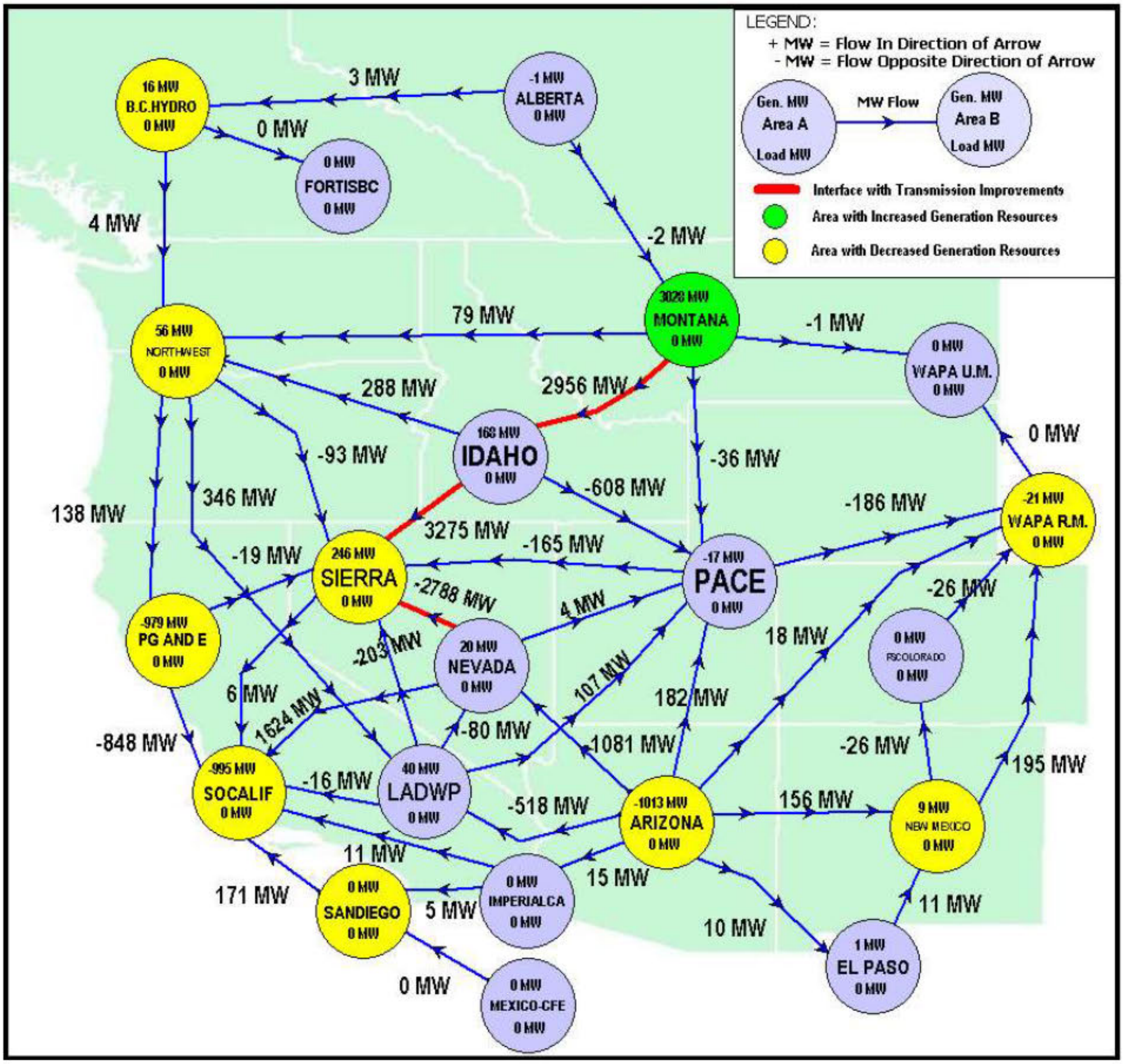
After the addition of the generic transmission improvements, one N-0 interface violations was found within the NTTG footprint: COI operating at 107%. Pre-contingency, this study hour was found to have

25 overloaded branch elements ranging from 103.5% to 174% of the nominal rating. The N-0 overloaded elements comprised three lines, three series capacitors and 19 transformers. There were 12 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 77 violations, with two unsolved contingencies. The two unsolved contingencies were BOARDT2-DALREED and JONESCYN-DALREED. Of the 77 violations, 11 were elements overloaded above the 100% rating. Of those 11, six were overloaded greater than 115%. The maximum overload was 224%. There were 65 violations for high bus voltage and one violation for low bus voltage.

A difference flow diagram is shown in Figure 6.25. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-25 – Scenario 3 Difference Flows: MAR02H21



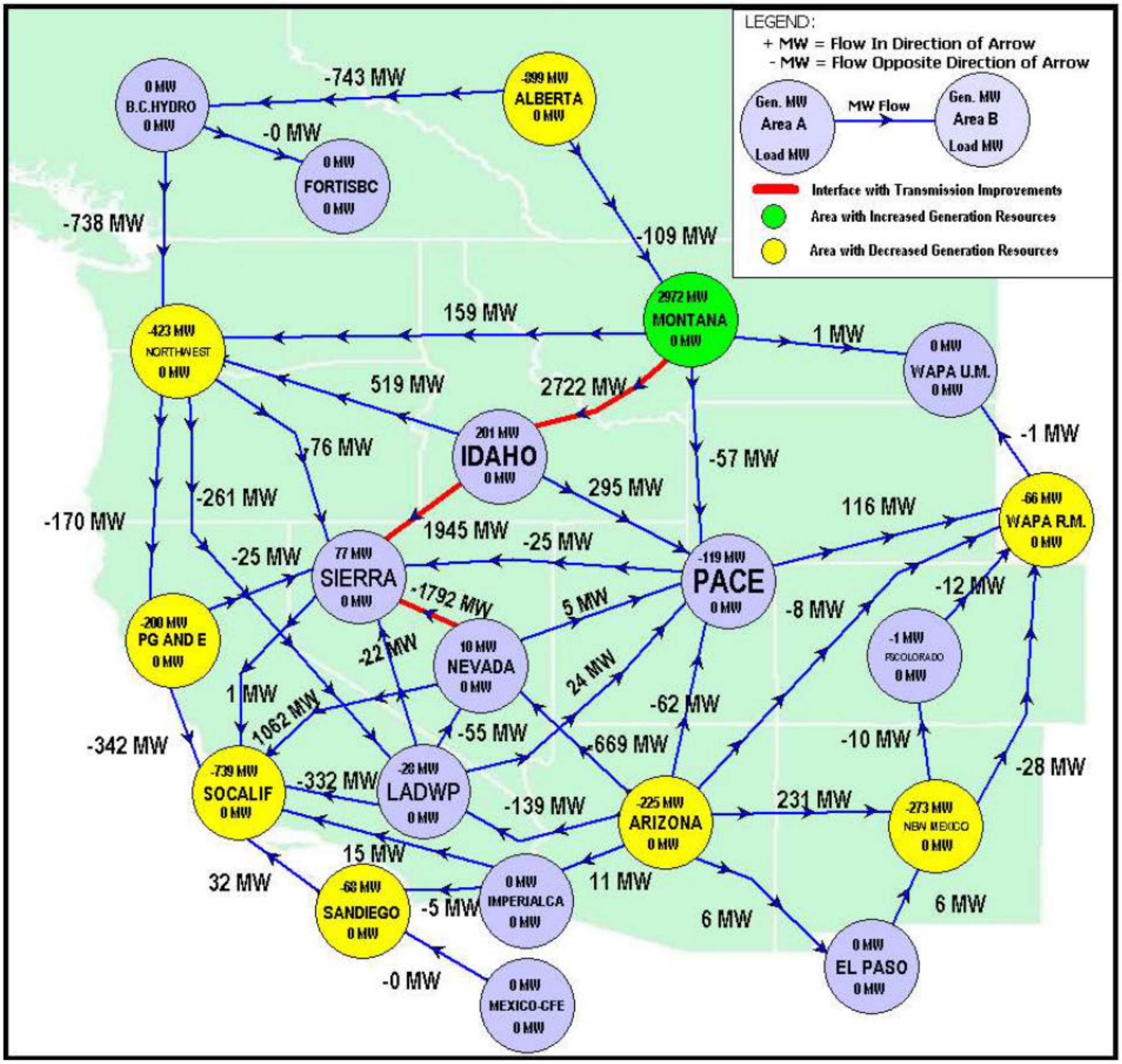
3.4: 3,000 MW in Montana – Heavy Autumn Export – October 4, Hour 21

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 16 overloaded branch elements ranging from 100.3% to 127% of the nominal rating. The N-0 overloaded elements comprised one line, one series capacitor and 14 transformers. There were 27 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 86 violations, with one unsolved contingency. The one unsolved contingency was BOARDT2-DALREED. Of the 86 violations, 28 were overloaded elements. The extreme overload was 165% of the continuous rating. The remaining 44 violations resulted from elements with a bus voltage greater than 1.1 p.u.

A difference flow diagram is shown in Figure 6.26. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-26 – Scenario 3 Difference Flows: OCT04H21



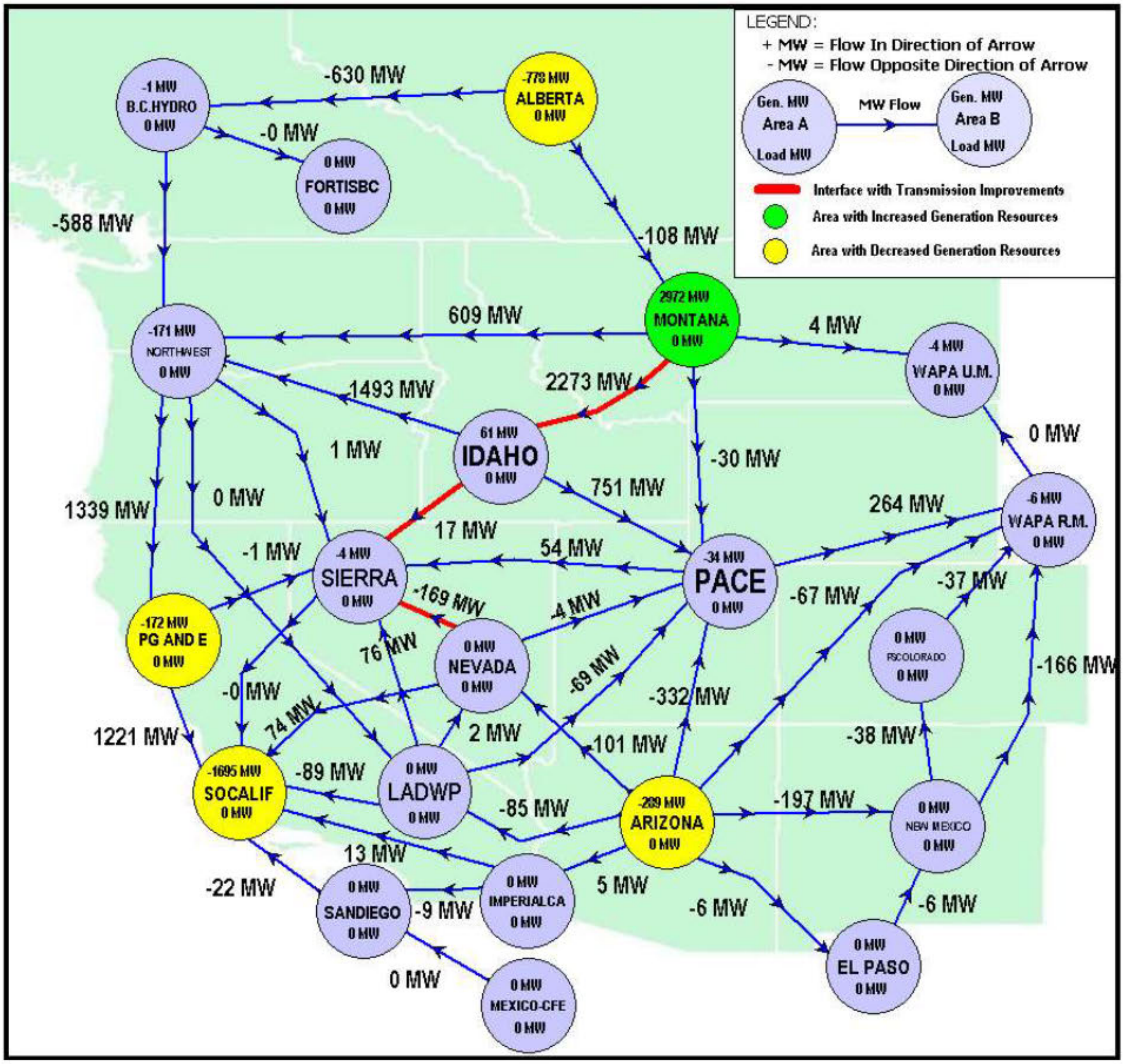
3.5: 3,000 MW in Montana – Maximum Import – August 10, Hour 13

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 17 overloaded branch elements – all transformers – ranging from 101.1% to 150% of the nominal rating. There were 70 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 30 violations, with zero unsolved contingencies. Of the 30 violations, 10 were overloaded elements ranging from 101% to 136%. There were 19 violations for high bus voltages and one violation for low bus voltage.

A difference flow diagram is shown in Figure 6.27. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-27 – Scenario 3 Difference Flows: AUG10H13



4.0: Scenario 4 – 3,000 MW in Wyoming

This scenario represents the effect of an additional 3,000 MW of alternative generation in Wyoming, equally distributed amongst the Anticline, Aeolus and Windstar busses. These busses are part of the

Gateway West project, one of the Foundational Transmission Projects, expected to be in place to help move energy from alternative generation resources in Wyoming.

3,000 MW in Wyoming – Case Development

Case development for Scenario 4 began with the Core Case from each study hour. Generation resources were added to the Core Case for each study hour to develop five power flow cases for Scenario 4. Table 6.13 shows the generation resources added to the Core Case used to develop the five study hour cases for Scenario 4.

Table 6-13 – Scenario 4 Generation Resource Additions

Area Name	Bus Name	Generation Addition
PACE	AEOLUS	1000 MW
	ANTICLIN	1000 MW
	WINDSTAR	1000 MW
	Total	**3000 MW**

A sink was also created for each of the five study hours by removing generation resources in order to offset the 3,000 MW resource addition. Table 6.14 shows the generation resources removed from the Core Case used to develop the five study hour cases for Scenario 4.

Table 6-14 – Scenario 4 Generation Resource Reductions

Area Name	Generation Reduction (MW) July 27 Hour 16	Generation Reduction (MW) December 22 Hour 18	Generation Reduction (MW) March 2 Hour 21	Generation Reduction (MW) October 4 Hour 21	Generation Reduction (MW) August 10 Hour 13
SOCALIF	1168	550	914	760	1695
SANDEIGO		178	451	70	
NORTHWEST	8		274	107	
NEWMEXICO			289	270	
ARIZONA	520		776	213	295

PG&E	1300	1122	248	495	436
SIERRA		47	47		
ALBERTA		1019		898	776
WAPA RM			45	60	
PACE			182	129	
BC HYDRO			539		
	2996 MW	**2916 MW**	**3765 MW**	**3002 MW**	**3202 MW**

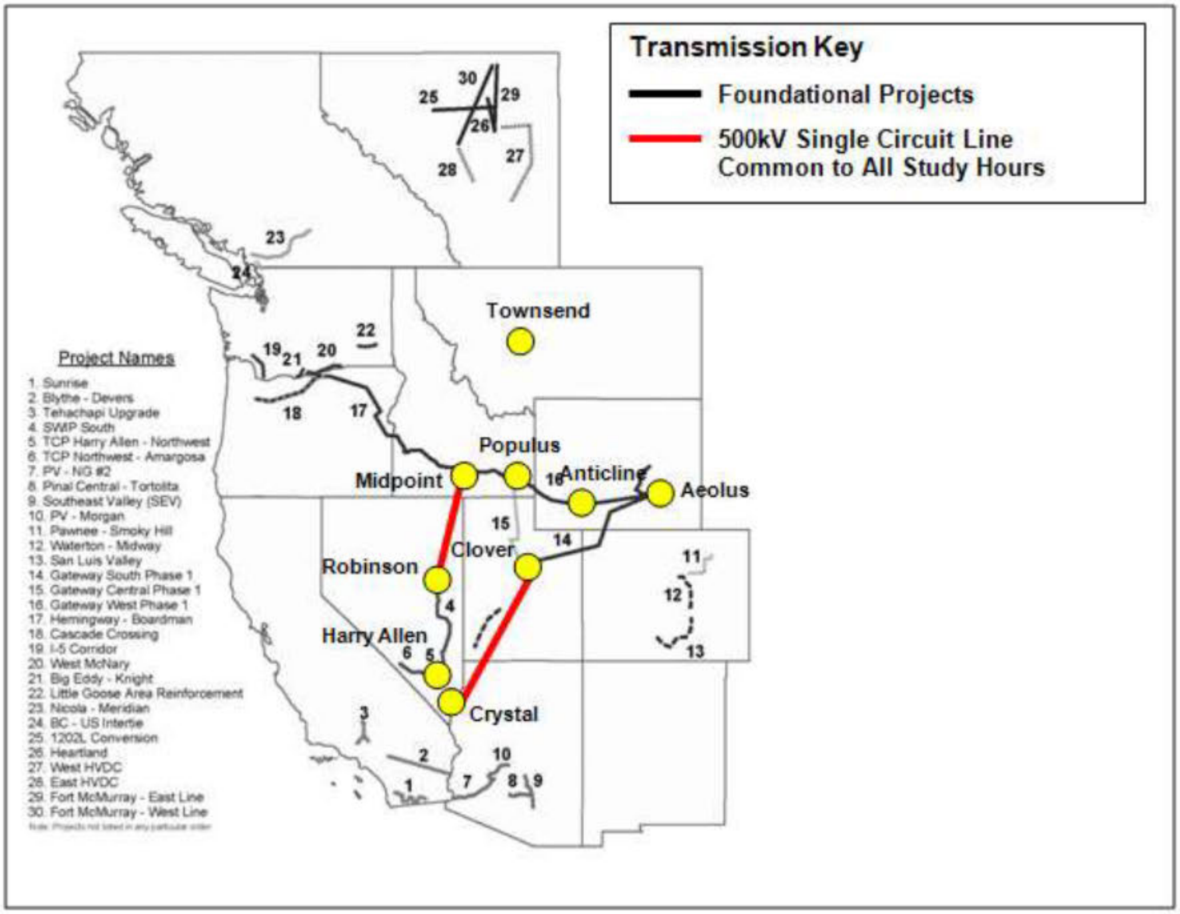
Once the generation additions and reductions were completed, the power flow case was solved and overloads of transmission elements prior to the addition of generic transmission improvements were identified. Table 6.15 shows the N-0 path flows for Scenario 4 prior to the addition of generic transmission improvements for each study hour analyzed in Scenario 4.

Table 6-15 – Scenario 4 N-0 Path Flows (Pre-Generic Transmission Improvements)

SCENARIO 4	ID-NW (3800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW
JUL27H16	1093	906	4417	2600	5767	1932	3119	1061	66
DEC22H18	2296	1387	1809	2600	3426	3490	3326	109	836
MAR02H21	3122	1752	**6084**	2946	3323	2761	**3790**	**2421**	398
OCT04H21	**4139**	2037	2491	2600	1591	**5404**	**4096**	**1943**	**1620**
AUG10H13	692	342	-97	2600	3340	1556	3312	460	-245

Generic Transmission improvements that appeared as adequate solutions to overloads that were common to the five study hours for Scenario 4 are shown in Figure 6.28.

Figure 6-28 – Scenario 4Generic Transmission Improvements


Transmission Key
Foundational Projects
500kV Single Circuit Line Common to All Study Hours
Project Names
1. Sunrise
2. Blythe - Devers
3. Tehachapi Upgrade
4. SWIP South
5. TCP Harry Allen - Northwest
6. TCP Northwest - Amargosa
7. PV - NG #2
8. Pinal Central - Tortolita
9. Southeast Valley (SEV)
10. PV - Morgan
11. Pawnee - Smoky Hill
12. Waterton - Midway
13. San Luis Valley
14. Gateway South Phase 1
15. Gateway Central Phase 1
16. Gateway West Phase 1
17. Hemingway - Boardman
18. Cascade Crossing
19. I-5 Corridor
20. West McNary
21. Big Eddy - Knight
22. Little Goose Area Reinforcement
23. Nicola - Meridian
24. BC - US Intertie
25. 1202L Conversion
26. Heartland
27. West HVDC
28. East HVDC
29. Fort McMurray - East Line
30. Fort McMurray - West Line
Townsend
Populus
Midpoint
Anticline
Aeolus
Robinson
Clover
Harry Allen
Crystal

3,000 MW in Wyoming – Study Results

The study results indicated that the addition of 3,000 MW of generation in Wyoming resulted in overloaded paths as shown in Table 6.15. Overloaded paths for Scenario 4 common between study hours were overloads on Bridger West.

The transmission improvements for all hours were: 1.) a 500kV transmission line from the Midpoint and Robinson busses and 2.) a 500 kV transmission line from the Clover to Crystal busses.

The N-0 path flows shown in Table 6.16 indicate that the proposed generic transmission improvements resolved the majority of the overloads shown in Table 6.15. Study hours with overloads after the generic transmission improvements were added to the study case were March and October. The March study hour recorded a slight overload on COI: 101.8% on a 4,800 MW rating. The October study hour recorded overloads on Bridger West (113% on 3,700 MW rating) and Path C (108% on 1,400 MW rating).

N-1 contingency analysis for each study hour in Scenario 4 indicated that the majority of the 420 contingencies solved for each study hour. The March study hour showed two unsolved contingencies.

The sum of the N-1 violations for all the study hours in Scenario 4 was 457 violations. The majority of overloaded elements for all the study hours were transformer overloads for N-1 conditions. The most common N-1 violation for all study hours was high bus voltage.

N-0 and N-1 violations discussed in this report are violations on elements 200 kV and above within the NTTG footprint. N-0 and N-1 violation tables for each study hour within this scenario are provided in Appendix 8.

A DC transmission solution originating in Wyoming as described in Scenarios 1 and 2 above would likely resolve the transmission overloads created by the increased Wyoming generation in this Scenario.

Table 6-16 – Scenario 4 N-0 Path Flows (Post-Generic Transmission Improvements)

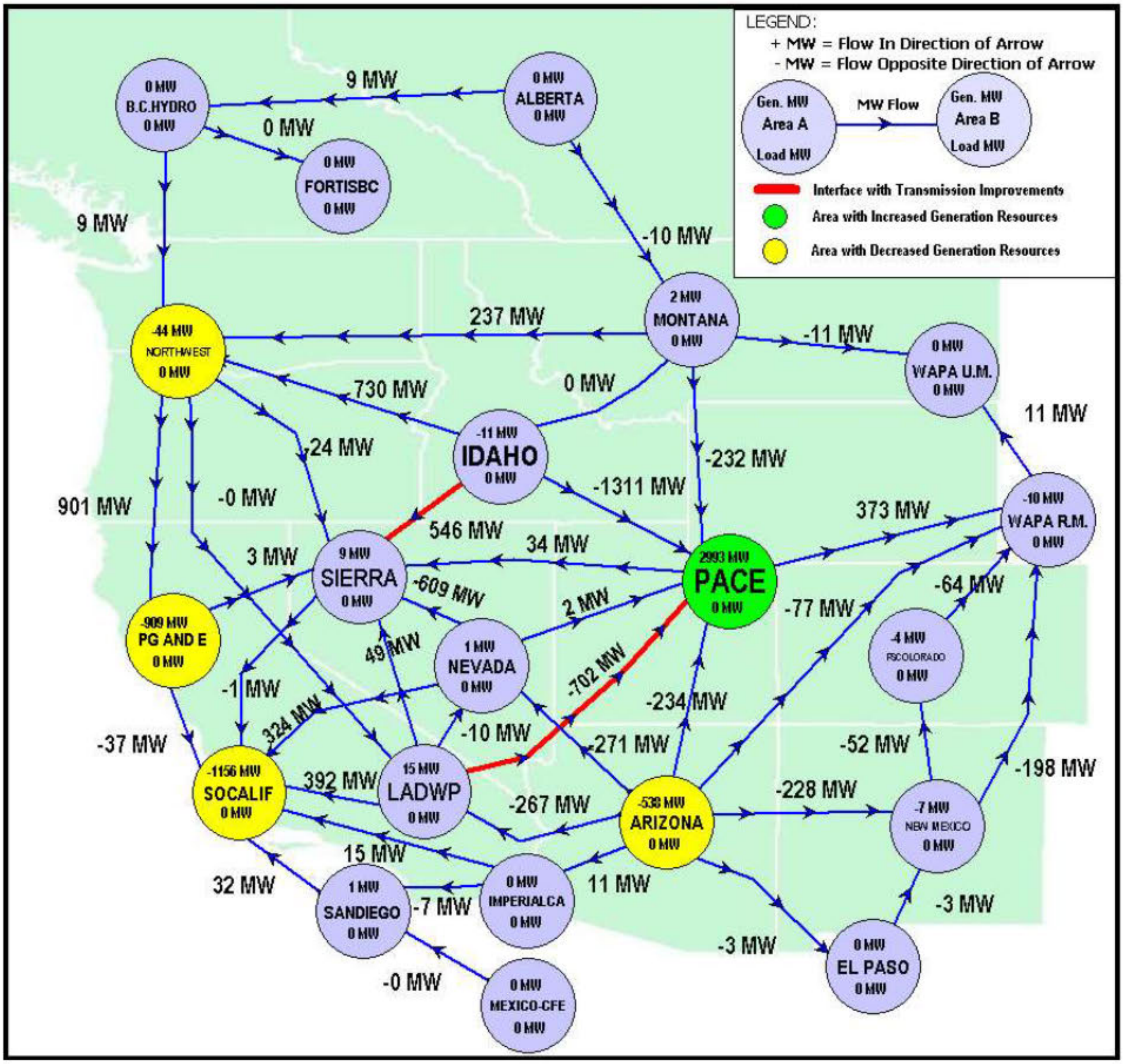
SCENARIO 4	ID-NW (4800) MW	MT-NW (2200) MW	COI (4800) MW	PDCI (3100) MW	N. OF JOHN DAY (7900) MW	BORAH WEST (4450) MW	BRIDGER WEST (3700) MW	TOT2 (A,B,C) (2070) MW	PATH C (1400) MW	SGL CKT 500kV Clover-Crystal (1500) MW	SGL CKT 500kV Midpoint-Robinson (1500) MW
JUL27H16	610	871	3931	2600	5678	1800	3081	739	-41	654	463
DEC22H18	2382	1376	1889	2600	3425	3122	119	50	651	256	-405
MAR02H21 (AC Option)	1827	1673	**4884**	2946	3025	2752	3672	1760	445	1277	**1707**
OCT04H21	3717	1870	1250	2600	816	4269	**4179**	1162	**1512**	1236	623
AUG10H13	831	348	44	2600	3355	1479	3281	445	-286	-32	-255

4.1: 3,000 MW in Wyoming – Summer Peak – July 27, Hour 16

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 17 overloaded branch elements – all transformers – ranging from 102% to 167% of the nominal rating. There were 19 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 37 violations, with zero unsolved contingencies. Of the 37 violations, five were overloaded elements ranging from 101% to 138%. The remaining 37 violations resulted from elements with a bus voltage greater than 1.1 p.u. A difference flow diagram is shown in Figure 6.29. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-29 – Scenario 4 Difference Flows: JUL27H16



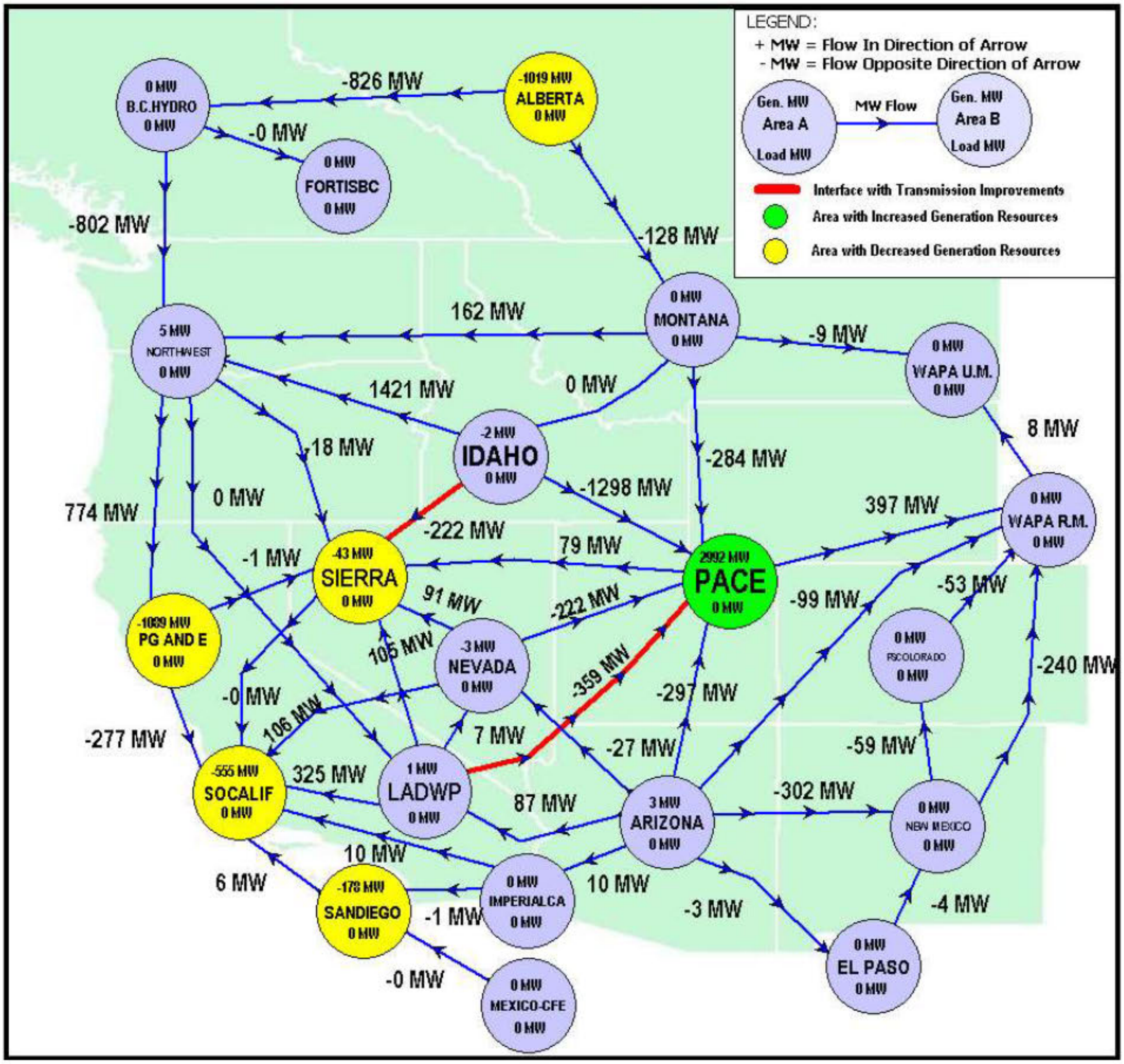
4.2: 3,000 MW in Wyoming – Winter Peak – December 22, Hour 18

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 11 overloaded branch elements – all transformers – ranging from 102% to 145% of the nominal rating. There were 36 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 56 violations, with zero unsolved contingencies. Of the 56 violations, there were eight violations for overloaded elements. The maximum overload was 112% of the continuous rating. There were two violations for low bus voltage and 46 violations for high bus voltage.

A difference flow diagram is shown in Figure 6.30. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-30 – Scenario 4 Difference Flows: DEC22H18



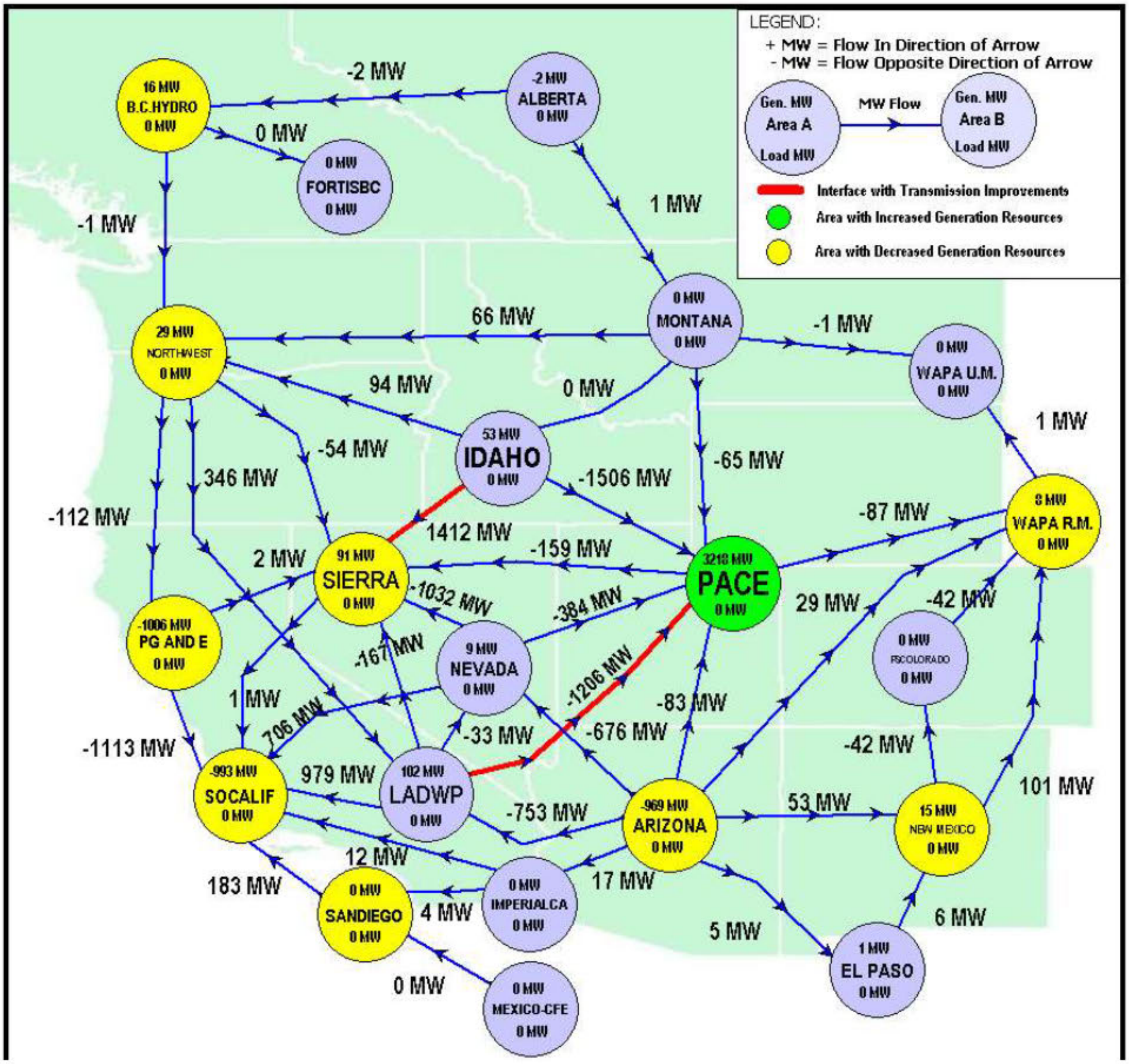
4.3: 3,000 MW in Wyoming – Heavy Spring Export – March 2, Hour 21

After the addition of the generic transmission improvements, one N-0 interface violation was found within the NTTG footprint: COI operating at 102%. Pre-contingency, this study hour was found to have 24 overloaded branch elements ranging from 101% to 188% of the nominal rating. There were five overloaded lines, one overloaded series capacitor and 18 overloaded transformers. Twenty-one busses in the case showed a voltage magnitude greater than 1.1 p.u. All these result were pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 200 violations, with two unsolved contingencies. The two unsolved contingencies were BOARDT2-DALREED and JONESCYN-DALREED. Of the 200 violations, 91 were elements overloaded above the 100% rating. There were two violations for bus voltage less than 0.9 p.u. and 107 violations for bus voltage greater than 1.1 p.u.

A difference flow diagram is shown in Figure 6.31. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-31 – Scenario 4 Difference Flows: MAR02H21



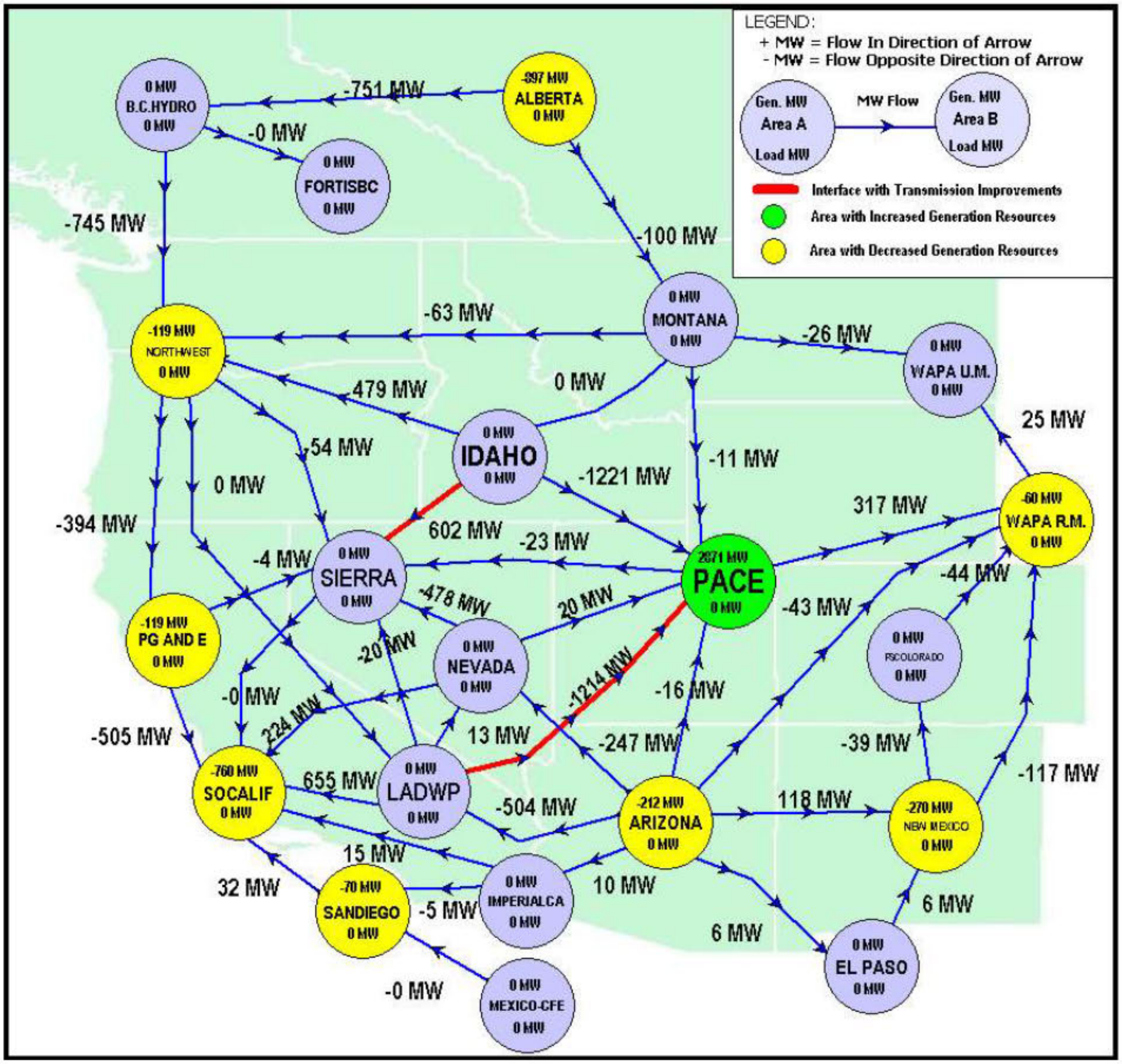
4.4: 3,000 MW in Wyoming – Heavy Autumn Export – October 4, Hour 21

After the addition of the generic transmission improvements, three N-0 interface violations were found within the NTTG footprint: Midpoint-Summer Lake at 118%, Bridger West at 113% and Path C at 108%. Pre-contingency, this study hour was found to have 16 overloaded branch elements ranging from 100.5% to 128% of the nominal rating. The pre-contingency overloaded elements consisted of three series capacitor elements and 13 transformers. Pre-contingency, there were 41 busses in the case with a voltage magnitude greater than 1.1 p.u.

A set of 420 N-1 contingencies was run on this study hour, resulting in 122 violations, with zero unsolved contingencies. Of the 122 violations, 25 resulted in overloaded elements above the 100% rating. The maximum overload was 1147% [correct?] of the continuous rating. The remaining 97 violations were either high or low bus voltages. Four violations were for bus voltages less than 0.90 p.u., and 93 violations were for bus voltages greater than 1.10 p.u.

A difference flow diagram is shown in Figure 6.32. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-32 – Scenario 4 Difference Flows: OCT04H21



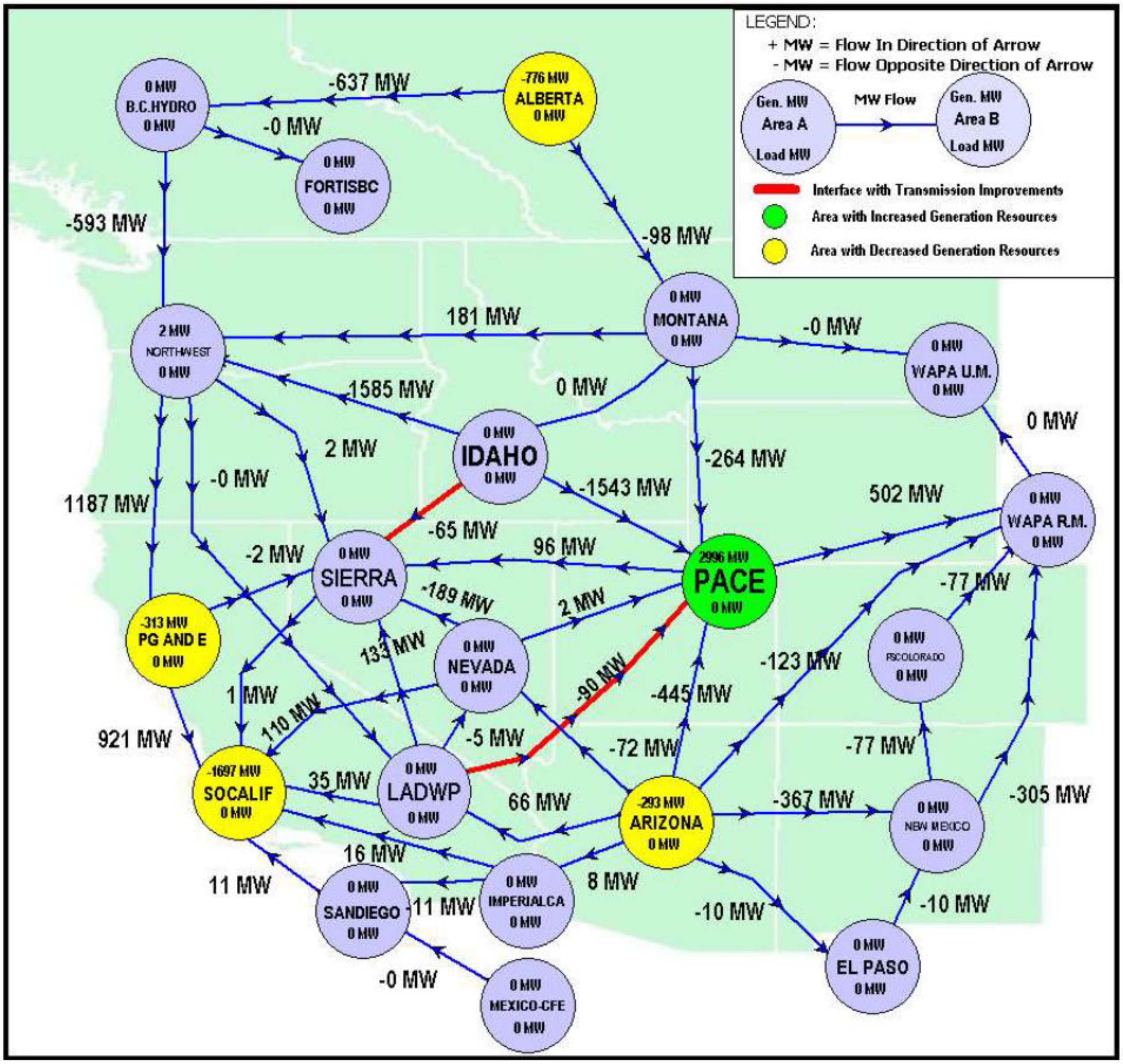
4.5: 3,000 MW in Wyoming – Maximum Import – August 10, Hour 13

After the addition of the generic transmission improvements, zero N-0 interface violations were found within the NTTG footprint. Pre-contingency, this study hour was found to have 13 overloaded branch elements – all transformers – ranging from 101.2% to 150% of the nominal rating. There were 71 busses in the case with a voltage magnitude greater than the 1.1 p.u., pre-contingency.

A set of 420 N-1 contingencies was run on this study hour, resulting in 42 violations, with zero unsolved contingencies. Of the 42 violations, eight resulted in elements overloaded above the 100% rating. The eight overloaded elements contained seven near or below 115% of the 100% rating and one at the maximum overload of 139% of the continuous rating. The remaining 32 violations were mostly bus voltages greater than 1.1 p.u. Two of these had bus voltage violations less than 0.90 p.u. voltage.

A difference flow diagram is shown in Figure 6.33. MW values shown on the difference diagram represent the MW change between the study hour and the Core Case. Additional area interchange diagrams for this study hour are located in Appendix 5.

Figure 6-33 – Scenario 4 Difference Flows: AUG10H13



Chapter 7 - Conclusions

The NTTG TWG performed reliability analysis in the traditional method using the Null Case to analyze the performance of the existing NTTG transmission system to serve the increased loads forecasted for the year 2020. The method of exporting production cost simulation to power flow cases was successfully developed and allowed the simulation of five NTTG transmission system loading conditions representing heavy load, maximum export and maximum import conditions. These production cost simulation-generated cases were further analyzed for performance under the addition of 3,000 MW of wind generation in Montana or Wyoming, or both; and 6,000 MW in Wyoming. In conclusion:

1. The NTTG TWG, through the Null Case analysis, has determined that the existing NTTG transmission system is not adequate to serve the projected NTTG system load in the year 2020.

2. The NTTG TWG has demonstrated the ability to develop hourly power flow cases from production cost simulation exports. This provides the ability to identify and perform reliability analysis on an appropriate set of transmission system loading conditions for future system dispatch configurations.

3. The Core Cases power flow reliability analysis has demonstrated that the Foundational Transmission Projects increase the system capability to reliably integrate planned energy resources and serve the forecasted NTTG system load.

4. The development of large amounts of Montana or Wyoming wind generation, as studied in the Scenario Cases, will exceed the capability of the NTTG transmission system and its Foundational Transmission Projects. Therefore, additional AC, DC, or a combination of AC and DC transmission lines, such as the projects listed in Appendix 3, from the NTTG system to forecasted RPS driven load are required under these resource expansion scenarios.

NORTHERN TIER TRANSMISSION GROUP

2012-2013 Biennial Transmission Plan

Final Report

November 26, 2013

NORTHERN TIER
TRANSMISSION GROUP

Approved by the NTTG Planning Committee: September 11, 2013
Approved by the NTTG Steering Committee: December 3, 2013

Chairman's Message

Dear Stakeholders:

We're pleased to present our third biennial regional transmission plan for the Northern Tier Transmission Group.

Much dedicated work went into this report, and it's my pleasure to recognize the efforts of all who contributed. In particular, I'd like to acknowledge the Northern Tier transmission-provider engineers and Comprehensive Power Solutions staff for soliciting and collecting the data, running the analyses, listening to and incorporating feedback, and preparing the studies. We appreciate their efforts.

We'd also like to thank you, our stakeholders, for your continued interest and participation in NTTG public processes. Your involvement improved this plan.

As with the 2011-2012 report, the Planning Committee approached the planning process by generating the study cases though production cost simulation. Planners identified the hours of significance and exported the production cost data to the power-flow simulation tool to test transmission system reliability.

If you are familiar with the prior biennium's report, you may notice this report's reduced size. Three reasons accounted for the slimming down. One, project proposers submitted fewer transmission projects and associated generating plants. Two, we saw reduced interest in building multiple scenarios – perhaps as a result of an industry shift away from Montana and Wyoming as potential wind-power sites. And three was the deferral and/or cancelation of proposed regional transmission projects considered in our prior biennial plan. For that reason, for example, we only analyzed the MSTI transmission project for the economic study. And while we studied the 500-kV Cascade Crossing transmission project, the developer canceled the project by the time the study was completed.

Overall, transmission providers forecasted greatly reduced loads and generation this biennium compared with the prior two-year period.

Nevertheless, we did conduct a Montana wind study and a 3,000-MW scenario for Wyoming.

We'd enjoy hearing your comments or suggestions. Our contact information is on the back page.

Thanks again for your interest, not only in this report, but in the larger mission of energy system reliability. Through your participation, you help ensure a more reliable transmission system for the more than 3 million people in the NTTG subregion who depend on us for safe, dependable, least-cost electricity.

Please stay involved as we begin work on the 2014-2015 planning process.

Sincerely,

Dave Angell, 2012 Chair

John Leland, 2013 Chair

NTTG Planning Committee

Disclaimer

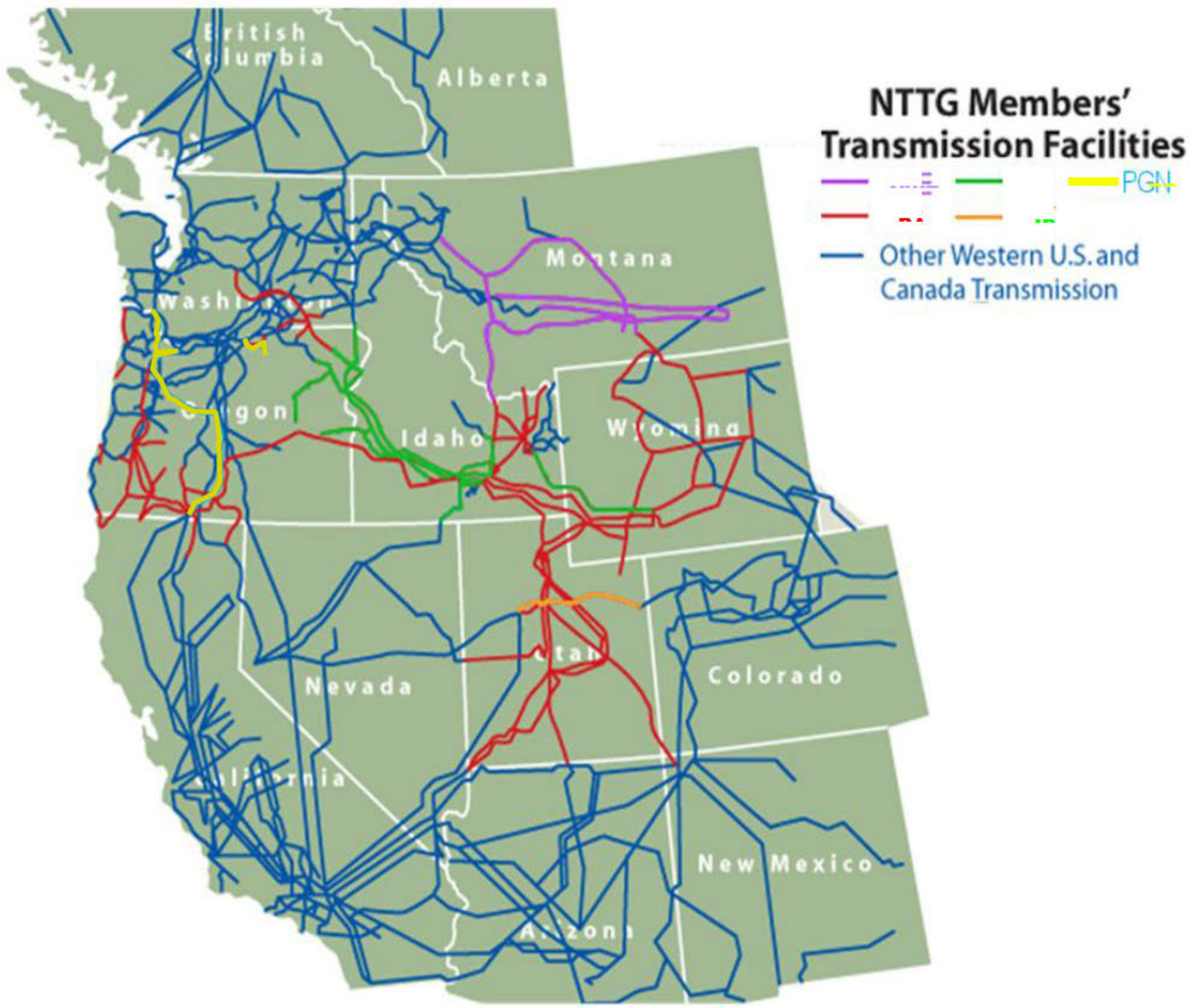
This report was prepared by the members of the Northern Tier Transmission Group (Northern Tier) and other stakeholders participating in the effort to provide coordinated, efficient and effective planning for expansion of transmission within the Northern Tier footprint. While Northern Tier cannot assure the plan will be implemented as designed, it represents the best information available during the current planning cycle. Changing needs or new information will be accommodated through appropriate data submittals during the next planning cycle.

Northern Tier accepts no duty of care to third parties who may wish to make use of or rely on information presented in this report. Northern Tier has exercised due and customary care in developing this report, but has not independently verified information provided by others and makes no further express or implied warranty regarding the report's preparation or content. Consequently, Northern Tier shall assume no liability for any loss due to errors, omissions or misrepresentations made by others.

This report may not be modified to change its content, character or conclusions without the express written permission of Northern Tier.

Approved by the NTTG Planning Committee: September 11, 2013
Approved by the NTTG Steering Committee: December 3, 2013

Northern Tier Transmission Group Mission: To ensure efficient, effective, coordinated use and expansion of the members' transmission systems in the Western Interconnection to best meet the needs of customers and stakeholders.



Map Illustrating Northern Tier Members' Principal Transmission Lines

The extensive high-voltage transmission network of the Northern Tier Transmission Group's transmission providers reaches to all states of the U.S. Western Interconnection

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Abstract

The 2012-2013 Northern Tier Transmission Plan uses power-flow reliability analysis to establish whether proposed transmission additions can reliably meet forecasted load and resource portfolios at stress times expected during 2022. The report reviews and summarizes the results of an economic-congestion study along with the results of null, core and scenario case studies performed by the Northern Tier Transmission Group (NTTG) during the biennium. The economic study demonstrates that the addition of a 500 kV line from Great Falls to Townsend to Midpoint and series capacitor upgrades at Burns, Malin and Midpoint would allow the transfer of 1,500 MW of power from Great Falls to Malin. The Null Case concludes that the existing NTTG transmission system cannot reliably serve 2022 forecasted loads and resources and will require additional transmission capacity. The five core cases demonstrate, however, that the NTTG transmission system can accommodate projected 2022 loads and resources without additional transmission facilities beyond the 30 proposed projects listed in the Common Case Transmission Assumptions (CCTA) for 2022.[1] Lastly, a Scenario Case finds the need to remedy the loss of both poles of a proposed 600-kV, direct-current electric transmission line to accommodate a 3,000-MW wind resource projected for southwest Wyoming. By reducing DC line flow to 2,650 MW at the receiving end, however, the loss of the DC bipole would be less severe, with few or no violations, depending on whether Fast Alternating Current Reactive Insertion (FACRI) action was employed.

Executive Summary

The 2012-2013 Northern Tier Transmission Plan describes the components of a reliable transmission system in 2022. The plan uses power-flow reliability analysis to establish whether proposed transmission additions can dependably meet forecasted load and resource portfolios at stress times expected that year.

This is the third biennial plan developed by the Northern Tier Transmission Group (NTTG or Northern Tier).

The report explains the study methodology, assumptions, data and analyses underlying the planning effort. The plan's components – the economic study and the null, core and scenario case studies – are reviewed and their results summarized.

Planning and preparation of the report spanned two years. Two planning cycles ran on parallel tracks during that time. One track comprised the biennial transmission planning cycle. The other track included two annual economic-congestion study cycles. Both tracks began in January 2012 and concluded with the final approval and publication of this report in December 2013.

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[1] The developer of the 500-kV Cascade Crossing transmission line canceled its project after completion of the transmission plan. Thus, the report includes this project in its assumptions.

An introductory chapter outlines, in addition to the biennial planning process, the structure of NTTG and its various planning entities, and the local, sub-regional and regional planning process in the Western Interconnection. The relationship between Northern Tier and other subregional and regional entities is outlined, and their synchronized planning cycles are described.

Next, the report expands on study methodology, looking at the process used to create study plans, core cases, power-flow analysis and reliability criteria. Another chapter describes how the study case was developed from load forecasts, resources and expected transmission additions.[2] Notably, it points out, NTTG transmission providers' current 10-year load and resource forecast changed significantly from the prior two-year cycle, prompting NTTG to assess future transmission requirements.

The economic study demonstrates that the addition of a 500 kV line from Great Falls to Townsend to Midpoint, along with series capacitor upgrades at Burns, Malin and Midpoint, would allow 1,500 MW of power to be transferred from Great Falls to Malin. Under the maximum export case, some combination of capacitor upgrades and transmission improvements would be needed beyond the 30 projects included in the Western Electricity Coordinating Council (WECC) Common Case Transmission Assumptions (CCTA) for 2022.

The Null Case seeks to discover whether the near-term transmission system can meet the demands of the load forecasted for the NTTG footprint in 2022. The case concludes that the existing NTTG transmission system cannot reliably serve 2022 forecasted loads and resources and will require additional transmission capacity.

The core cases analyze future system reliability under five different stressed conditions within the NTTG footprint. The committee selected peak-load hours as well as high-import and high-export conditions that produced those stress points.

The five core cases demonstrate that the NTTG transmission system can accommodate projected 2022 loads and resources without additional transmission facilities beyond the 30 proposed projects listed in the 2022 CCTA.

Lastly, a Scenario Case combines a 3,000 MW wind resource projected for southwest Wyoming with a proposal for a 600 kV, direct-current electric transmission line with 3,000 MW capacity. The study finds the need to remedy the loss of both poles of the new DC line, if transferring 3,000 MW. If DC line flow were reduced to 2,650 MW at the receiving end, the loss of the DC bipole would be less severe, with few or no violations, depending on whether Fast Alternating Current Reactive Insertion (FACRI) action was employed.

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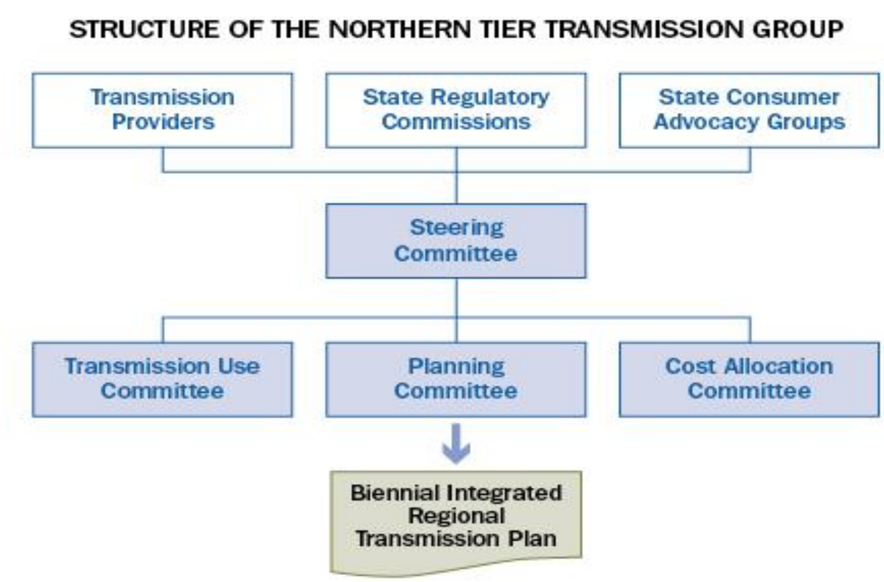
[2] The developer of the 500 kV Cascade Crossing transmission line canceled this project after NTTG completed this biennial transmission plan. Thus, the report continues to include this project in its assumptions.

Chapter 1 – Background

The Northern Tier Transmission Group

The Northern Tier Transmission Group (Northern Tier or NTTG) was formed voluntarily in 2007 to promote effective planning and use of the multi-state electric transmission system within the Northern Tier footprint.[3] NTTG fulfills Federal Energy Regulatory Commission (FERC) Order No. 890 requirements that local transmission providers participate in regional and subregional planning. Northern Tier provides a forum where all interested stakeholders, including transmission providers, customers and state regulators, can participate in planning, coordinating and implementing a robust transmission system.

Figure 1-1: Structure of the Northern Tier Transmission Group



NTTG focuses on evaluating transmission projects that move power across the subregional bulk-electric transmission system, serving load in its footprint and delivering electricity to external markets. The transmission providers belonging to Northern Tier serve over 4 million retail customers with more than

[3] The Northern Tier footprint means the geographical area comprised of the retail electric service territories of the entities enrolled in NTTG as Full Funders. Currently, these Full Funders are (i) Portland General Electric Company (Portland General), (ii) PacifiCorp, (iii) Idaho Power Company, (iv) Deseret Generation & Transmission Co-operative, and (v) NorthWestern Corporation.

29,000 miles of high-voltage transmission lines. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, along with parts of Washington and California.

Northern Tier Members

The Northern Tier Transmission Group's organizational structure has multiple levels, as shown in Figure 1-1 above. Overall planning direction is provided by the Steering Committee, whose membership at publication was as follows:

- Deseret Power Electric Cooperative
- Idaho Power Company
- Idaho Public Utilities Commission
- Montana Consumer Counsel
- Montana Public Service Commission
- NorthWestern Energy
- Oregon Public Utility Commission
- PacifiCorp
- Portland General Electric
- Utah Associated Municipal Power Systems
- Utah Office of Consumer Affairs
- Utah Public Service Commission
- Wyoming Public Service Commission

Transmission Planning Committee

The NTTG Transmission Planning Committee (Planning Committee or committee) coordinates transmission planning for the Northern Tier footprint. It also coordinates with other subregional planning groups and the Western Electricity Coordinating Council's planning committees. Execution of the committee's charter occurs through the biennial planning process. Northern Tier designs its planning process to be open, transparent and participatory. Transmission providers, regulators, customers and other stakeholders are encouraged to join the committee's activities and meetings, including semi-annual stakeholder meetings.

NTTG's 2012-2013 biennial plan was produced through its public processes in conjunction with related activities of the NTTG Cost Allocation Committee and NTTG Transmission Use Committee.

At publication, the Transmission Planning Committee had members from the following organizations:

- Avista Corporation
- Basin Electric
- Black Hills Power
- Deseret Power Electric Cooperative

- Gaelectric, LLC
- Grasslands Renewable Energy
- Idaho Office of Energy Resources
- Idaho Power
- Idaho Public Utilities Commission
- Montana Public Service Commission
- NextEra Energy Resources
- NorthWestern Energy
- PacifiCorp
- Portland General Electric
- Sea Breeze Pacific
- TransCanada
- Utah Associated Municipal Power Systems
- Utah Public Service Commission
- Wyoming Public Service Commission

Coordination Within the Northern Tier Footprint

Planning is an iterative process that must work in concert with local transmission plans and integrated resource plans, where they exist. This Northern Tier transmission plan uses a bottom-up load-service process, employing stakeholder data and input to ensure that the transmission system planned for the Northern Tier footprint can reliably serve forecasted load growth and conditions. While this plan addresses transmission issues and solutions within the Northern Tier footprint, it is informational only. It neither requires construction nor seeks to accommodate broader regional needs.

Each of the Northern Tier transmission providers is also responsible for transmission planning and implementation in its own service area and for any balancing authority areas it administers. This local transmission planning process is designed to parallel and interact with the planning done at Northern Tier.

The local planning process digs deeper than the subregional process, in terms of its analysis both of finer detail (lower voltages and system dynamics) and more extensive construction detail. The transmission provider's responsibilities include path ratings, project financing, permitting and approvals, and construction.

The NTTG planning process provides a mechanism for coordinating stakeholder load and resource data, as well as for considering potential non-transmission-provider transmission projects. Additionally, this process coordinates analysis of the existing subregional transmission system and the proposed projects that affect the transmission of electricity throughout the NTTG footprint.

Coordination with Others in the Western Interconnection

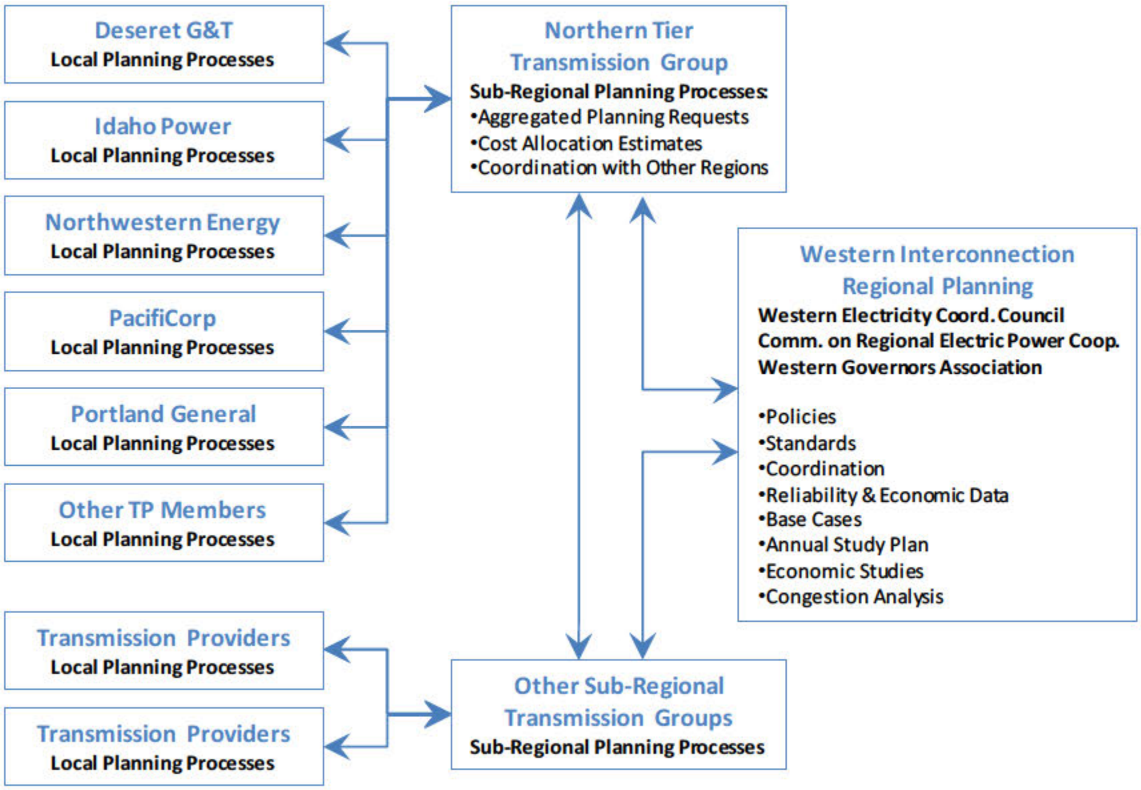
NTTG is committed to coordinating subregional planning efforts with adjacent subregional groups and other planning entities. In addition to working directly with the ColumbiaGrid and WestConnect subregional planning groups, Northern Tier relies on the data collection, validation and transmission modeling work done by the Western Electricity Coordinating Council (WECC), the regional reliability organization. This Northern Tier transmission plan is consistent with the work of WECC.

WECC provides valuable services to transmission planners across the Western Interconnection. WECC's services include providing regional reliability planning and facility rating, and supplying economic planning data and analysis to its members through its Transmission Expansion Planning Policy Committee (TEPPC).

Relationships Among Planning Entities in the West

Transmission planning in the Western Interconnection has evolved to incorporate three distinct organizational levels: transmission providers, subregional transmission groups and regional planning entities. The relationships among regional, subregional and individual transmission entities are illustrated in Figure 1-2 below.

Figure 1-2: Three-level Planning Process in the Western Interconnection



Each of the transmission providers develops and maintains an Open Access Transmission Tariff process, which receives and acts on requests for transmission service in accord with a well-defined procedure. The transmission providers also assess future load and resource developments to plan the evolution of an efficient transmission system, and undertake reliability analysis and improvements.

Planning and analysis of improvements are coordinated at the subregional level. This occurs when service requests and other identified needs call for the development of transmission requiring participation of multiple providers within a subregional transmission group's footprint.

At the regional level, the WECC TEPPC provides a forum for wider coordination and completes the three-level framework that addresses regional, subregional and local issues.

The Northern Tier Transmission Group's planning timelines are designed to coordinate with those of WECC. Those timelines include a two-year cycle for transmission expansion and reliability and a one-year economic study cycle. The economic study process examines preliminary plans during the first year of the biennial cycle and draft plans during the second year of the cycle.

Review of NTTG 2012-2013 Planning Activities

Stakeholder participation is important to the processes of the Northern Tier Transmission Group. All interested parties are encouraged to attend and contribute to the many stakeholder meetings conducted by the Transmission Use, Planning and Cost Allocation committees, and to help in preparing, developing and analyzing planning studies. A chronology of activities in the 2012-2013 biennial planning cycle is provided in Table 1.1 below.

The Northern Tier Planning Committee conducted open conference calls on a frequent basis during the 2012-2013 biennium. The planning process was developed and managed in these conferences. Participants discussed and reached agreement on assumptions, data and methodologies.

The Planning Committee decided to perform studies using the staff of member transmission providers, taking advantage of their internal expertise and software tools. The committee formed a Technical Work Group (TWG), to separate detailed technical and model discussions from the policy-level Planning Committee and to provide proper control of confidential information.

An Economic Studies Team was similarly formed to plan and perform any needed economic studies resulting from NTTG's economic-study request solicitation during the biennium.

Table 1-1: Biennial Planning Activities

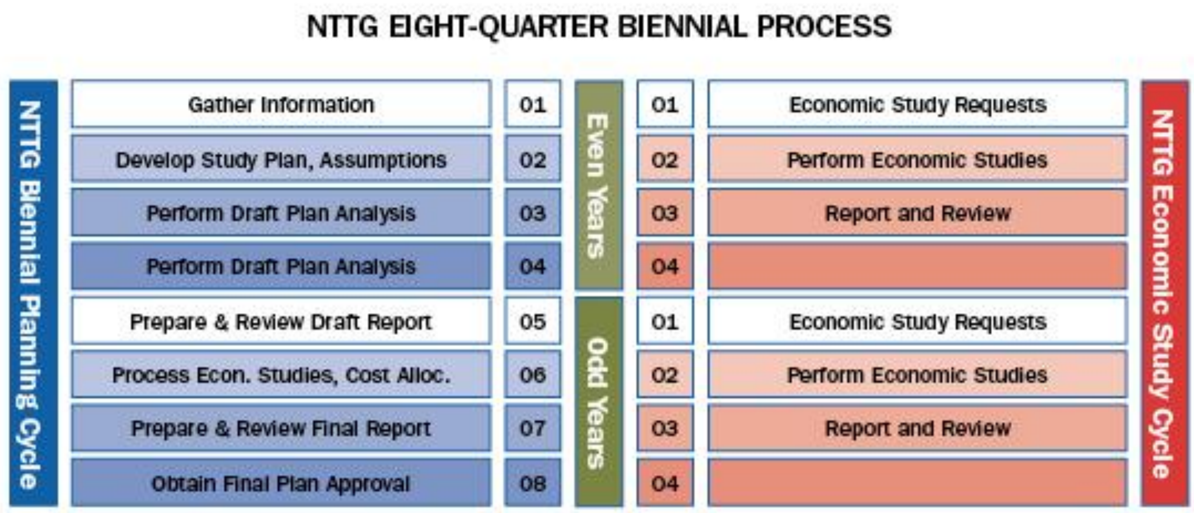
Year	Month	Day	Activity
2012	Jan	9	Planning Committee Meeting discussion of data and economic study requests
	Feb	3	2012 Public Semi-Annual Stakeholder Meeting
	Apr	4	Planning Committee Meeting selection of economic study requests
	May	2	Planning Committee Meeting review of Transmission and Economic Study Plans
	June	6	Planning Committee Meeting Transmission and Economic Study Plans Approved and Posted
	Aug	4	2012 Public Semi-Annual Stakeholder Meeting
	Sep	5	Planning Committee Meeting discussed scenario case
	Oct	3	Planning Committee Meeting review of study progress
	Nov	14	Planning Committee Meeting review of economic study results
	Dec	12	Planning Committee Meeting review of economic study results
2013	Jan	9	Planning Committee Meeting discussion of draft Biennial Transmission Plan, data and economic study requests
	Feb	7	2013 NTTG Semi-Annual Public Stakeholder Meeting
	Mar	13	Planning Committee Meeting
	Apr	17	Planning Committee Meeting discussion of economic study requests
	May	8	Planning Committee Meeting
	Jul	25	2013 NTTG Semi-Annual Public Stakeholder Meeting
	Aug		Stakeholder input to the Biennial Plan
	Nov		Biennial Plan Approval by NTTG Steering Committee
	Dec		Biennial Plan publication

Details of the Eight-Quarter Northern Tier Planning Process

The biennial transmission planning process at Northern Tier is broken down into eight quarters and two tracks. Figure 1.3 diagrams this process for the 2012-2013 cycle. The planning process during this biennial cycle is described in further detail in the Northern Tier Transmission Group's Planning Committee Order No. 890 Charter[4].

[4] In the respective compliance filings by the Full Funders of NTTG regarding the FERC Order No. 1000, the NTTG committee charters were substantially revised. Pursuant to these revisions, as of October 2013, the Planning Committee Charters have been revised such that the details of the planning process have been removed from the charter and are now found in each of the Full Funders' respective Attachment K. Although the current biennial cycle ends on December 31, 2013, for purposes of preparation and consideration of this report, the planning procedures of the Planning Committee are based on the prior Planning Committee Charter established under Order No. 890.

Figure 1-3: NTTG Eight-Quarter Biennial Planning Process



The current biennial cycle began in January 2012 with a three-month window of opportunity for stakeholders to submit data for loads, resources and transmission projects to be studied, and to submit requests for economic congestion studies.

The second quarter was dedicated to developing a study plan based on the data collected, along with the appropriate study assumptions. Additionally, development of the economic study plan ensued during this quarter.

The Economic Studies Team presented its economic-congestion study results for the biennium in the fourth quarter of 2012.

The TWG developed and exported the production cost cases to the power-flow simulation program during the second quarter. This allowed the TWG to analyze the null and core cases during the third and fourth quarters. It further allowed the TWG to share the draft Transmission Plan with the Planning Committee in the first quarter of 2013. The biennial planning process concluded with the preparation, review and acceptance of this report.

In October 2013, the fourth biennial planning cycle will begin, with data, models and processes enhanced by prior experiences and in accordance with FERC Order 1000. FERC found the NTTG transmission providers' compliance filings to be partially compliant, accepted the filing subject to further compliance filings, and set an October 2013 effective date. Based on this FERC action, NTTG's 2014-2015 biennial planning process will analyze the NTTG footprint to select a more cost-effective or efficient transmission plan.

Chapter 2 – Study Methodology

The objective of the 2010-2011 Northern Tier Transmission Plan is to determine what a reliable transmission system may look like in 2022. The plan used power-flow reliability analysis to establish whether the proposed transmission additions can reliably meet the forecasted load and resource portfolios at anticipated stress times in 10 years.

Creation of the Study Plans

As described in Chapter 1, NTTG begins the biennial transmission planning and economic study processes through a solicitation of data and study requests. This is followed by the creation of their respective study plans. During this planning cycle, the biennial transmission plan was revised several times in order to correct information and incorporate the approved scenario study. The final NTTG 2012/2013 Biennial Transmission Study Plan and Economic Study Plan are included as Appendix A and B, respectively.

Creation of the Study Core Cases

NTTG creates the power-flow core cases from a chronological, security-constrained generator-commitment-and-dispatch program to identify and select specific conditions, e.g., peak load and maximum export, to perform reliability analysis of the NTTG transmission system. The use of this technique goes beyond the traditional focus of power-flow analyses on WECC winter and summer peaks. NTTG examines all hours of the year for situations where available resources and forecasted loads across the Western Interconnection cause the highest stress on the transmission system in the Northern Tier footprint, as described in Chapter 3.

Power-Flow Analysis

Power-flow analysis is performed on the developed cases to determine if any voltage- or thermal-overload violations exist under two conditions: system normal (N-0 pre-disturbance analysis with all lines in service) and one transmission element out of service at a time (N-1 contingency analysis). The contingency analysis includes a comprehensive set of 420 single-element outages of NTTG footprint elements with an operating voltage of 230 kV and above. During this analysis, autotransformer taps and phase-shifting transformers are not allowed to adjust (locked), and the switching of shunts and tie lines is disabled. Remedial Action Schemes (RAS) are executed for contingencies that normally utilize RAS. Transient stability, reactive margin and N-2 (or more) contingency analyses are not performed for this study.

Criteria

The power-flow simulation results are measured against North American Electric Reliability Council (NERC) and WECC reliability criteria. Specifically, the NERC Reliability Standards TPL-001 and TPL-002 b require that transmission facilities maintain operation within normal and emergency limits. The WECC business practice TPL-001-WECC-RBP-2 establishes the voltage-violation threshold for N-1 contingency analysis at 5% for other systems. Thus, the software application's reporting threshold for a thermal-overload violation is based on the normal ratings for system normal and emergency summer ratings for N-1 contingency analysis. Additionally, the voltage violation threshold is set at 5%. However, only voltage deviations greater than 5% on other transmission systems and substations busses constitute a violation. Thus, the TWG carefully analyzes software-tabulated violations to cull any reported violations on local transmission-provider (within the same transmission system where contingency applied), series-capacitor and non-bulk-electric-system busses.

Path Constraints

Path constraints, also referred to as interface limits, are included in the power-flow cases. They are based on the WECC Path Rating Catalog. The TWG may modify the interface limit if transmission additions impact the limit.

Chapter 3 – Study Case Development

Comparison of NTTG 10-Year Forecast

In the first quarter of the two-year study process, stakeholders submitted loads, resources and expected transmission additions for the next 10 years. The following comparison of the 2012 and 2010 submittals led to the decision to proceed with the 2012-2013 study process.

1. Balancing authorities provided their 10-year load forecasts to NTTG in response to the first-quarter data request. The loads are generally the official load forecasts of the load-serving entities and are also provided to the WECC Loads and Resources Committee. Table 3-1 shows a load comparison from data submitted during the first quarter of 2012 compared with the same quarter of 2010.

Table 3-1: 10-Year Forecasted Load Comparison

Submitting Entity	10-yr. Summer Load Data submitted in Q1 2012	10-yr. Summer Load Data submitted in Q1 2010	Difference
Basin Electric	476	None submitted	n/a
Black Hills Energy	465	None submitted	n/a
Idaho Power	4383	4161	222
NorthWestern Energy	1680	1618	62
PacifiCorp East	9842	10105	-263
PacifiCorp West	3795	3730	65
Portland General Electric	4119	4421	-302
TOTAL	*24760*	*24035*	*-216**

** Note: The total difference in the load comparison does not include Basin Electric or Black Hills, since the 2010 data was incomplete.*

2. Resources provided in response to the first quarter data request add to existing resources within the Northern Tier footprint and are summarized in Table 3-2 (2010 Q1 data submittal) and Table 3-3 (2012 Q1 data submittal). Resource data come from integrated resource plans, interconnection queues, resource developers and transmission providers who provide indications of expected resource additions.

Table 3-2: Resource Additions Identified in 2010 Q1 Data Submittals

Submitting Entity	*Natural Gas*	*Wind*	*Geo-thermal*	*Hydro-electric*	*Coal*	*Market*	*TOTAL*
Basin Electric	*0*	*0*	*0*	*0*	*385*	*0*	*385*
Grasslands Renewable Energy	0	0	0	350	0	0	*350*
Idaho Power	300	150	40	49	0	425	*964*
NorthWestern Energy	890	2195	0	50	290	0	*3425*
PacifiCorp	1574	1156	0	39	0	1870	*4639*
Power Company of Wyoming	0	3000	0	0	0	0	*3000*
Portland General Electric	450	700	0	0	0	0	*1150*
TransWest Express	325	2900	0	0	0	0	*3225*
TransCanada	0	3000	0	0	0	0	*3000*
TOTAL	*3539*	*13101*	*40*	*488*	*675*	*2295*	*20138*

Table 3-3: Resource Additions Identified in 2012 Q1 Data Submittals

Contributing Utility	*Natural Gas*	*Wind*	*Solar*	*Biomass*	*Oil*	*Geo-thermal*	*Hydro-electric*	*Coal*	*Market*	*TOTAL*
Avista		*100*								*100*
Black Hills Energy	55									*55*
Idaho Power	300	201	20	43		52	49		470	*1135*
NorthWestern Energy	46	709					23			*778*
PacifiCorp	1627	1240	17	92	47	65	10	20	961	*4079*
Power Company of Wyoming		3000								*3000*
Portland General Electric	650	1301								*1951*
TOTAL	*2678*	*6551*	*37*	*135*	*47*	*117*	*82*	*20*	*1431*	*11098*

3. Transmission

A number of transmission projects were submitted in response to the first-quarter data request. Table 3-4 below summarizes those transmission projects. The table also denotes if a transmission project was submitted in the previous biennial cycle or if it was included in the Common Case Transmission Assumptions (CCTA) by Transmission Expansion Planning Policy Committee (TEPPC), or both. Absent from the 2012 data submittal are the Grasslands Renewable Energy project and the TransCanada project.

Table 3-4: Transmission Projects Identified in 2012 Q1 Data Submittal

Utility	Voltage	Project
Black Hills	230 kV	Teckla-Osage-Lange [WY]
Idaho Power Co.	500 kV	Boardman-Hemingway [ID-OR]*,†
	500 kV	Gateway West (with PacifiCorp) [WY-ID]*,†
NorthWestern Energy	500 kV	MSTI Project [MT-ID]*
	500 kV	Montana Intertie (Path 8) Upgrade [MT-WA]*,†
	230 kV	AMPS line (Path 18) Upgrade [MT-ID]*
	230 kV	MSTI Collector (up to 5 segments) [MT]*
PacifiCorp	500 kV	Gateway Central [ID-UT]*,†
	345 kV	Gateway Central – Sigurd to Red Butte [UT] *,†
	500 kV	Gateway South [WY-UT]*,†
	500 kV	Gateway West (with Idaho Power) [WY-ID]*,†
	500 kV	Hemingway-Captain Jack [ID-OR]*
	230 kV	Walla Walla-McNary [WA-OR]*,†
Portland General Electric	500 kV	Cascade Crossing (Boardman-Salem) [OR]*,†
	230 kV	Horizon-Keeler [OR]*
	230 kV	Blue Lake-Gresham [OR]
	230 kV	Pearl-Sherwood [OR]
TransWest Express	600 kV	DC line [WY-NV]*
Facilities from Last Cycle not submitted in current cycle:		
Grasslands Renewable	230 kV	Collector System [MT]
	500 kV	DC line, Colstrip to Bismarck {MT-ND]
TransCanada	500 kV	Chinook Project (AC+DC) [MT-ID-NV]
	500 kV	Zephyr Project (AC+DC) [WY-ID-NV]

* indicates that this facility was submitted in the last biennial cycle
† indicates that this project was included in the CCTA

4. First Quarter Data Submittal Comparison Conclusions:

The comparison tables show that, in this biennial cycle, the total 10-year load forecast (for the balancing authorities that submitted load data during both biennial cycles) has actually decreased by 216 MW from the prior cycle. However, the amount of new resources submitted in the current cycle is down significantly. Of the total, 3,000 MW was double-counted in the last cycle and 3,000 MW from the TransCanada project was not submitted this cycle. Also, NorthWestern Energy reduced its latest resource forecast by 2,647 MW to represent only committed projects. Another 350 MW of resource was canceled with the Grasslands Renewable Energy project. Finally, Basin Electric's coal plant (385 MW) submitted last cycle is now in service.

The NTTG transmission providers' current 10-year load and resource forecast has changed significantly from the prior cycle. This change prompted NTTG to assess future transmission requirements. During the study plan development phase, members of the NTTG TWG reviewed the TEPPC 2022 PC1 model to determine its suitability for the assessment. The members found it to adequately represent the NTTG first quarter load, resource and transmission submission. The TEPPC PC1 model is described in detail in the next section.

Development of the System Model

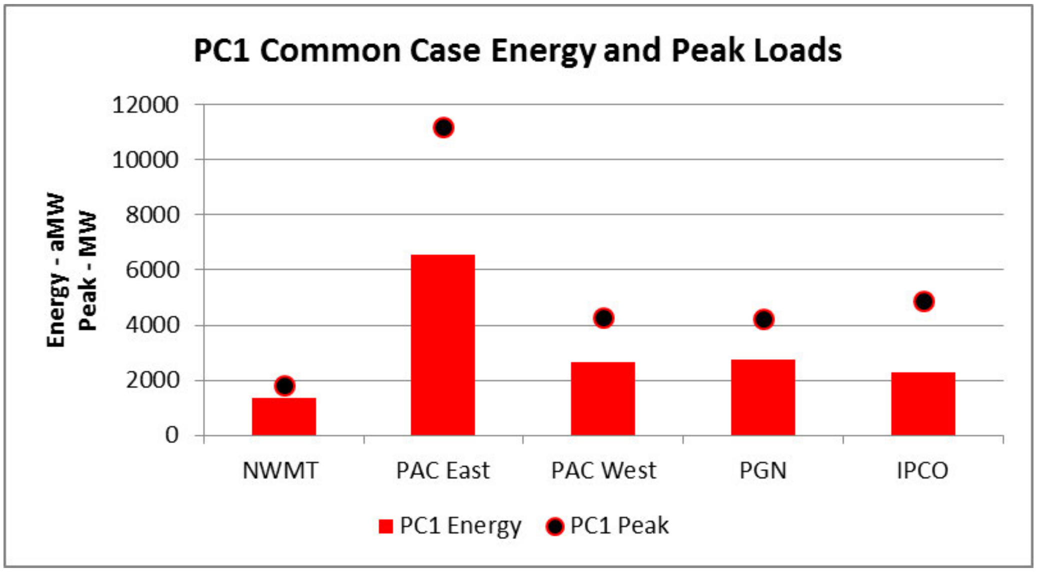
Northern Tier relies on the region-wide data collection and model-development work of TEPPC's Technical Advisory Subcommittee (TAS) for the chronological, security-constrained generator-commitment-and-dispatch model. The subcommittee's extensive efforts to acquire, review and agree on the many datasets needed in these studies not only saves considerable work by Northern Tier but also provides a widely accepted and well-vetted starting point. TEPPC in turn relies on the load-and-resource and transmission-network modeling of WECC's Planning Coordination Committee Loads and Resources Subcommittee (LRS) and Technical Studies Subcommittee (TSS). The TAS and TSS develop reference base cases used for subsequent WECC studies and for the use of WECC members in their own work. A flow chart showing the NTTG study case process is in Appendix A.

For security-constrained economic-commitment-and-dispatch modeling, TEPPC developed a production-cost case, known as the 2022 production-cost model (PC1). This case is based on the TEPPC 2020 power-flow base case, where the WECC transmission system has been modified to reflect known or highly likely future changes. These transmission additions comprise the CCTAs, discussed below. The power-flow cases used in the biennial study process were derived from the TEPPC 2022 PC1. From this model, five core cases were generated based on NTTG transmission providers' coincident: 1) peak summer load, 2) peak winter load, 3) maximum export and 4) maximum import/minimum export; and, additionally, 5) high California-Oregon Intertie (COI) plus Pacific DC Intertie (PDCI) southbound flow coincident with low NTTG export.

TEPPC 2022 PC1 Model

The TEPPC 2022 PC1 model is based on forecasted loads and resources for the year 2022 that were submitted to the LRS from all WECC balancing authorities. The balancing authorities supply monthly peak and energy forecasts. The forecasts are then dispersed into hourly load demands. The coincident WECC peak load for the 2022 Common Case is 173,161 MW and occurs on Thursday, July 21 at 16:00 hours. The table below details the average energy and peak loads in the PC1 case for each transmission provider within the NTTG footprint.

Figure 3-1: Loads in TEPPC PC1 Case



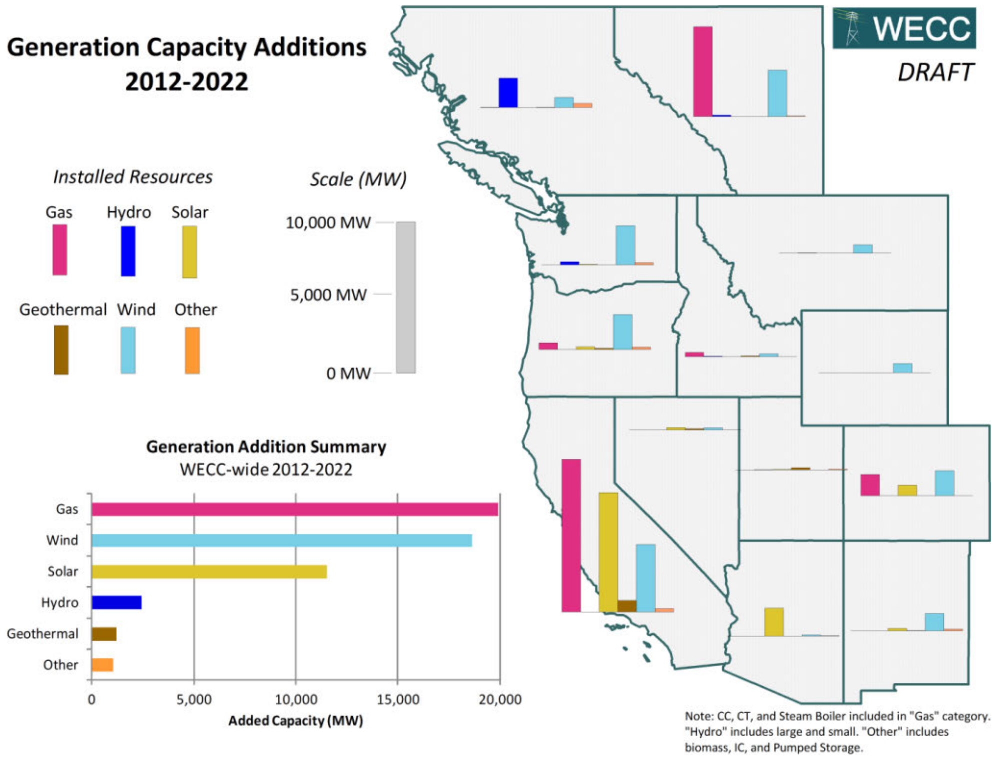
The PC1 case assumes that all state-enacted Renewable Portfolio Standards (RPS) and targets will be met in 2022. Table 3-5 details the RPS requirements by state or province. To meet these requirements, significant amounts of incremental renewable resources are added to the case. Based on the TEPPC data, this equates to an increase of 148% of existing renewable capacity.

Table 3-5: Renewable Standards for 2022

RPS Percentages in 2022 by State/Province					
State/Province	IOU	Public	Federal	Cooperative	Other
Alberta	Renewable resources, no requirement				
Arizona	12%		12%	12%	
British Columbia	Renewable resources, no requirement				
California	33%	33%	33%	33%	33%
Colorado	30%	10%		10%	
Idaho	Renewable resources, no requirement				
Montana	15%				
Nevada	23.5%				
New Mexico	20%			10%	
Texas-EPE	5%				
Utah	16%	16%		16%	
State	Utilities > 3% state load	Utilities < 3% and > 1.5%	Utilities < 1.5% state load		
Oregon	22%	8%	4%		
State	Utilities > 25k customers	Utilities < 25k customers			
Washington	15%				

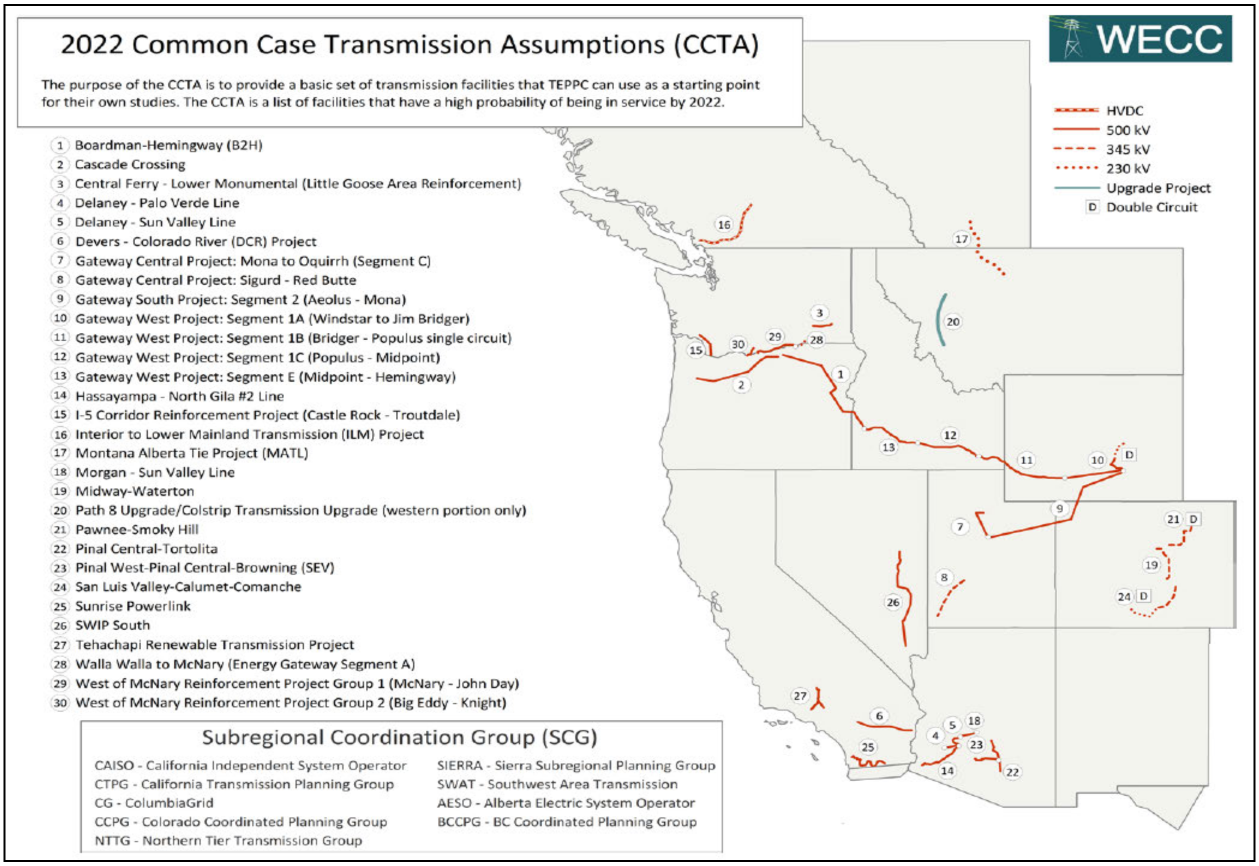
The generation additions in the PC1 case, detailed by state, can be found in Figure 3-2**Error! Reference source not found.**. The majority of generation resources added between 2012 and 2022 are gas, wind and solar. Most of the incremental gas resources are located in California and Alberta. It is worth noting that a large number of the gas resources in Alberta were implemented by TEPPC due to insufficient resources within that province.

Figure 3-2: Generation Capacity Additions by State



The model also includes transmission modifications to reflect the CCTAs, shown in Figure 3-3. Several of the transmission projects submitted in quarter 1 of the NTTG biennial process were included in the CCTA.

Figure 3-3: 2022 Common Case Transmission Assumptions (CCTA)



Selecting Hours for Power-Flow Analysis

The NTTG TWG examined the PC1 hourly loads and interface flows for the NTTG footprint. Examining hourly flows on the NTTG interface paths, the TWG reached consensus to study transmission congestion that would likely occur during peak loads and high-transfer hours. These hours represented times when local load-serving transmission could be stressed and when transmission used to export from or import into the NTTG footprint could be stressed. High-transfer hours were selected representing hours with maximum flows, resulting in paths at or near their limits. NTTG peak load and high-transfer hours selected were:

Peak Hours:

July 21 16:00 –Coincident NTTG summer peak load (Fig. 3-4)

Jan. 5 08:00 – Coincident NTTG winter peak load (Fig. 3-5)

High-Transfer Hours:

Nov. 6 10:00 – Maximum coincident NTTG footprint export (Fig. 3-6)

Sept. 8 17:00 – Minimum coincident NTTG footprint export (or maximum import) (Fig. 3-7)

June 6 12:00 – Highest COI/PDCI flow coincident with low NTTG footprint exports (Fig. 3-8)

Figures 3-4 through 3-8, below, show the load and transmission flows for specific months of the year 2022 and indicate the date and time for the selected core cases.

Figure 3-4: NTTG Summer Peak-Load Hour Selection

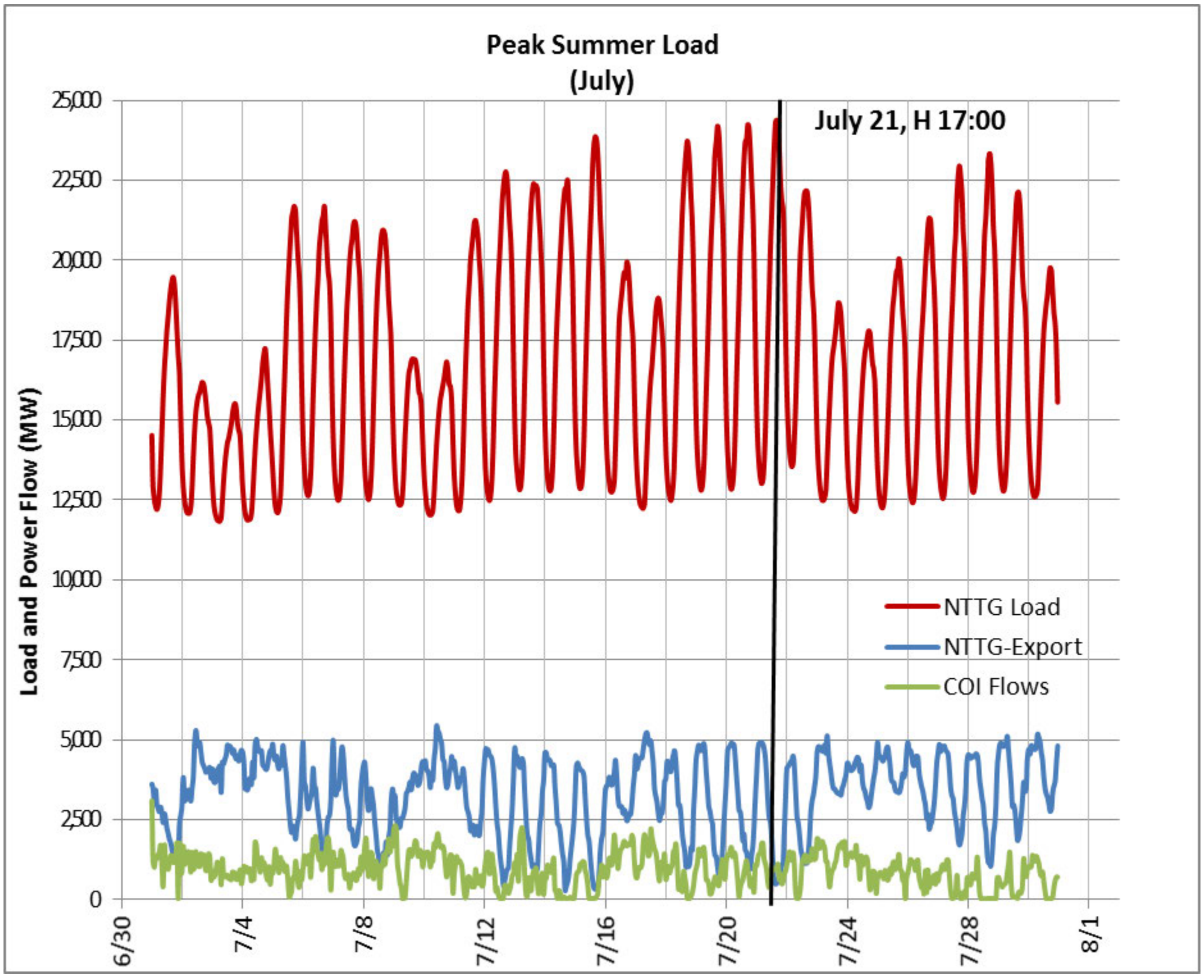


Figure 3-5: NTTG Winter Peak-Load Hour Selection

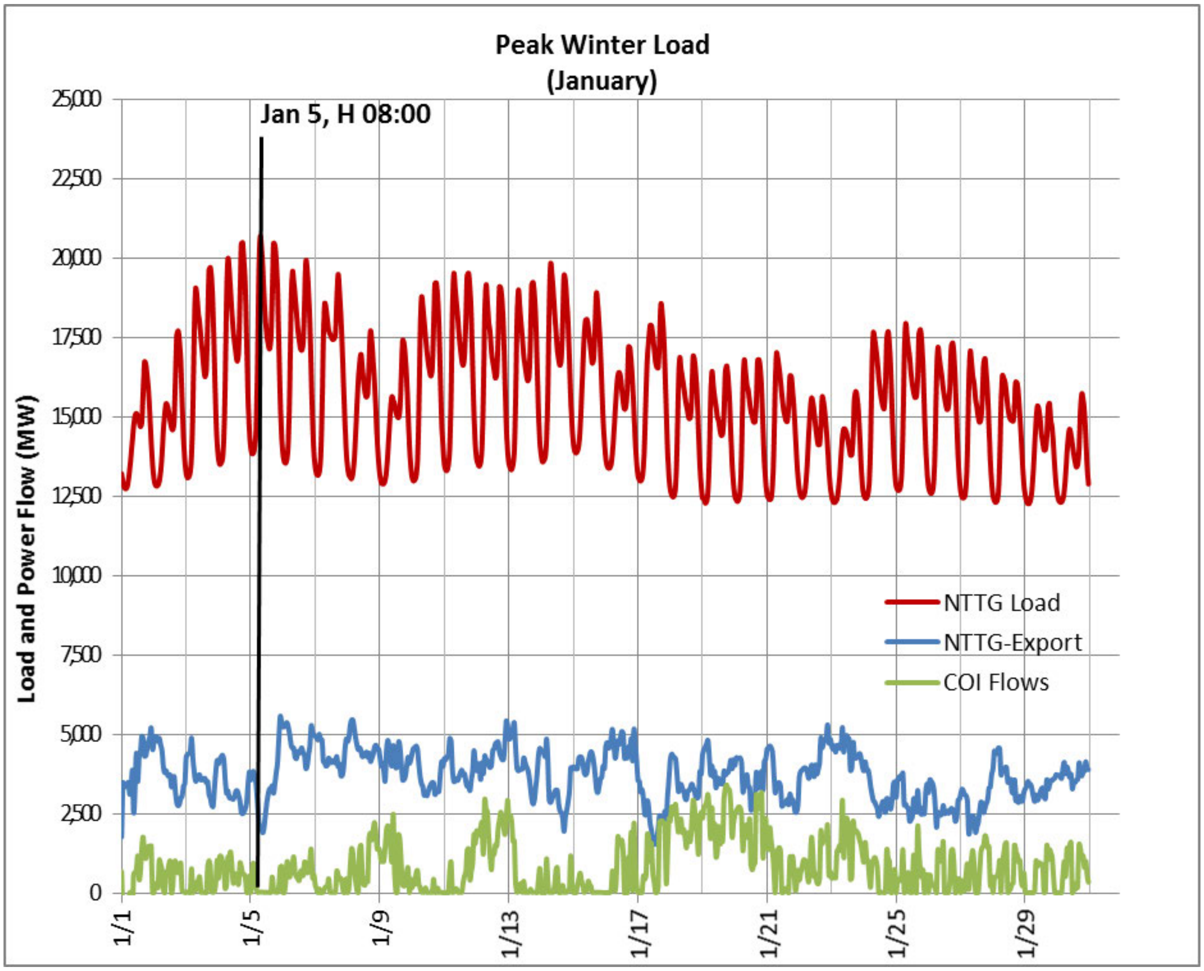


Figure 3-6: NTTG Maximum-Export Hour Selection

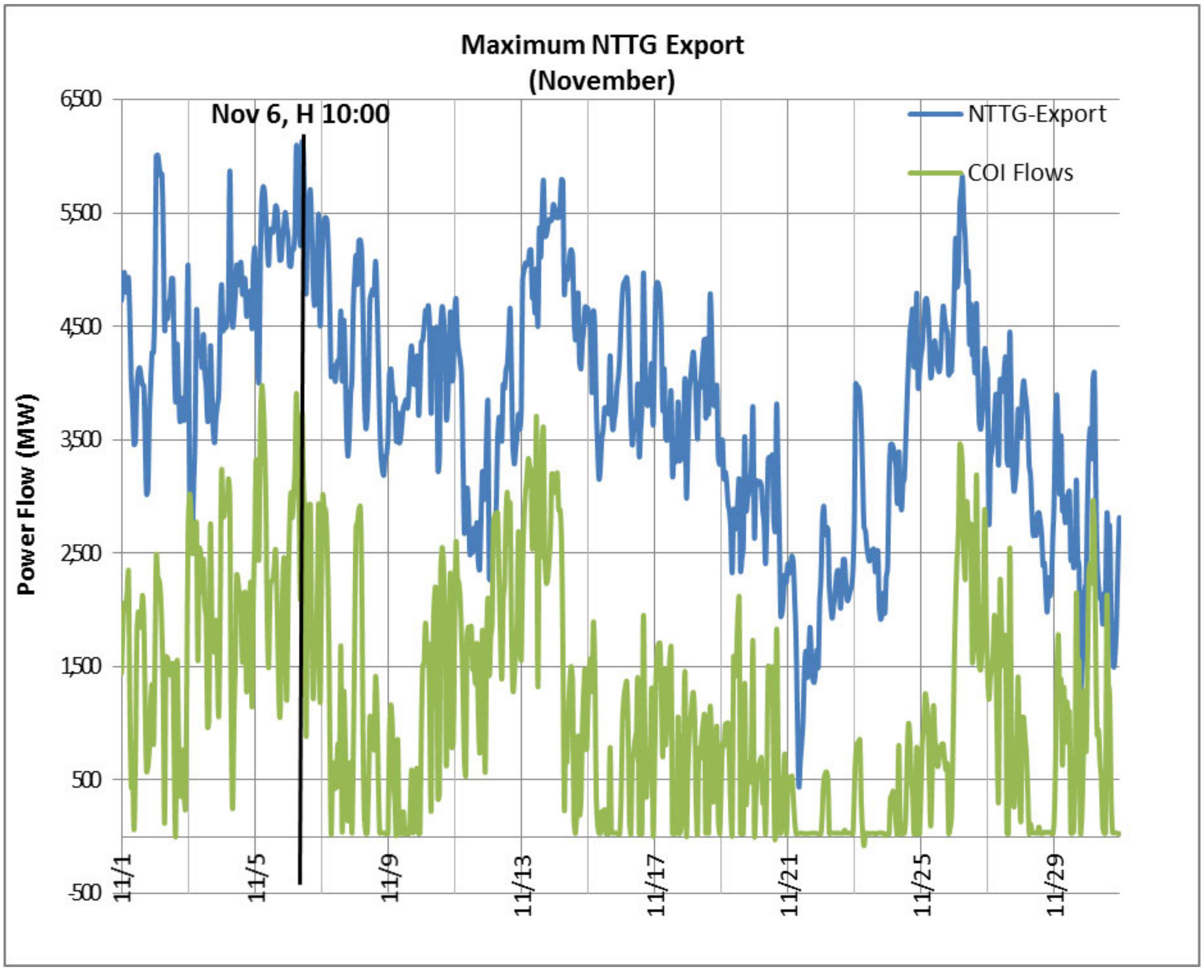


Figure 3-7: NTTG Maximum Import Hour Selection

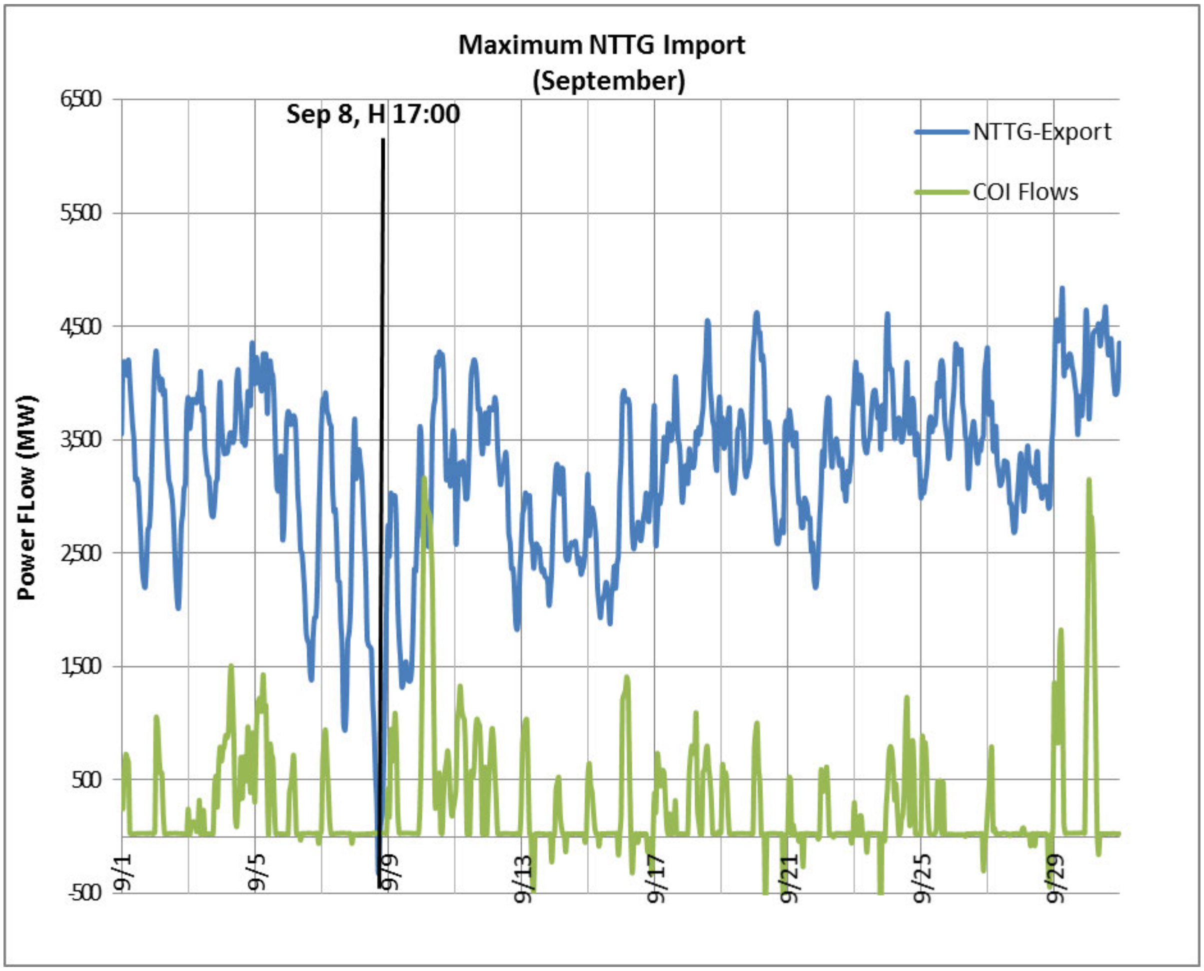
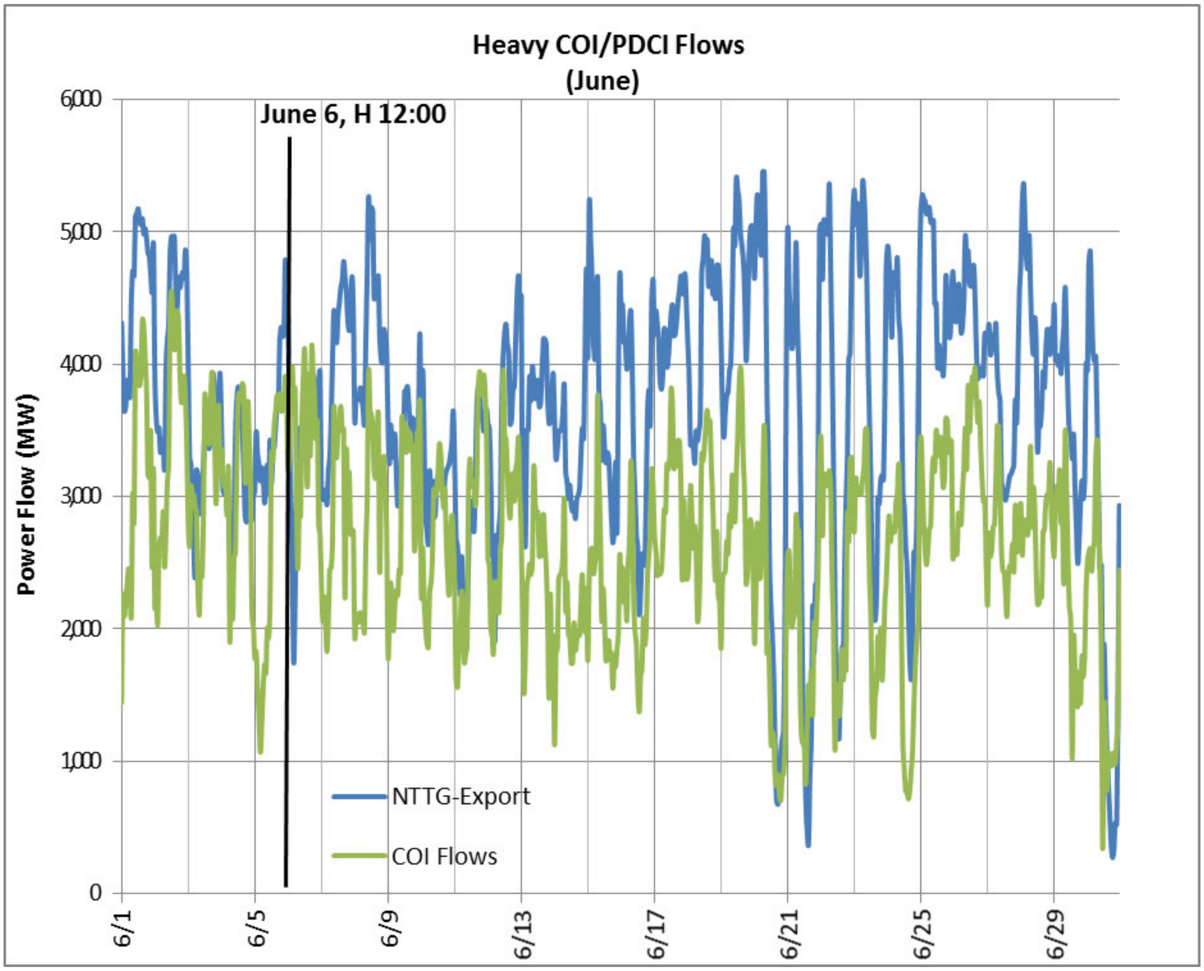


Figure 3-8: High COI/PDCI and low NTTG Export Hour Selection



Transferring Load and Resource Data and Solving Cases

Once the hours of interest were selected, the economic model was re-run and the data for those specific hours were exported to the power-flow program. Initially, data issues arose when trying to find a successful power-flow solution, resulting in specific network elements prohibiting a solution. Each issue was addressed until a successful solution was achieved.

Even after a successful solution was achieved, some generator units exceeded their reactive power limits. This was likely because the PC1 case didn't account for reactive power output requirements of generators. Additionally, because some generator output was altered as part of the process to find a successful power solution, some of the path flows differed from the PC1 data analysis. Therefore, further manipulation of the generation dispatch and loads was done to achieve the desired stressed conditions with generators operating within proper limits. Through these adjustments, NTTG assured that the cases represent real-time operating configurations and thus are more representative of the system than cases based on superficial loading and generation profiles. The cases were also minimally modified to ensure that there were no system normal overloads.

The Core Cases

Table 3-6 below presents the major path flows for each core case. Additional path flow details are provided in Appendix C. Note that a path generally consists of several lines, not just a single line. Flows shown in red text indicate an overload on the specified path.

Table 3-6: Path Flows in Core Cases

Path (Rating)	COI	PDCI	NORTH OF JOHN DAY	TOT2A	TOT2B	TOT2C	ID-NW	MT-NW	PATH C
	N-S 4800 MW	N-S 3220 MW	N-S 8400 MW	N-S 690 MW	N-S 865 MW	N-S 600 MW	E-W 3400 MW	E-W 2200 MW	N-S 1600 MW
Case	S-N -3675 MW	S-N -3220 MW	S-N N/A	S-N N/A	S-N -900 MW	S-N -580 MW	W-E -2250 MW	W-E -1350 MW	S-N -1250 MW
JUL21 16:00 – Summer	781	1235	6222	79	-148	1	-2238	484	1306
JAN5 8:00 - Winter	-2352	2600	3827	-594	-518	-8	-956	375	281
NOV6 10:00 – Export	4710	3440	4814	662	765	369	3031	2197	-905
SEP8 17:00 Import	-415	851	3544	363	21	8	-1505	158	281
JUN6 12:00 - COI	4478	2946	6234	453	328	-4	-1210	-215	1047

As seen in the table above, the PDCI flows in the Maximum Export Core Case exceed the indicated ratings. At the time the core cases were created and evaluated, the NTTG TWG assumed that planned upgrades would increase the PDCI path rating to 3,600 MW by 2022. Thus, the 3,440 MW flow level fell within the assumed future rating. However, the proposed upgrades were cancelled after the analysis was performed.

The Western Interconnection can be represented by balancing areas (e.g., areas where a transmission provider or several transmission providers balance the generation to the load) that are connected by paths. The flows across these paths (or tie-line flows) between balancing areas for each core case are shown in Figures 3-9 through 3-13. Megawatt values for the total area generation, total area load and total area interchange are shown on each diagram. Area losses can be determined from the diagram by taking the sum of the area total interchange and area total generation, then subtracting the total area load.

Figure 3-9: Tie-line Flows for Summer Peak-Load Core Case – July 21 16:00

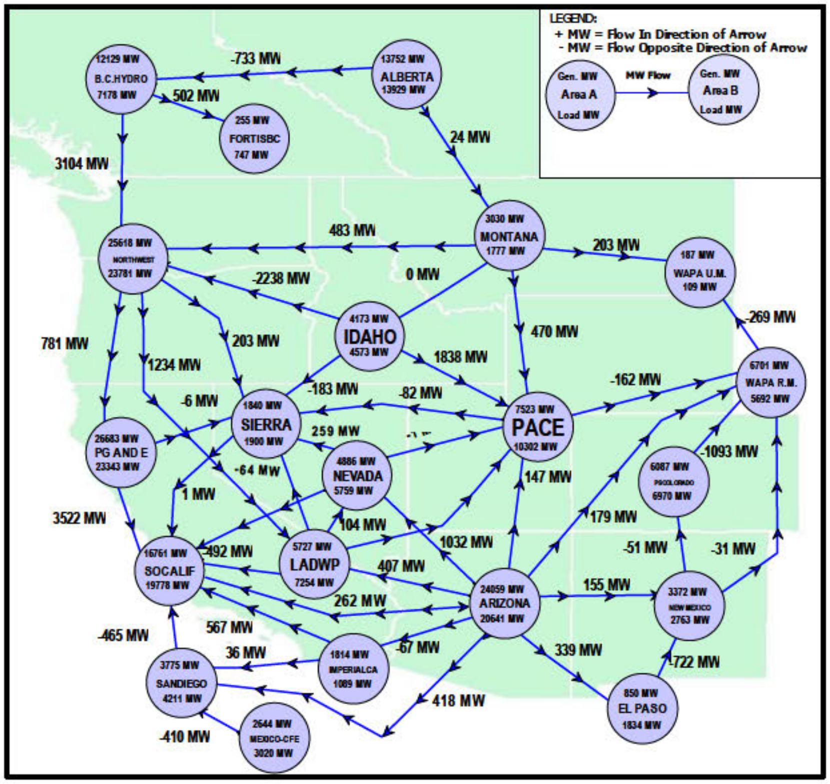


Figure 3-10: Tie-line Flows for Winter Peak-Load Core Case – Jan. 5 08:00

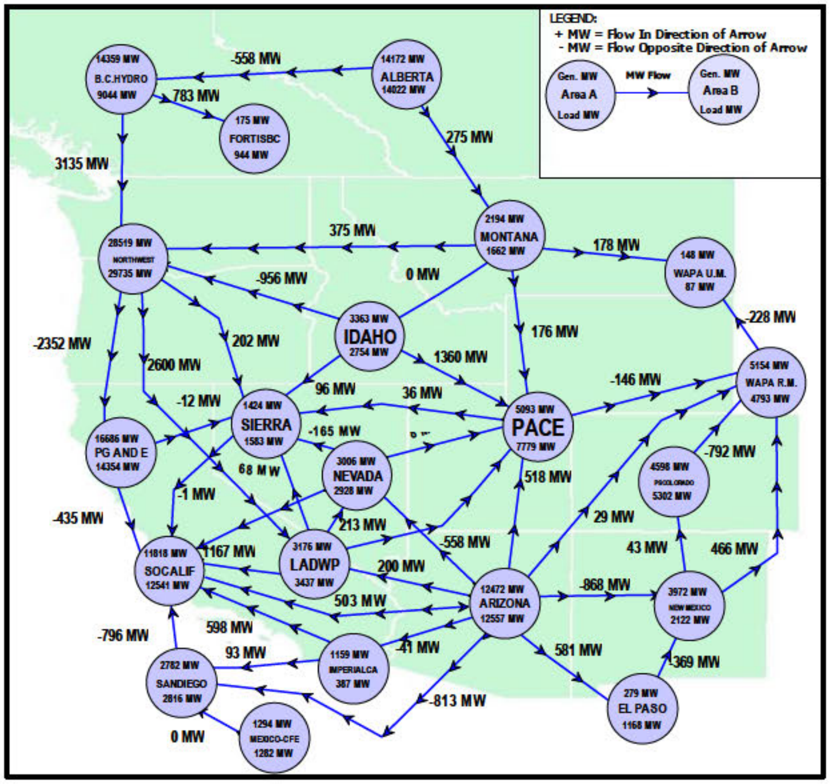


Figure 3-11: Tie-line Flows for Maximum Export Core Case – Nov. 6 10:00

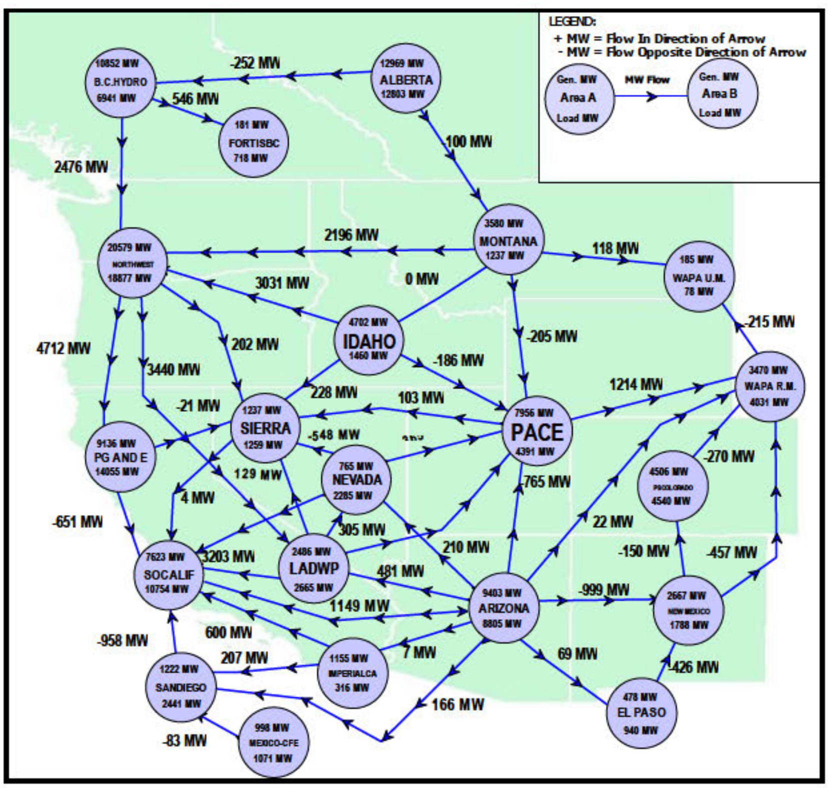


Figure 3-12: Tie-line Flows for Maximum Import Core Case – Sept. 8 17:00

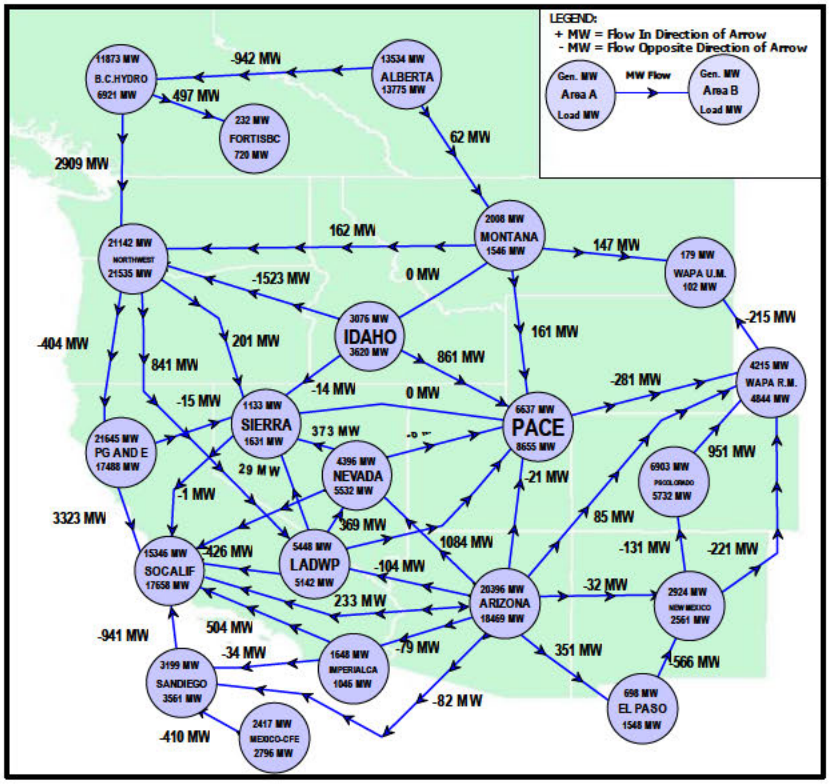
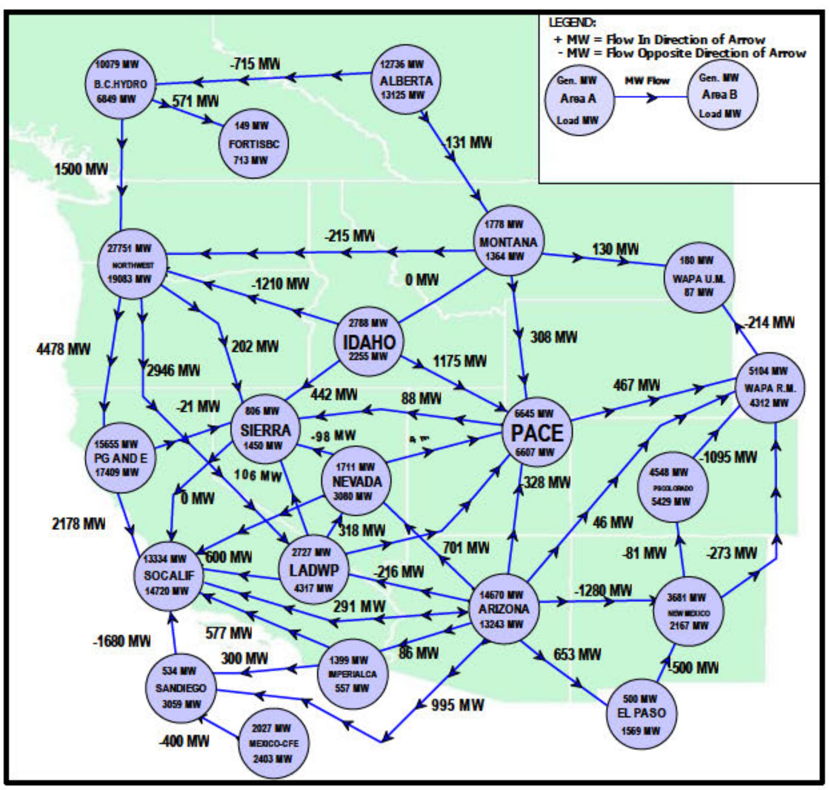


Figure 3-13: Tie-line Flows for COI/PDCI Core Case – June 6 12:00



Chapter 4 – NTTG Economic Studies

Obligation to Perform Economic Studies

FERC Order 890 mandates that transmission planning involve both reliability and economic considerations. Transmission providers fulfill the economic requirement by conducting economic planning studies, if requested by stakeholders. These studies evaluate transmission upgrades to reduce congestion or to integrate new resources and loads. In the process, the transmission provider must determine if the request is of local, subregional or regional scope. Those studies that are deemed regional in nature are forwarded to the regional transmission planning body. Economic study requests may be merged if the requests are similar in scope. NTTG performs up to two high-priority subregional studies, as determined by the Transmission Use Committee, each year of the two-year transmission planning process. Additional economic planning studies may be requested and funded by a stakeholder.

Economic Study Requests

NTTG received three economic study requests through NorthWestern Energy during the 2012-2013 planning process. Gaelectric requested a review of the transmission additions required to deliver up to 1,500 MW of renewable wind energy from Great Falls, Mont., to the California-Oregon border at the Malin, Ore., substation. They also requested the analysis of the amount of power that could be delivered without transmission additions. NorthWestern Energy requested studies of a new 500 kV line from Townsend, Mont., to Midpoint, Ida., (MSTI project) and a new 500 kV transmission-capacity upgrade from Colstrip through Townsend to Mid-Columbia in the Northwest. The requests were determined to be subregional in nature, and NTTG developed an Economic Study Plan.

Additionally, both submitters requested only power-flow reliability analysis be performed as opposed to security-constrained economic-dispatch analysis. The NTTG planning committee evaluated these requests and determined that all three requests could be combined as one cluster study. The combined study would determine if transmission additions were required to transport 1,500 MW of power from Great Falls to Malin, and to determine the how much power may be transported from Great Falls to Malin without transmission additions.

Study Procedure

NTTG analyzed four transmission configurations for the economic study. The analysis was an iterative process, with each configuration building on and incorporating prior additions. The additions were:

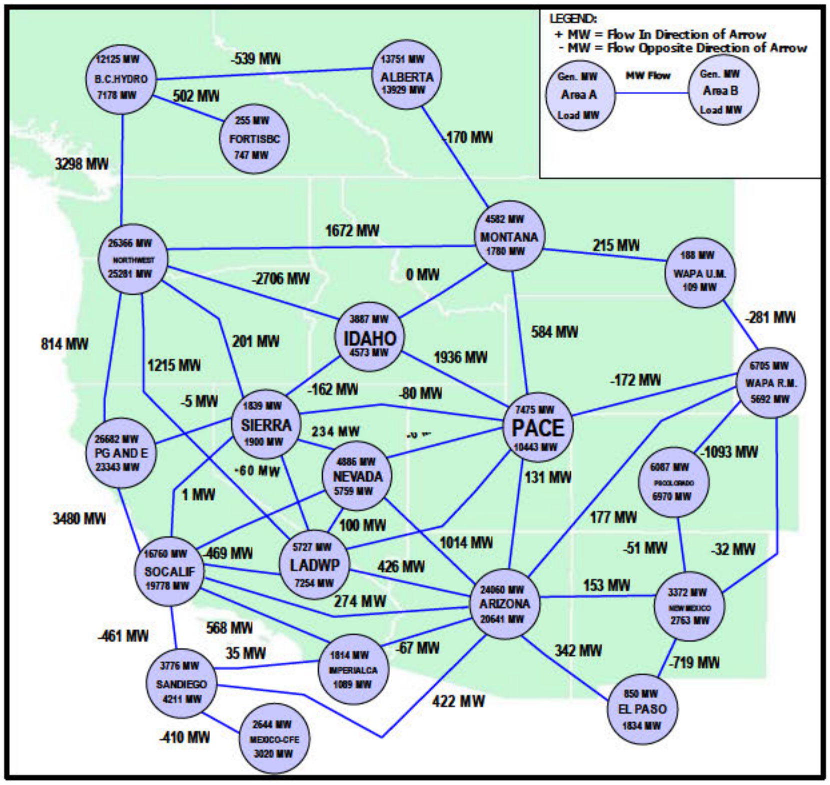
1. 1,500 MW of generation resource added to Great Falls and a 1,500 MW load in Malin
2. 500 kV line from Great Falls to Townsend to Midpoint with a new substation at Townsend
3. 500 kV line from Hemingway to Captain Jack
4. Second 500 kV line from Midpoint to Hemingway

As noted above, the combined study sought to identify what, if any, transmission additions were required for moving 1,500 MW of wind generation from Great Falls through Townsend to Malin. The first step was to study the NTTG Summer Peak-Load and Maximum Export cases without the requested transfer to determine if any transmission additions were required. This was done by performing a contingency analysis of each case. If any violations were identified in this analysis, they were investigated to resolve any incorrect information in the case or irrelevant busses, i.e., radial or sub-transmission busses. The next step was to model 1,500 MW of new generation in Great Falls along with a new 500 kV line from Great Falls to Townsend and a new substation at Townsend. A 1,500 MW load was also modeled at the Malin substation. The same contingencies were studied; any violations were identified and solutions recommended.

If the full 1,500 MW transfer produced unacceptable results, additional transmission facilities were added and evaluated in the following order: 1) a 500 kV line from Townsend to Midpoint, 2) a new 500 kV line from Hemingway to Captain Jack and 3) a second 500 kV line from Midpoint to Hemingway. See the Economic Study Report, Appendix D, which provides more detail about the modifications made to the core case. With each line addition, the cases were again tested to see if the reliability criteria were met for the contingency analysis. Any violations were identified and solutions recommended in order to obtain acceptable results.

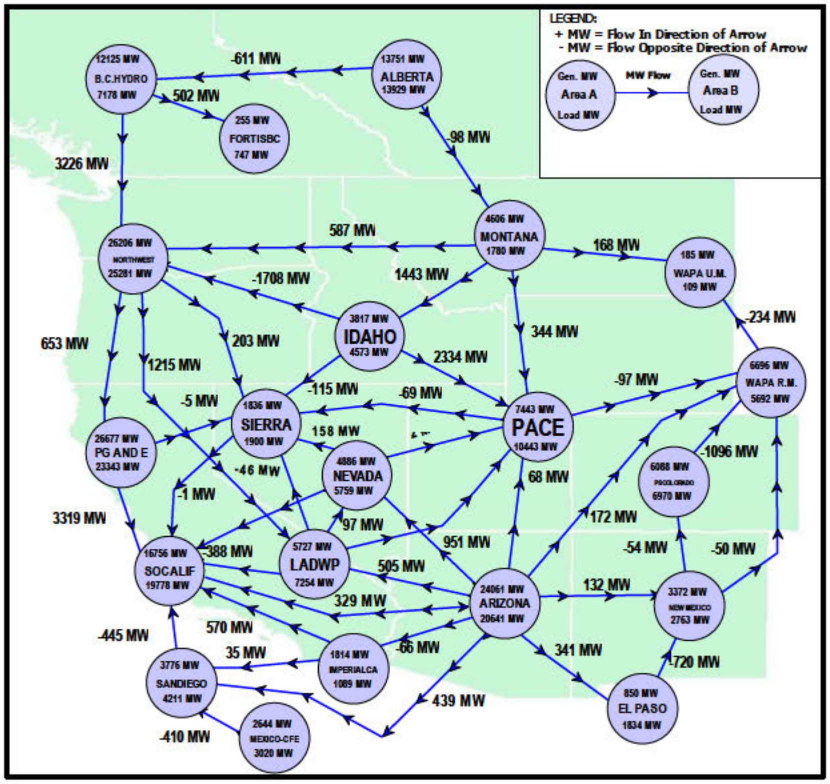
Figures 4-1 through 4-8 below display the tie-line flows between balancing areas for the Western Interconnection for each economic study case evaluated. Megawatt values for the total area generation, total area load and total area interchange are shown on each diagram.

Figure 4-1: Tie-line flows for Economic Study Summer Peak-Load Case 1



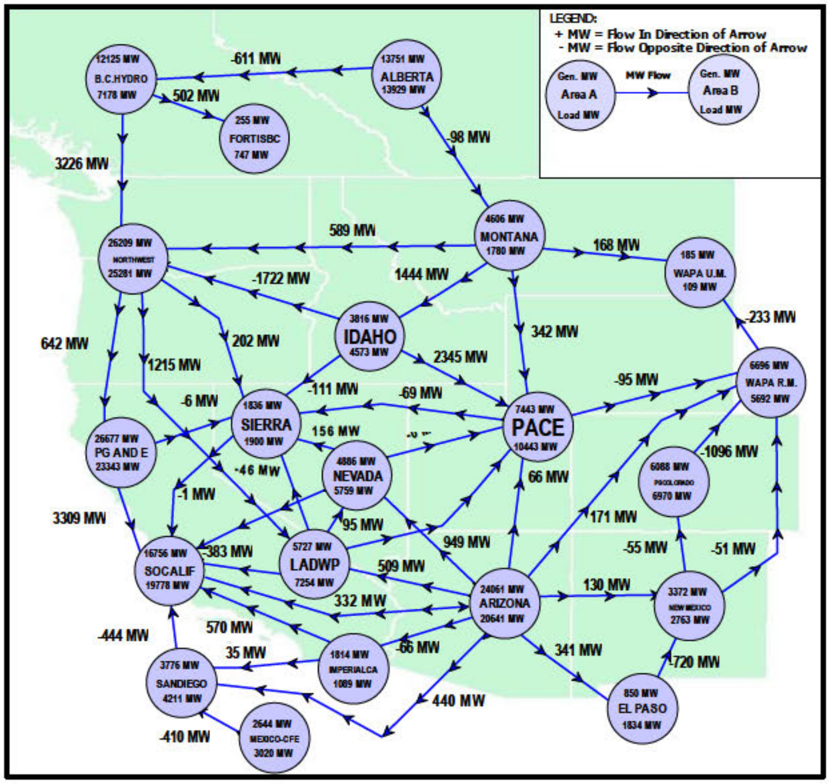
1,500 MW of generation added at Great Falls and 1,000 MW of load added at Malin

Figure 4-2: Tie-line flows for Economic Study Summer Peak Load Case 2



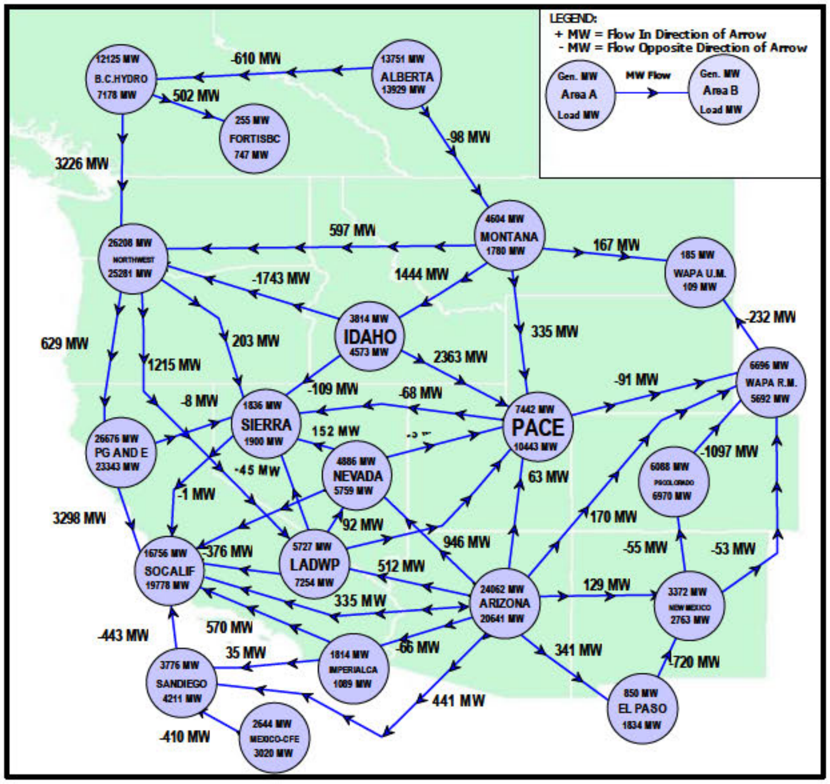
Generation added at Great Falls and load added at Malin with addition of 500 kV line from Townsend to Midpoint

Figure 4-3: Tie-line flows for Economic Study Summer Peak-Load Case 3



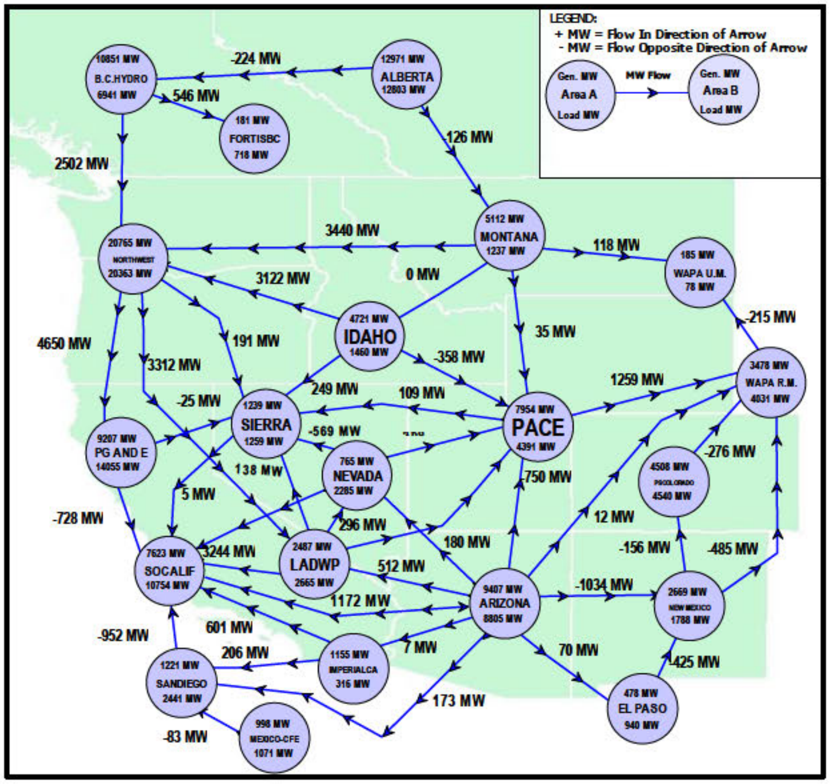
Generation added at Great Falls and load added at Malin with addition of 500 kV line from Townsend to Midpoint and a new 500 kV line from Hemingway to Captain Jack

Figure 4-4: Tie-line flows for Economic Study Summer Peak-Load Case 4



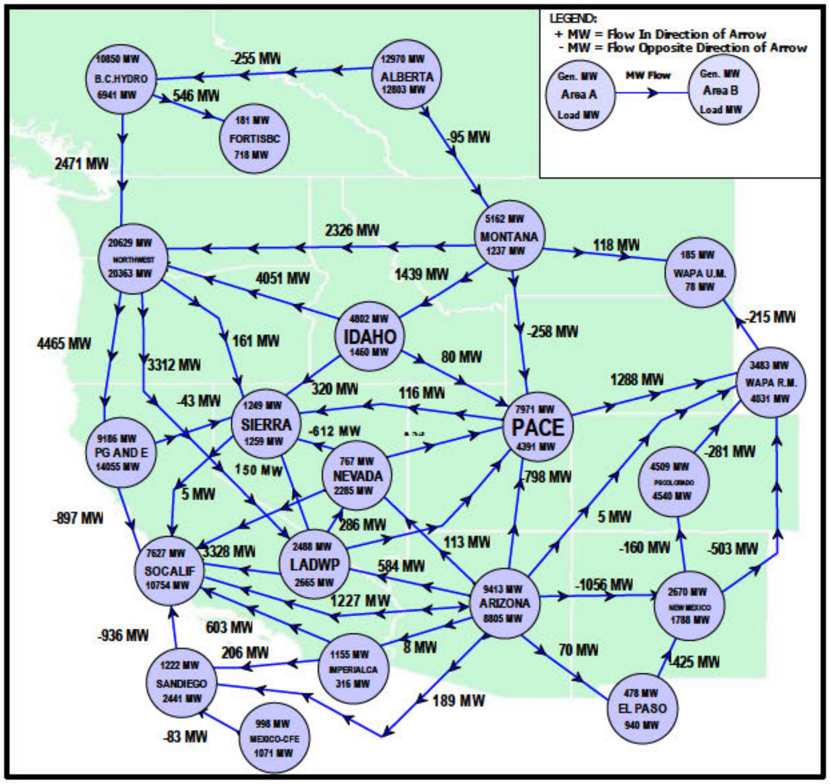
Generation added at Great Falls and load added at Malin with addition of 500 kV line from Townsend to Midpoint and a new 500 kV line from Hemingway to Captain Jack and a second 500 kV line from Midpoint to Hemingway

Figure 4-5: Tie-line flows for Economic Study Maximum Export Case 1



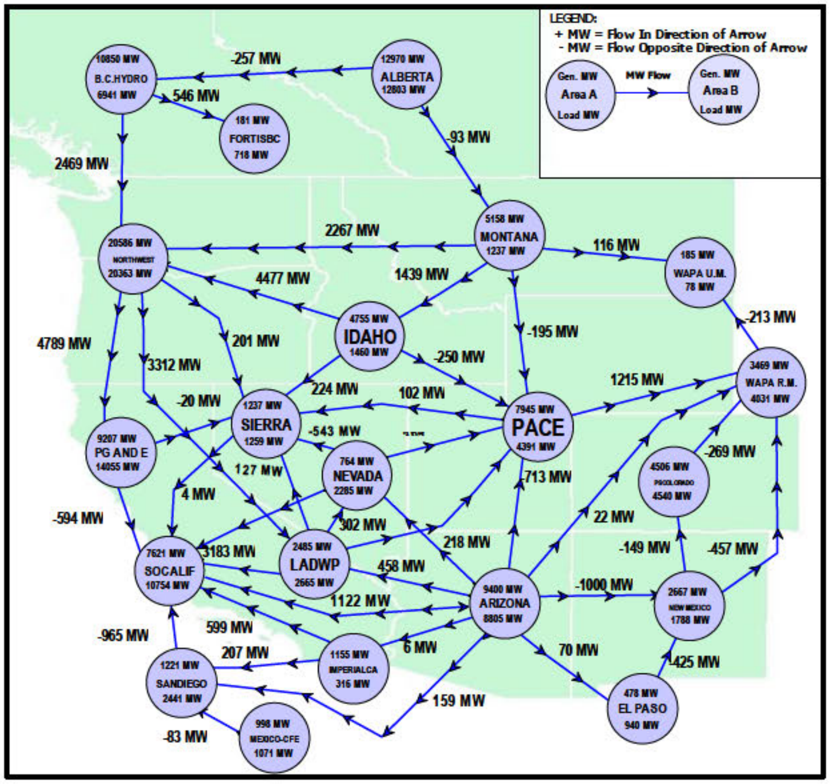
1,500 MW of generation added at Great Falls and 1,500 MW of load added at Malin

Figure 4-6: Tie-line flows for Economic Study Maximum Export Case 2



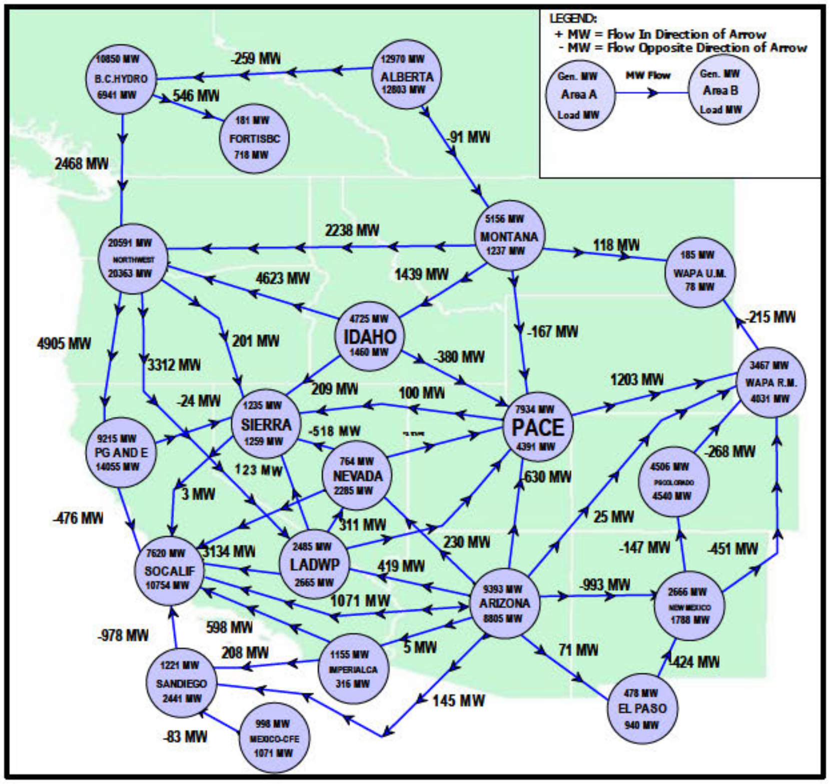
Generation added at Great Falls and load added at Malin with addition of 500 kV line from Townsend to Midpoint

Figure 4-7: Tie-line flows for Economic Study Maximum Export Case 3



Generation added at Great Falls and load added at Malin with addition of 500 kV line from Townsend to Midpoint and a new 500 kV line from Hemingway to Captain Jack

Figure 4-8: Tie-line flows for Economic Study Maximum Export Case 4



Generation added at Great Falls and load added at Malin with addition of 500 kV line from Townsend to Midpoint and a new 500 kV line from Hemingway to Captain Jack and a second 500 kV line from Midpoint to Hemingway

Study Results

In the Summer Peak-Load Case iterations, there were no N-0 thermal overloads or voltage-deviation issues. The only iteration with any N-1 contingency issues was Case 0, the case with an additional 1,500 MW of generation in Great Falls and an additional 1,500 MW load in Malin. See Appendix D for the complete contingency results of the Summer Peak-Load Case. The full 1,500 MW of requested transfer capability can be accommodated under heavy summer conditions with the addition of a new 500 kV line from Great Falls to Townsend to Midpoint.

In the Maximum Export Case iterations, only the core case without the 1,500 MW of additional transmission service and case 3, which includes all the proposed new transmission components, did not demonstrate N-0 voltage issues or thermal overloads. Cases 0, 1 and 2 all had both N-0 and N-1 voltage issues, thermal overloads or both. See Appendix D for the complete contingency results of the Maximum Export Case. The full 1,500 MW of requested transfer capability can be accommodated under maximum export conditions only with all the proposed additions to the transmission system. Up to 400 MW can be transferred with the single 500 kV line from Great Falls to Townsend to Midpoint.

Economic Study Conclusions

Summer Peak-Load Case: The results of the Summer Peak-Load Case show that the 1,500 MW transfer can be accommodated in the base case (N-0) without any transmission upgrades. The contingency analysis demonstrates that even with the CCTA additions, there are still a number of violations that need to be mitigated. Adding a 500 kV line from Townsend to Midpoint eliminates all of the significant violations in the Summer Peak-Load Case iterations. The study results do not show a substantial improvement by adding the Hemingway to Captain Jack or Midpoint to Hemingway 500 kV lines for the summer load study.

Maximum Export Case: The results of the Maximum Export Case show that in order to accommodate the 1,500 MW transfer from Great Falls to Malin in the base case, upgrades must be made to the Burns and Malin series capacitors. In addition to these upgrades, contingency analysis results show the need to also upgrade the Garrison series capacitors or add transmission improvements beyond the 30 CCTA projects that are already included. Results show that adding a 500 kV line from Townsend to Midpoint reduces some voltage issues and eliminates the Garrison series capacitor overload, but it overloads the Midpoint series capacitors in addition to the series capacitors at Burns and Malin. The study results do show a substantial improvement in adding the Hemingway to Captain Jack or Midpoint to Hemingway 500 kV lines, or both, for the Maximum Export Case study. However, even without these additional lines the results are acceptable with a new 500 kV line from Townsend to Midpoint and series capacitor upgrades at Burns, Malin and Midpoint.

The Maximum Export Case is the most limiting condition for establishing the maximum transfer utilizing a single 500 kV line from Great Falls to Townsend to Midpoint and no additional upgrades. The maximum transfer determined in the study, based on power-flow studies only, is 400 MW.

Several WECC-rated paths exceed the proposed future ratings in the export cases, namely Idaho-Northwest, Montana-Northwest, West of Hatwai and Hemingway-Summer Lake paths. Additional path-rating studies would be required to determine the scope of improvements required to operate these paths at the flows in the export base cases. Only power-flow studies—no stability studies—were conducted for this study request.

These study results are contingent on the loads, resources and transmission facilities used in the TEPPC 2022 production cost model. This includes 30 future transmission projects that constitute the CCTAs. Any changes to these assumptions, the generation dispatch or additional transmission would likely result in different transmission requirements.

Chapter 5 – The Null Case

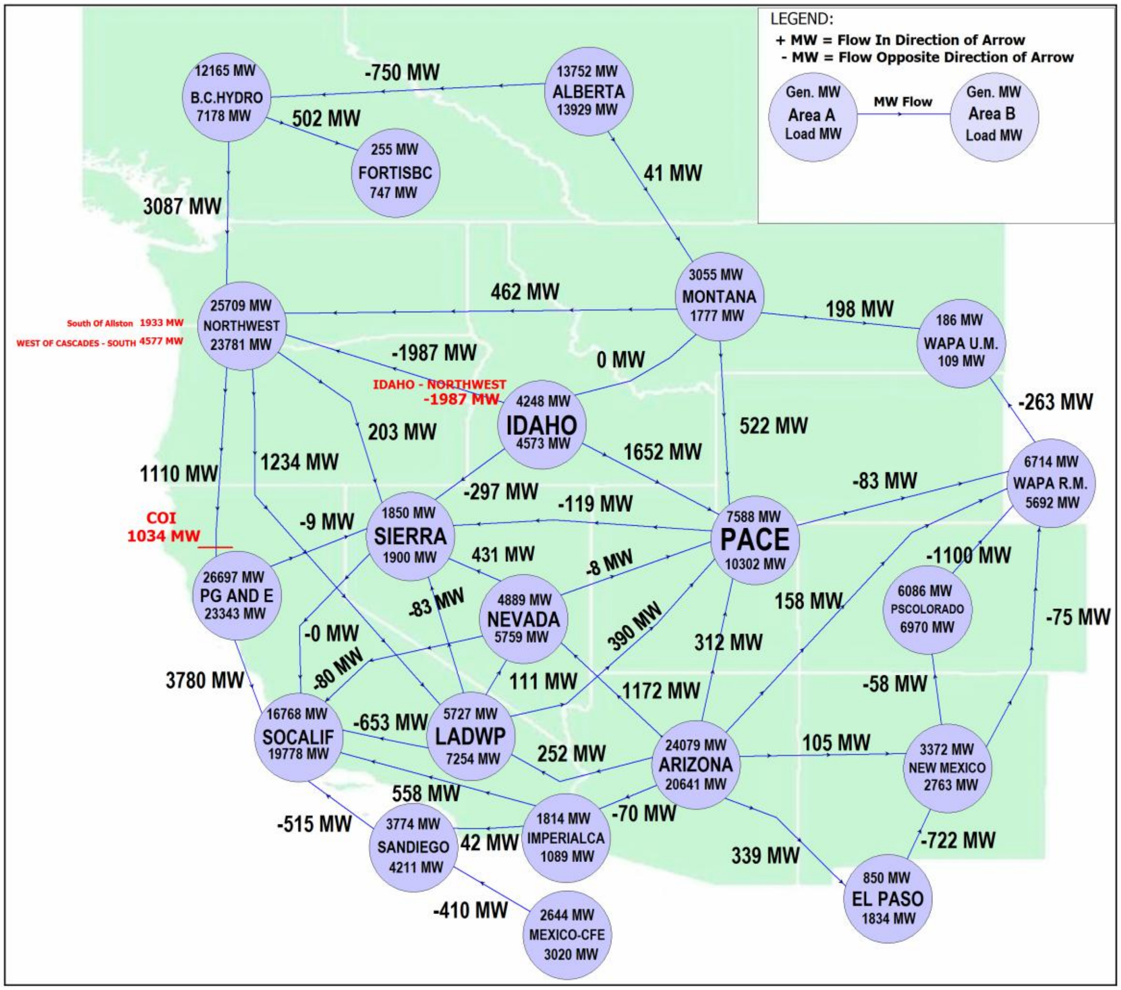
Introduction

The Null Case seeks to discover whether the near-term transmission system can meet the demands of the NTTG footprint year 2022 forecast load. In the 2010-2011 biennial planning cycle, NTTG adjusted a near-term WECC power-flow case to 2022 by increasing the NTTG loads to the submitted 10-year forecast. This was done without inclusion of the submitted 10-year network-resource additions. This produced a power-flow case with an unrealistic generation dispatch and resulted in many improbable transmission-facility violations. The NTTG planning committee decided not to repeat this process but instead to use the NTTG summer peak load case. Thus, the Null Case was derived from the July 21, 2022 @ 16:00 Hours Case. This case was modified to reflect the near-term transmission system by removing 23 of the 30 CCTA projects. The remaining seven of the 30 CCTA projects, listed in Table 5-1, are either currently in service or are expected to be in service within the planning cycle.

Table 5-1: Common Case Transmission Assumptions (CCTA) Projects Retained

Project	In Service	Under construction	Comments
04-Delany-Paloverde line		✓	WECC Portal, updated April 24, 2012, indicates line is under construction
16-Interior to Lower Mainland Project		✓	Project website indicates construction will be completed January 2015
17-Montana Alberta Tie Project (MATL)		✓	Construction to resume after right-of-way access permits are received
19-Midway to Waterton line	✓		Project completed and energized May 25, 2011
25-Sunrise Power Link	✓		Completed construction June 2012
29-West of McNary: McNary-John Day line	✓		Completed construction November 2011
30-West of McNary: Big Eddy-Knight line		✓	Began construction; schedule has been delayed. BPA estimates line will be energized winter 2014.

Figure 5-1: Null Case Area Tie-lines



Null Case Study Methodology

Other than the removal of all but seven CCTA projects, the transmission topology was not changed from the Summer Peak-Load Core Case. Power-flow analysis was performed on the Null Case to determine if any voltage or thermal overload violations existed during system normal (N-0 pre-disturbance analysis with all lines in service) and one transmission element out of service at a time (N-1 contingency analysis) as described in Chapter 2. Additionally, no transmission improvements were studied to resolve any deficiencies identified in the study process.

Power-Flow Analysis Results

The N-0 power-flow analysis on the Null Case identified five voltages below the 0.90 per unit threshold, 14 branch overloads and one path interface where the flow exceeded the path rating (Path 18-Montana-

Idaho). A high-level summary of overloads and voltage issues on major transmission elements under N-0 conditions is presented in Table 5-2. The detailed results regarding violations under N-0 conditions are shown in Appendix E.

Table 5-2: N-0 Performance Comparison between Summer Peak-Load Core Case and Null Case

Category	Summer Peak-Load Core Case *	Null Case
Branch Amp	5	14
Branch MVA	0	0
Bus Voltage High	0	0
Bus Voltage Low	0	8
* The branch overloads in the Summer Peak-Load Core Case were found to be acceptable.		

The N-1 contingency analysis resulted in many violations during outage conditions. Tables 5-2 and 5-3 compare the Null Case and NTTG Summer Peak-Load Core Case results. Two N-1 contingencies failed to solve to a stable operating point. The summary of these results is shown in Table 5-3. Detailed results for contingencies that reached maximum iterations and contingencies that failed to solve are located in Appendix E.

Table 5-3: N-1 Contingency Performance Comparison between Summer Peak-Load Core Case and Null Case

Category	Summer Peak-Load Core Case*	Null Case
Branch Amp	0	70
Branch MVA	5	18
Bus Voltage High	0	12
Bus Voltage High Deviation	0	30
Bus Voltage Low	0	23†
Bus Voltage Low Deviation	0	0- Unacceptable‡
* The branch overloads in the Summer Peak-Load Core Case were found to be acceptable		
† All Voltages are below 0.9 pu		
‡ Voltage Deviations >5% and falls below 0.9 pu		

The N-1 outage analysis showed thermal overload violations on several transmission elements. Five contingencies had overload violations greater than 125% under outage conditions, 15 exceeded 110% and the other overloads were under 110%. Detailed results of transmission elements that observed overloads greater than 125% are shown in Appendix E. Three different thermal overloads (>100%) were observed in the Northwest area, eight overloads (>100%) were observed in the PacifiCorp East area, six overloads (> 100%) were observed in the Idaho area and three overloads (>100%) were observed in the WAPA Rocky Mountain area. Voltage at some busses fell below 0.90 per unit under certain outage conditions. Detailed descriptions of the thermal overloads and voltage issues observed for different outage conditions are shown in Appendix E.

Null Case Conclusion

The Null Case study demonstrates that the transmission system will be subjected to overloads beyond NERC and WECC reliability criteria. The Null Case power-flow analysis discovered overloads on transmission elements under normal operating conditions and for N-1 contingencies. Voltage criteria violations were also observed on several 500 kV busses and at other voltage levels under certain N-1 outage conditions. Thus, the Null Case reveals that the existing NTTG transmission system is inadequate to fulfill the transmission requirements to reliably serve the 2022 forecast loads and resources. Additional transmission is required to reliably meet future needs.

Chapter 6 – The Core Cases

Introduction

As described in Chapter 3, the NTTG TWG created a set of five core cases to analyze future system reliability under five different stressed conditions within the NTTG footprint. The committee selected peak-load hours as well as high-import and high-export conditions that produced those stress points as described in Chapter 3.

Power-Flow Analysis

The power-flow software, PowerWorld Simulator, was used to perform power-flow analysis on the five core cases. See Section 2 for more detail about the analysis process. The violation tables for all five core cases can be found in Appendix F.

Summer Peak-Load Case – July 21 16:00 Hours

This case represents the maximum NTTG coincident summer peak-load condition of 23,846 MW. The net NTTG export is minimal (1,454 MW) in the case since most of the NTTG internal generation is utilized to serve the peak NTTG load. As stated previously, this case, along with all other core cases, contains all 30 of the CCTA projects.

The pre-disturbance (N-0) screening resulted in five overloaded elements. One local-area 46 kV line was within the NTTG footprint while the four other elements were outside the NTTG footprint. All elements were 161 kV or below and determined to be acceptable as a result of the generator dispatch or case stressing, or both, on local-area systems. Contingency analysis resulted in a total of five thermal overloads; however, the five overloads were on the same transformer for five different contingencies. The overloads occurred on a 161kV/100kV transformer in Montana that was loaded to 98% pre-contingency. The NTTG TWG determined that the overload condition was acceptable for NTTG purposes because the overload was a previously identified local planning issue.

Four voltage-deviation issues resulted from the contingency analysis. In all four instances, the post-disturbance voltage remained within the acceptable range. Therefore, each voltage deviation issue was determined to be acceptable.

Winter Peak-Load Case – Jan. 5 8:00 Hours

This case represents the NTTG winter peak-load condition of 20,280 MW. Similar to the summer peak case, most of the NTTG generation is used for serving NTTG loads, with only 731 MW of exports.

The pre-disturbance (N-0) screening resulted in no overloaded elements and no voltage issues. The N-1 contingency analysis resulted in zero thermal overloads and 14 voltage-deviation issues. Each voltage deviation produced a post-disturbance voltage within the acceptable range. Therefore, each voltage-deviation issue was determined to be acceptable.

Maximum Export Case – Nov. 6 10:00 Hours

This case represents a heavy NTTG export condition with NTTG exports totaling 10,077 MW. The heavy export condition corresponds with a low NTTG load (11,970 MW) and high internal generation.

The pre-disturbance (N-0) screening resulted in four elements with thermal overloads; however, all were deemed to be acceptable for study purposes. Three of the overloads were within the NTTG footprint, with each overload resulting from generation modeling in the PC1 base case. The overload outside of the NTTG footprint was a load-serving branch; it had no impact on the NTTG study. Two busses in the case exceeded 1.1 per unit voltage. The two busses were 500 kV busses in Arizona. Since the busses were outside of the NTTG footprint, they were each deemed to be acceptable for NTTG study purposes.

Contingency analysis resulted in four thermal overloads within the NTTG footprint. Upon further review, each overload was determined to be acceptable.

A total of 40 voltage deviation issues resulted from the contingency analysis. The 40 voltage-deviation issues all resulted in a post-disturbance voltage within an acceptable range.

Maximum Import Case – Sept. 8 17:00 Hours

This case represents the minimum coincident export condition from the NTTG footprint, also referred to as the Maximum Import Core Case. The net NTTG import was 81 MW. The net NTTG load is fairly high (20,086 MW), with reduced internal generation, thus producing an import condition.

The pre-disturbance (N-0) screening resulted in two slight overloads (both less than 0.5%), both outside of the NTTG footprint. Each overload was determined to be acceptable for NTTG study purposes. Nine busses had voltages below 0.9 per unit, but each of the low-voltage busses was within a 69 kV local-area network. Since the low voltages were isolated to a 69 kV local area network, the voltages were deemed acceptable for NTTG study purposes.

The N-1 contingency analysis resulted in zero thermal overloads and two voltage-deviation issues. The two reported voltage deviations resulted in a post-disturbance voltage within the acceptable range, and therefore, each issue was determined to be acceptable.

COI/PDCI Case – June 6 12:00 Hours

This case was studied to look at a relatively low NTTG footprint net-export coincident with fairly heavy flow conditions on the Pacific Intertie lines. Flows were 4,478 MW on COI and 2,946 MW on PDCI lines, while NTTG exports totaled 3,290 MW.

The pre-disturbance (N-0) screening resulted in no overloaded elements and no voltage issues.

The N-1 contingency analysis resulted in zero thermal overloads and 29 voltage-deviation issues. Each of the 29 reported voltage-deviation issues resulted in a post-disturbance voltage within the acceptable range, and therefore, each issue was determined to be acceptable.

Core Case Conclusion

The results of the five core cases demonstrate that, with the CCTA projects added, there is adequate transmission to accommodate the projected 2022 loads and resources. No additional transmission facilities are needed in this time frame based on the analysis of the five stressed conditions represented in the core cases

Chapter 7 – The Scenario Case – TransWest Express

Introduction

In the first quarter of the biennial planning cycle, Power Company of Wyoming (PCW) submitted data for a new 3,000 MW wind resource in southwest Wyoming. TransWest Express (TWE) also submitted data for a proposed 600 kV extra-high-voltage direct-current electric-transmission system with 3,000 MW capacity. The planned 725-mile route begins in south-central Wyoming, extends through northwestern Colorado and central Utah and ends near Las Vegas as shown in Figure 7-1. The TWE project requested that the PCW generation and DC line be studied as a scenario case. The Planning Committee agreed to study the impact of these new facilities as a scenario case in the study process.

Figure 7-1: TransWest Express Transmission Project

The dotted line indicates the approximate route of the proposed transmission line project.

The power-flow data submitted to the TWG consisted of 3,120 MW of new generation at the sending end of the DC line in southwest Wyoming to provide for losses on the DC line, while still delivering 3,000 MW to Nevada. TWE also proposed limiting the DC line flow to 2,650 MW at the Nevada end during periods of high flow on the COI in order to resolve contingency violations during higher flows.

The Scenario Case

NTTG modified the Maximum Export Core Case by adding a new wind resource in Wyoming and delivering the power to Las Vegas via a new direct current (DC) bipole transmission line. The TransWest scenario was represented with both 3,000 and 2,650 MW flow levels on the DC line delivered to Las Vegas. Both scenarios were developed from the NTTG Maximum Export Core Case (Nov. 6 10:00).

The TWG incorporated the following TransWest Express recommendations regarding the scenario to be studied:

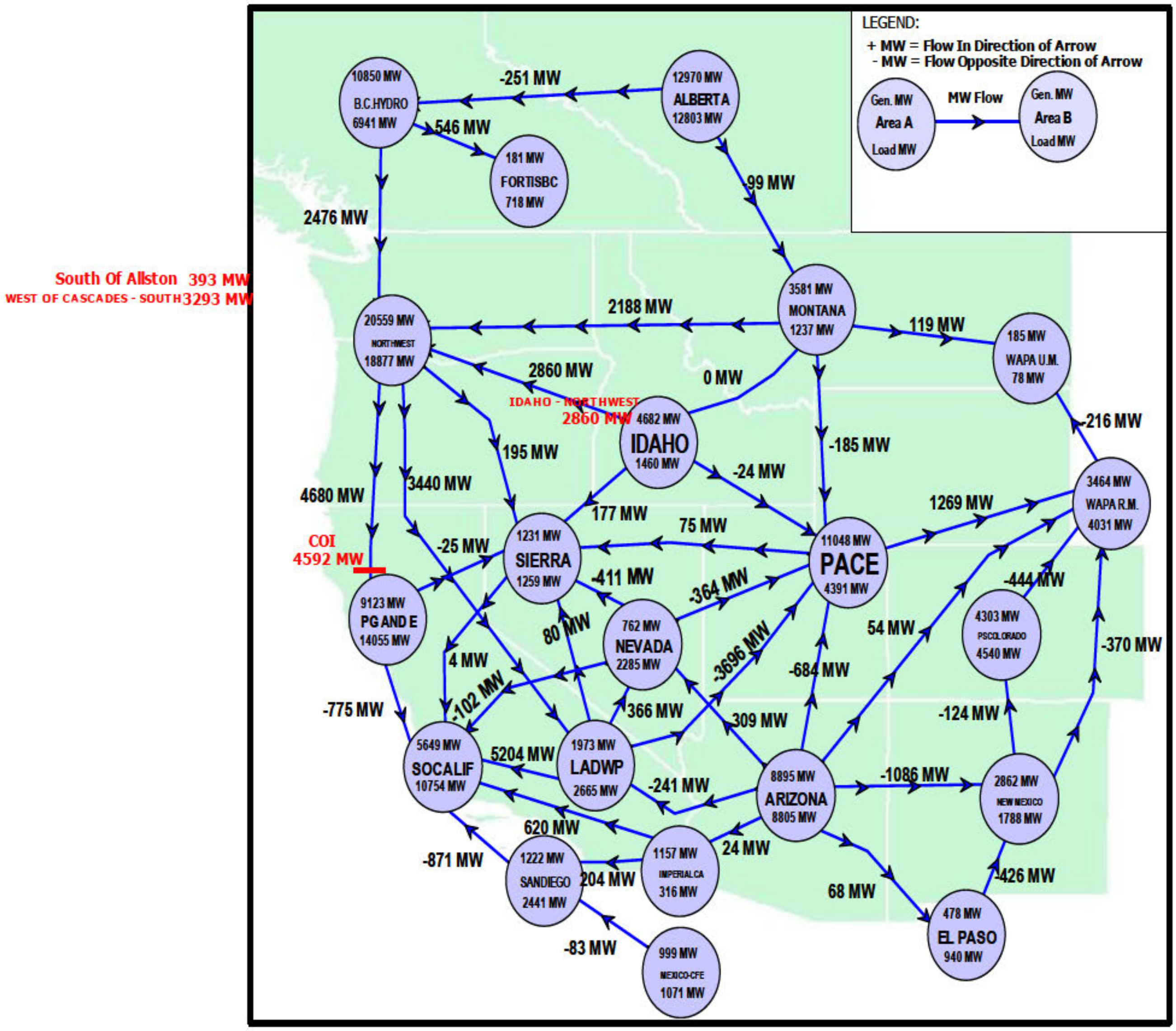
- Analyze the NTTG Maximum Export Core Case
- Schedule 3,000 MW at the Las Vegas end of the TWE DC line
- Reduce generation 2,000, 500 and 500 MW in Southern California Edison, Los Angeles Department of Water Power and Arizona state, respectively, to receive the scheduled power
- Trip 50% of PCW generation for the bipole transmission line contingency
- If the COI flow is near its 4,800 MW rating, reduce the scheduled flow in 100 MW increments while maintaining PCW generation, tripping at 50% of the flow until the case solves

3,000 MW Delivered to Nevada

The TransWest Express full-capacity scenario modeled 3,000 MW at the receiving end of the DC line, with 3,120 MW of new wind generation in southwest Wyoming. Path flows on adjacent transmission paths included 4,661 MW on COI, 465 MW on TOT 2B1, 219 MW on TOT 2B2 and 364 MW on TOT 2C. The scenario modifications required some re-dispatch of generators throughout the interconnection. These changes, as well as the resulting interface changes for this scenario, are listed in Appendix G.

Study results showed no violations for the TransWest Express DC monopole outage. However, the DC bipole outage did not solve without remedial actions. Tripping 1,560 MW (half of the sending-end flow on the DC line) of Wyoming wind generation for the DC bipole outage still resulted in 11 violations. These violations were for branch overloads on the Red Butte-Harry Allen 345 kV line (113% of limit) and the Pinto phase shifters (102% of limit). There were also low voltages (<0.9 p.u.) at several busses in the Pinto area (PACE-owned substations). The post-transient Malin voltage dipped to 95.6% in this case, which likely would cause the FACRI RAS scheme to initiate. With the switching of reactive devices associated with FACRI, the number of violations for the DC bipole outage reduced to only three — the overload of the two Red Butte-Harry Allen line sections (105% of limit) and one low-voltage bus in the Pinto area.

Figure 7-2: Maximum Export TransWest Express Full Capacity Scenario



2,650 MW Delivered to Las Vegas

The TransWest Express reduced scenario modeled the TransWest Express project with 2,650 MW of flow on the receiving end of the DC line and with high COI flow. The NTTG Maximum Export Core Case was modified to represent this DC line flow with 4,670 MW on COI, 466 MW on TOT 2B1, 220 MW on TOT 2B2 and 369 MW on TOT 2C. This was done by increasing generation in Nevada by 350 MW and reducing the new Wyoming wind generation to 2,740 MW. The results of the DC bipole outage, without generator tripping, showed that the case did not solve, producing 46 violations, including overloading on the Red Butte-Harry Allen line (134% of limit) and the Pinto phase shifters (107% of limit). By tripping 1,370 MW of wind generation (equal to one-half of the sending-end DC line flow) the number of violations was reduced to only two – the two sections of the Red Butte-Harry Allen line (106% of limit). The Malin post-transient voltage dipped to 507 kV in this case, which would likely initiate the FACRI scheme. The results for the same contingency with generator tripping and with FACRI employed showed no violations.

Figure 7-3: Maximum Export TransWest Express Reduced Scenario

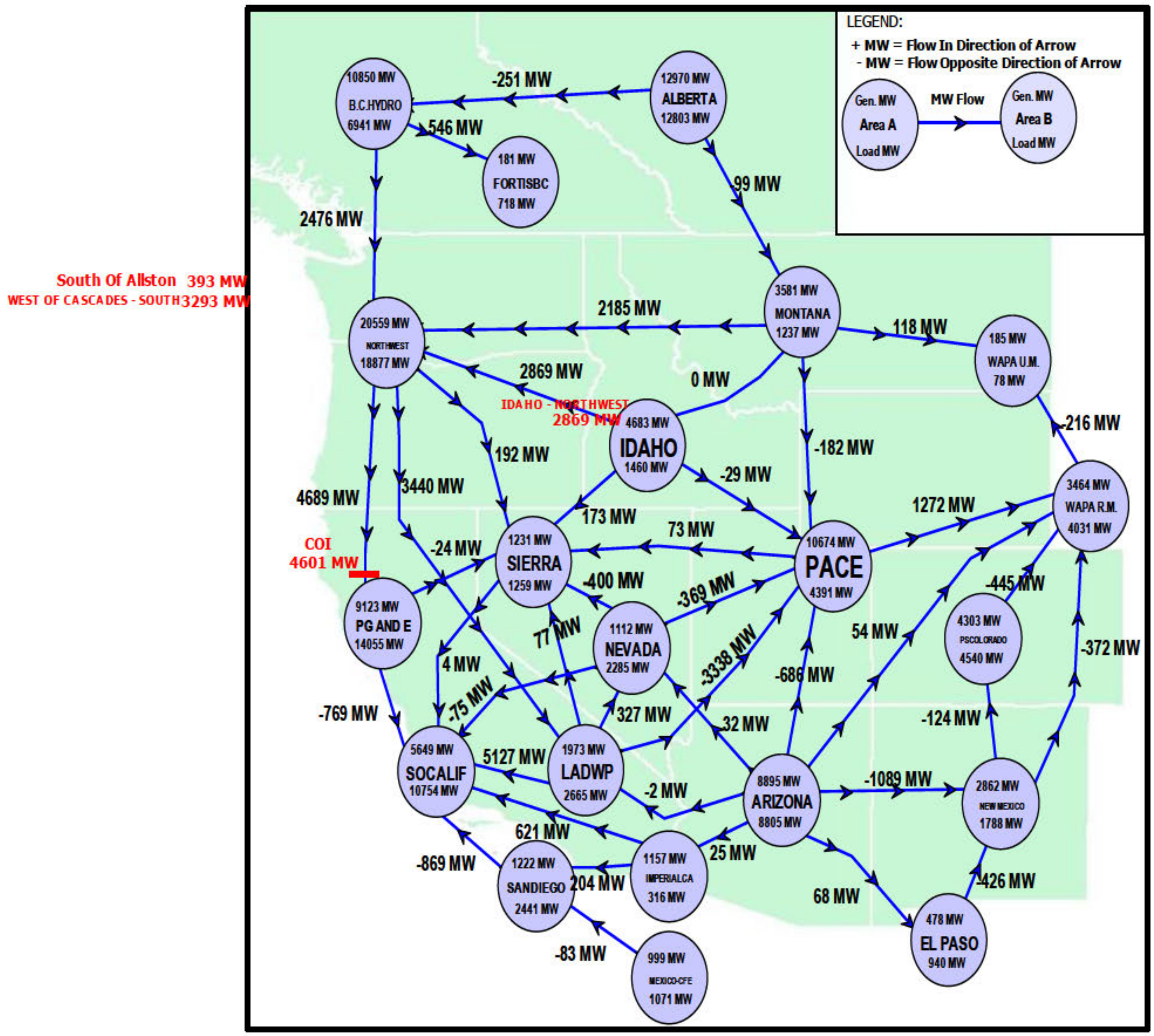


Table 7-1: Scenario Study Results

	3000 MW TWE DC line receiving end	2650 MW TWE DC line receiving end
Contingencies	Violations	Violations
TWE Bipole DC line outage	No Solution	47
TWE Bipole outage with 1560 MW WY gen-tripping	11	2
TWE Bipole outage with 1560 MW WY gen-tripping, FACRI	2	0
TWE Single pole DC line outage	0	0
TWE Single pole with 1560 MW WY gen-tripping	0	0
2PV unit outage with FACRI, RAS	0	0

Scenario Case Conclusion

Study results for the TransWest Express 3,000 MW Scenario Case show the need for remedial actions for loss of both poles of the new DC line. Even tripping one-half of the DC line flow (1,560 MW) of wind generation in Wyoming, as recommended by TransWest Express, was insufficient to achieve acceptable results within the NTTG footprint. Study results also show that if the TransWest Express DC line flow is reduced to 2,650 MW (receiving end), the loss of the DC bipole is less severe, with few or no violations, depending on whether FACRI action is employed.

Chapter 8 – Report Conclusions

The NTTG TWG performed reliability analysis on a Null Case (near-term transmission), five core cases (hours of NTTG transmission or load at maximum conditions) and a Scenario Case (TransWest Express DC line). NTTG expanded the use of exporting cases from security-constrained economic-dispatch modeling to power-flow cases in order to simulate five NTTG transmission-system loading conditions representing peak load, maximum NTTG export, maximum NTTG import and high COI path flow conditions. The Scenario Case analyzed 3,000 and 2,650 MW of Wyoming wind generation associated with a DC transmission line to southwest Nevada (Power Company of Wyoming and TransWest Express project).

In conclusion[5]:

1. The results of the Null Case demonstrate that the near-term transmission system is *not* adequate to meet the forecasted 2022 load and resource requirements.
2. The results of the five core cases demonstrate that the CCTA projects provide adequate transmission capacity to accommodate forecasted 2022 loads and resources.
3. The economic study demonstrates that 1,500 MW of power may be transferred from Great Falls to Malin, with the addition of a 500 kV line from Great Falls to Townsend to Midpoint and series capacitor upgrades at Burns, Malin and Midpoint. Additionally, only 400 MW may be transferred if only the 500 kV line from Great Falls to Townsend to Midpoint is added.
4. Study results for the Scenario Case show the need for remedial actions for loss of both poles of the new bipole DC line if transferring 3,000 MW. Even tripping one-half of the DC line flow (1,560 MW) of wind generation in Wyoming, as recommended by TransWest Express, was insufficient to achieve acceptable results within the NTTG footprint. Study results also show that if the TransWest Express DC line flow is reduced to 2,650 MW (receiving end), the loss of the DC bipole is less severe, with few or no violations, depending on the whether FACRI action is employed.[6]

[5] The study results presented in this report are contingent on the loads, resources and transmission facilities modeled. Different assumptions in load, generation dispatch and transmission would likely result in different transmission requirements.

[6] This Scenario Case study does not provide a transmission path rating. The TransWest Express project must initiate the WECC path rating process to determine the actual capability of the TransWest Express DC transmission line. Any studies and ratings that rely on the use of the FACRI remedial action scheme must be coordinated with Bonneville Power Administration.

NTTG 2014-2015
REGIONAL TRANSMISSION PLAN

December 30, 2015

Table of Contents

Executive Summary

The 2014-2015 Northern Tier Transmission Group (NTTG) Regional Transmission Plan (RTP) proposes a strategy to meet the transmission needs of the NTTG region in year 2024. The plan aims to reliably meet the region's future transmission needs in a manner that is more efficient or cost-effective than an Initial Regional Plan comprising a combination of the funding Transmission Providers' local transmission plans.

NTTG used a two-year process of identifying transmission requirements, conducting reliability analysis and evaluation of the Initial Regional Plan and Alternative Projects, selecting the more efficient or cost-effective projects, and performing robustness analysis to arrive at a final RTP.

Technical planning studies showed that one Sponsored Project and one Alternative Project produced a more efficient or cost-effective regional transmission plan than the Initial Regional Plan. The Sponsored Project is a non-committed 500-kV line from Boardman, Ore., to the Hemingway substation in Idaho. The Alternative Project is a grouping of four transmission elements.

The Alternative Project was analyzed for cost allocation. However, since all project costs could not be allocated to Beneficiaries, the Alternative Project was ineligible for cost allocation. The sponsored Boardman to Hemingway 500-kV project did not request regional cost allocation.

Stakeholder input on the RTP was accepted and evaluated throughout the biennial planning cycle. NTTG posted a final draft of the RTP in Quarter 6 of the biennial planning cycle for public comment. The Planning and Cost Allocation committees recommended submittal of the RTP to the NTTG Steering Committee in Quarter 7. The Steering Committee approved the RTP in Quarter 8.

Introduction

The Northern Tier Transmission Group

The Northern Tier Transmission Group (NTTG) was formed in 2007 to promote effective planning and use of the multi-state electric transmission system within the Northern Tier footprint. Northern Tier provides a forum where all interested stakeholders, including transmission providers, customers and state regulators, can participate in planning, coordinating and implementing a robust transmission system.

NTTG fulfills requirements of the Federal Energy Regulatory Commission (FERC) Order 1000 for each public utility transmission provider to participate in a regional transmission planning process that produces a regional transmission plan and has a regional cost-allocation method.

NTTG evaluates transmission projects that move power across the regional bulk electric transmission system, serving load in its footprint and delivering electricity to external markets. The transmission providers belonging to Northern Tier serve more than 4 million retail customers with more than 29,000 miles of high-voltage transmission lines. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, and parts of Washington and California.

NTTG works with other entities—the Western Electricity Coordinating Council (WECC) Planning Coordination Committee for reliability planning, the WECC Transmission Expansion Planning Policy Committee (TEPPC) for economic analysis, and neighboring Planning Regions (e.g., ColumbiaGrid, WestConnect and California Independent System Operator (CAISO)).

Participating Utilities

Deseret Power Electric Cooperative
Idaho Power
NorthWestern Energy
PacifiCorp
Portland General Electric
Utah Associated Municipal Power Systems

Purpose of the Plan

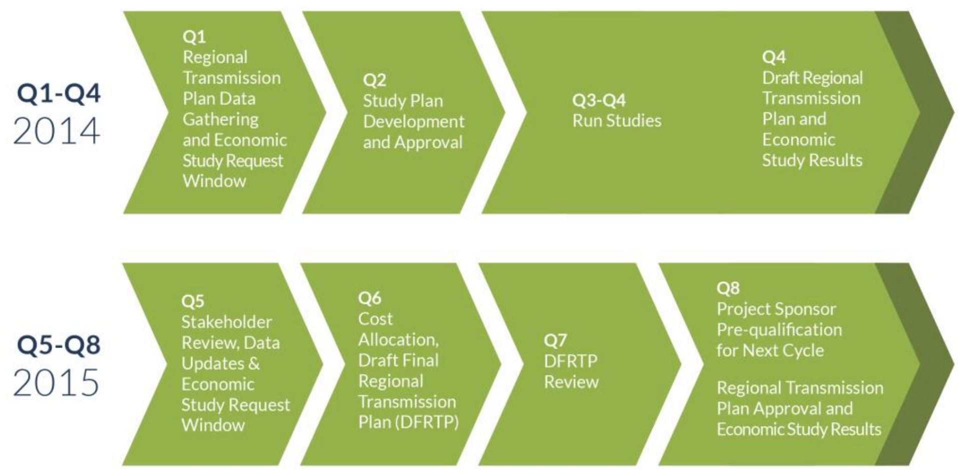
The NTTG Regional Transmission Plan (RTP) aims to produce a more efficient or cost-effective regional plan to transmit energy compared with a plan that rolls up the local Transmission Providers' transmission plans and other Change Case transmission plans studied. This study process complies with FERC Order No. 1000, Attachment K—Regional Planning Process. Order 1000 also calls for allocating the cost of regional transmission solutions fairly to beneficiaries.

Plan Development Process

The Regional Transmission Plan is developed through a two-year process of 1) identification of the transmission requirement for the NTTG footprint, derived from the data submissions; 2) reliability analysis and evaluation of the Initial Regional Plan and Alternative Projects; 3) selection of the more efficient or cost-effective projects; and 4) robustness analysis of the Final Regional Transmission Plan.

Biennial Cycle

NTTG followed a two-year, eight-quarter planning cycle to produce the 10-year Regional Transmission Plan. The biennial cycle includes steps to collect, evaluate and analyze transmission and non-transmission data, produce and publish a draft plan, gather stakeholder and public input, update the plan and complete the cycle with the publishing of a final transmission plan. The planning cycle starts with the Planning and Cost Allocation committees pre-qualifying[1] Transmission Developers who submit a transmission project to be considered for regional cost allocation, should the sponsor's project be selected in the Regional Transmission Plan for cost allocation.



Data Submission

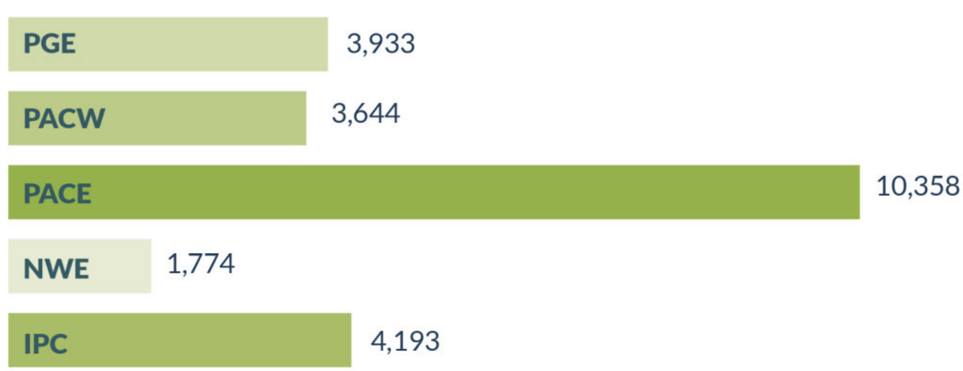
The Planning Committee accepted Transmission Provider data and stakeholder project data to be considered as part of the preparation of the RTP. NTTG's funding Transmission Providers and stakeholders submitted the following six sponsored transmission projects[2] for consideration in the development of the RTP.

[1] A project sponsor must be pre-qualified their project by the Planning Committee prior to the beginning of the 2014-2015 biennial planning cycle (i.e., the last quarter of the prior planning cycle) pursuant to Attachment K, Section Pre-Qualification for Cost Allocation.
[2] Some of the transmission projects that were submitted were local transmission projects that were not consider in the regional transmission planning process (or shown in the table).

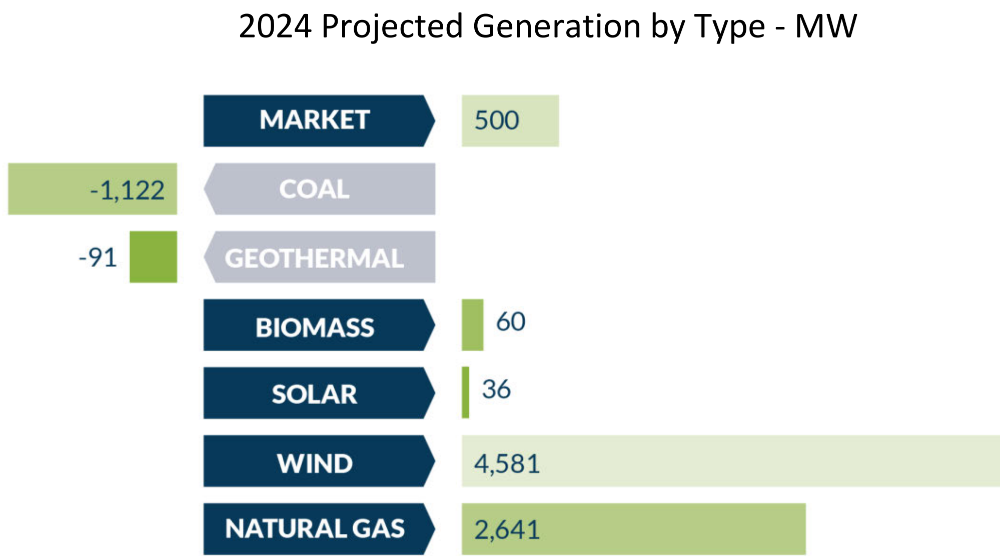
SPONSOR	TYPE	PROJECTS	VOLTAGE	CIRCUITS
IDAHO POWER (NON-COMMITTED)	LTP	Gateway West Project	500 kV	2
	LTP	B2H Project	500 kV – 230 kV	2
GREAT BASIN TRANSMISSION (NON-COMMITTED)	Sponsored	Southwest Intertie Project North	500 kV	1
NORTHWESTERN ENERGY	LTP	Broadview – Garrison Upgrade	500 kV	1
	LTP	Millcreek – Amps Upgrade	230 kV	1
PACIFICORP EAST (NON-COMMITTED)	LTP	Gateway South Project	500 kV	1
	LTP	Gateway West Project	500 kV – 230 kV	5
PORTLAND GENERAL	LTP	Blue Lake – Gresham	230 kV	1
TRANSWEST EXPRESS	Merchant Transmission Developer	TransWest Express	±600 kV DC	1

The forecasted loads for Balancing Authority Areas internal to the NTTG footprint were also provided to NTTG during Quarter 1. These load forecasts were generally those in the participating load-serving entities' official load forecasts (such as those in integrated resource plans) and are similar to those provided to the Load and Resource Subcommittee of the WECC Planning Coordination Committee.

2024 Summer Peak Load - MW

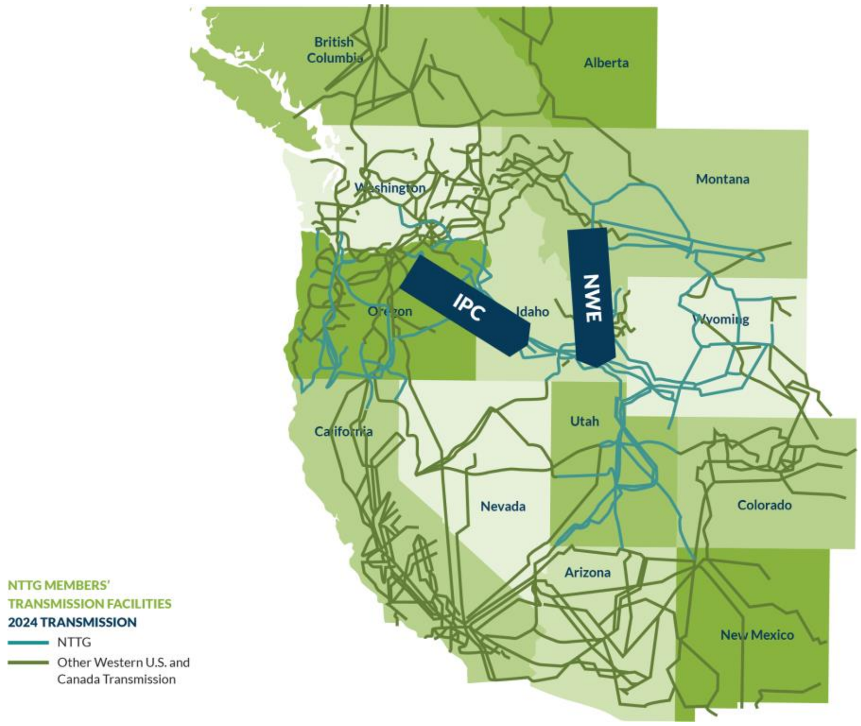


NTTG received 6,606 MW of proposed new generation resources from its funding Transmission Providers for consideration in the RTP. The following graph displays these incremental resources within the NTTG footprint.



NTTG also received two new potential resource additions during the Quarter 5 data submittal window: a 540-MW nuclear-energy project submitted by Utah Associated Municipal Power Systems and a 451-MW renewable resource submitted by Idaho Power. These new generation projects were considered to the extent feasible without delaying the development of the RTP. They were reviewed using power-flow analysis, and these high-level results were noted in the plan. These generation projects will be carried forward for consideration in the 2016-2017 planning cycle if they are properly submitted during the Quarter 1 2016 data-submittal window.

In support of the proposed transmission additions or upgrades, NTTG received firm transmission-service obligations (legal or contractual requirements to provide service): 750 MW from the Pacific Northwest to Idaho Power, received from Idaho Power and Bonneville Power Administration; and 46 MW from Montana to Idaho Power, received from Northwestern Energy. These are shown in the following map.



Public Policy Consideration Scenario Requests

NTTG received three Public Policy Consideration (PPC) study requests. Renewable Northwest Project (RNP) submitted a PPC request for a scenario analysis to assess the 2020 retirement of Colstrip Power Plant (Colstrip) units 1 and 2 (305 MW net per generator after accounting for auxiliary load) and integration of 610 MW of replacement wind resources at the Broadview substation in Montana. NTTG accepted this PPC request for study. RNP also submitted a PPC request to retire Colstrip units 3 and 4 in 2027, but NTTG denied the PPC request, as it was beyond the planning study horizon. In addition, NW Energy Coalition submitted a PPC request to study the accelerated phase-out of coal plants and a concurrent enhancement of new clean-energy resources. This PPC request was not accepted for study because it had already been performed by the WECC TEPPC.

Regional Economic Study Requests

NTTG received three economic study requests for consideration. Two of these requests were submitted after the study window closed and were not pursued by the Planning Committee. The third was a request to retire Colstrip units 1 and 2 (approximately 600 MW net) and replace with 1,000 MW wind and 400 MW pumped hydro. The Planning Committee declined to pursue this study request because points of receipt and points of delivery overreached the NTTG footprint.

Biennial Study Plan

The Biennial Study Plan (study plan) outlines the process that NTTG followed to develop its 10-year Regional Transmission Plan (RTP). It provided the framework to guide RTP development. The NTTG Planning Committee manages the study plan. The Planning Committee established the Technical Work Group (TWG) subcommittee to develop the study plan and perform the necessary technical evaluations for the RTP. TWG members have access to and expertise in power-flow analysis for power systems or production-cost modeling, or both.

Developed during Quarter 2 of the biennial planning cycle, the study plan established the:

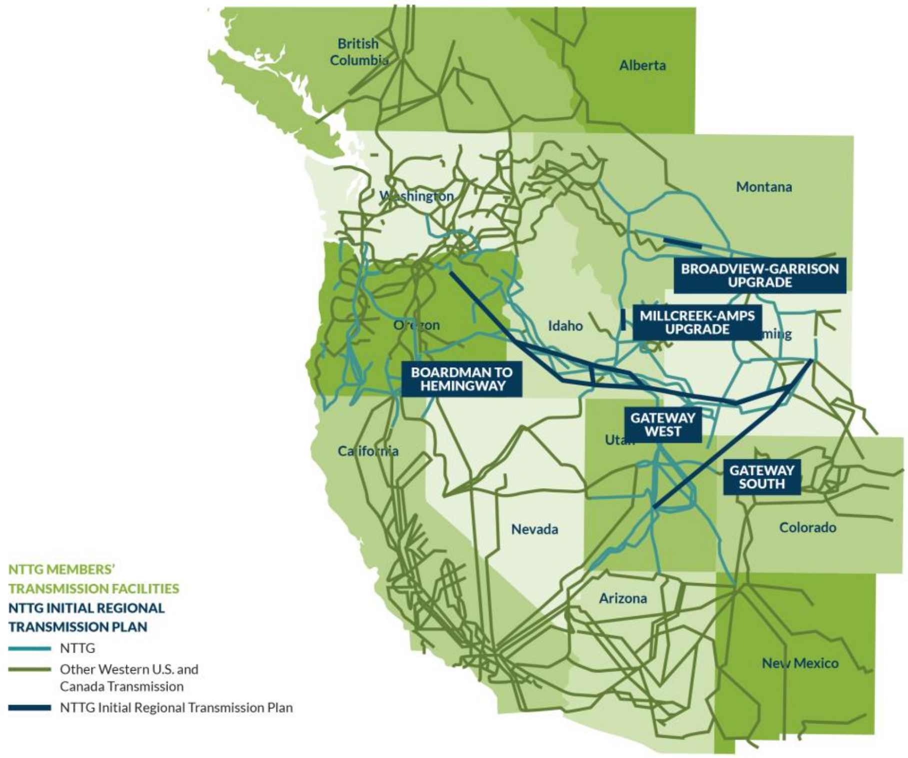
- Study methodology
- Study assumptions based on the load, resource, transmission service obligations, transmission projects and transmission alternatives received during the data submission period
- Production cost and power flow analysis software tools
- 2024 production-cost-model database and the hours selected for reliability analysis
- Reliability and transmission-service-obligation evaluation criteria
- Capital cost, energy losses and reserve-sharing metric calculations
- Resolution of Public Policy Consideration requests

The study plan was posted for stakeholder comment, recommended for approval by the Planning Committee and approved by the Steering Committee during Quarter 2 of the biennial cycle.

Creation and Evaluation of Initial Regional Plan

Under the direction of the Planning Committee, the TWG's first step in developing the Biennial Study Plan was to identify an Initial Regional Plan. The Initial Regional Plan took shape through a bottom-up approach by aggregating the funding Transmission Providers' local transmission plans into a single regional transmission plan. Next, the TWG developed Change Case plans. These plans were used to determine whether or not the non-committed projects[3] (i.e., Boardman to Hemingway Project and Energy Gateway project) were needed to meet the 2024 transmission needs, or if there were Alternative Projects that would provide a reliable transmission plan that was more efficient or cost effective. Projects in the Initial Regional Plan included the non-committed projects mentioned above, as well as series capacitor upgrades in Montana, as described in the map below.

[3] Non-committed projects lack all permits and rights of way required for construction by the end of Quarter 1 of the current Regional Planning Cycle.



Boardman to Hemingway Project. This non-committed project calls for a new 500-kV line from Idaho Power's Hemingway Substation, about 10 miles southwest of Melba, Ida., to a new substation near Boardman, Ore.

Energy Gateway Project. This non-committed project would consist of Boardman to Hemingway, Gateway West and Gateway South. The Gateway West component would include a new 230-kV transmission line from the Windstar substation, near Glenrock, Wyo., to the Aeolus substation in southeastern Wyoming, and 500-kV lines from the Aeolus Substation to the Hemingway Substation. The Gateway South segment would span from Aeolus Substation to Clover Substation near Mona, Utah.

The TWG then conducted a reliability analysis of the Initial Regional Plan and the Change Case plans. Reliability analysis sought to determine whether non-committed projects or Alternative Projects (including unsponsored projects) might yield a more efficient or cost-effective regional transmission plan. Two Alternative Projects were studied—the Southwest Intertie Project North (SWIPN) and an Alternative Project from Aeolus to Anticline to Populus.

The Change Case built a scenario in which one or more Alternative Projects displaced (either deferred or replaced) one or more non-committed projects in the Initial Regional Plan, while still meeting all regional transmission needs, reliability standards and Public Policy Requirements. This process determined if a Change Case was a more efficient or cost-effective solution for the NTTG footprint than the Initial Regional Plan project. Each Change Case was then compared against the Initial Regional Plan for the tenth year of the 10-year planning horizon.

The projects—either from the Initial Regional Plan or from the Change Cases—that defined the more efficient or cost-effective regional transmission plan, as measured by capital costs, losses and reserve margin, and adjusted by their effects on neighboring regions, were then incorporated within the Draft RTP. Eligible projects incorporated within the Draft RTP were then evaluated for cost allocation by the Cost Allocation Committee.

Study Cases

Identification of Stressed Hours for Study with Production-Cost Modeling

The TWG used GridView[4] production-cost software to review 8,784 hours (2024 is a leap year) of data to identify stressed conditions within the NTTG footprint. A case representing the year 2024 was obtained from the WECC TEPPC. This case included a representation of the load, generation and transmission topology of the WECC interconnection-wide transmission system 10 years in the future. The TWG accepted the TEPPC 2024 database as a reasonable representation for the Initial Regional Plan.

The TWG studies extended beyond the traditional focus on snapshots of winter and summer peaks. Instead, the TWG examined all hours of the year for situations where available resources and forecasted loads across the Western Interconnection caused highest stress. This included periods of peak load and high transfers with other regions on the transmission system in the NTTG footprint.

After running all 8,784 hours through the production-cost program, the data were analyzed and the hours representative of the five stressed conditions were identified:

- Maximum NTTG export
- Minimum NTTG export (import)
- Maximum NTTG summer peak
- Maximum NTTG winter peak
- Maximum flow from Montana to the Northwest (Path 8 in WECC Path Rating Catalog)

Reliability Analysis with Power-Flow Modeling

The TWG performed reliability analysis to establish whether proposed transmission additions could reliably meet forecasted load and resource portfolios at anticipated stress times in 10 years. The reliability studies used production-cost modeling to define the hours of stressed conditions of interest, and power-flow studies to analyze the reliability of these stressed conditions.

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[4] GridView is a registered ABB product

Criteria

After analyzing the steady-state performance of each of the five stressed conditions, the TWG ran a rigorous contingency analysis. Power-flow analysis was performed on the developed cases to determine if any voltage- or thermal-overload violations existed under two conditions: system normal (all lines in service, N-0 pre-disturbance analysis) and with transmission elements out of service (contingency analysis). The contingency analysis included both one element (N-1) and two transmission elements out of service at a time (credible N-2).

This contingency analysis consisted of 400 N-1 contingencies and 39 credible N-2 contingencies, to determine if each contingency met the system performance criteria. The contingencies were applied to all transmission elements, 230 kV and above, and credible N-2 contingencies, as defined by reliability coordinator PEAK Reliability, in the NTTG footprint. During this analysis, autotransformer taps and phase-shifting transformers were not allowed to adjust (locked), and the switching of shunts and tie lines was disabled. Remedial Action Schemes (RAS) were executed for contingencies that normally utilize RAS. Transient stability and reactive margin analyses were not performed for this study.

The power-flow simulation results were measured against North American Electric Reliability Corp. (NERC) and WECC reliability criteria, as described in the Study Plan.

If legitimate reliability violations were found, the TWG determined what additional facilities were needed to meet the criteria and adjusted the Initial Regional Plan to include the additional facilities.

Absent violations, the facilities proposed in the Initial Regional Plan were deemed adequate for serving the NTTG loads and resources in the year 2024. The results of each of the five stressed cases are discussed below.

NTTG Export Case

This case reflected an export from the NTTG area of approximately 1,531 MW, NTTG area load of 16,512 MW and NTTG generation of 18,043 MW. The N-0 or steady-state performance analysis resulted in two thermal violations on local 115-kV systems in the Pacific Northwest, which will be resolved by local plans in the next 10 years. All of the contingency results met system performance criteria.

NTTG Import Case

The NTTG load and generation for this import case were 12,211 MW and 11,683 MW, respectively. The case yielded an NTTG area net import of approximately 528 MW. The steady-state conditions of this case showed a few high voltages on local 69-kV systems, which will be resolved through local plans over the next 10 years. Otherwise there were no steady-state violations. The results of the contingency analysis showed no violations of the performance criteria.

NTTG Summer Peak Case

This case had an NTTG summer peak load of 21,789 MW, with 19,619 MW of generation and an import of 2,170 MW. In this case there were also a few steady-state high voltages on local buses (< 20 kV) to be resolved in future local plans. Otherwise there were no other steady-state violations. There were no contingency results that violated the performance criteria.

NTTG Winter Peak Case

The NTTG winter peak load in this case was 19,033 MW, with 16,784 MW of generation and an import of 2,249 MW. The steady-state results showed some voltages outside of the acceptable range on local lower voltage buses in the Pacific Northwest. These were assumed to be resolved through the local plans. The results of the contingency studies showed no system-performance criteria violations.

Maximum Path 8 Case

This case had a Path 8 flow of 2,076 MW. The NTTG load and generation in this case were 10,712 MW and 13,319 MW, respectively. The NTTG total export was 2,607 MW. The steady-state results in this case showed several voltages and line/transformer overloads on the local lower voltage system in the Northwest. These will need to be resolved through the local plans. The results of the contingency studies showed no reliability violations.

Public Policy Considerations Study

As described above, NTTG accepted one Public Policy Consideration request for study. Renewable Northwest Project (RNP) submitted a PPC request for a scenario analysis study to assess the 2020 retirement of Colstrip Power Plant (Colstrip) units 1 and 2 (305 MW net per generator after accounting for auxiliary load) and integration of 610 MW of replacement wind resources at the Broadview substation in Montana.

In addition, the NW Energy Coalition submitted a PPC request to study the accelerated phase-out of coal plants and a concurrent enhancement of new clean-energy resources. This PPC request was not accepted for study because this study had already been performed by WECC TEPPC.

Two base cases derived for NTTG's Regional Transmission Plan were used for the Public Policy Consideration request analysis. The cases were the NTTG Summer Peak Case and the Maximum Path 8 Case. Power-flow studies were evaluated using steady-state (N-0), single-contingency (N-1) and credible double-contingency (N-2) conditions to ensure the transmission system met the system performance requirements defined in the planning standards. The analysis showed that under the steady-state conditions studied, assuming a MW-for-MW online exchange in generation, and proper generator tripping (either the wind machines at Broadview or the

Colstrip units), wind generation interconnected to the 500-kV bus could possibly replace coal-fired generation at Colstrip. However, the study could not definitively conclude that the wind-for-coal replacement was possible. Nor did the analysis suggest or imply that a one-for-one substitution of wind for coal was feasible without further analysis or system improvements. It was noted that the study assumptions only give a limited conclusion and that with transient studies, using a dynamics-ready case and the actual Acceleration Trend Relay (ATR) simulation program would be the next step in confirming the assumptions made of the ATR for this study.

Development of the Regional Transmission Plan

Guided by the 2014-2015 Biennial Study Plan, the TWG began the technical studies that would ultimately define the RTP. The RTP development process started with reliability studies on the Initial Regional Plan and Change Case plans to ensure that each transmission plan was reliable and adequate to meet the 2024 electrical needs of the loads, resources, Public Policy Requirements, and transmission service obligations within NTTG's footprint. The plan that minimized the dollar sum of three benefit metrics and met the 2024 transmission needs was identified as the RTP. This process is described below.

Reliability Analysis

The TWG developed Change Cases to determine whether the non-committed projects in the Initial Regional Plan (i.e., Boardman to Hemingway project and Energy Gateway project) were needed to meet the 2024 transmission needs. This became Change Case 1. The TWG also studied whether an Alternative Project(s) would produce a more efficient or cost-effective regional transmission plan than the Initial Regional Plan. These were identified as Change Cases 2-7. The following table displays the Change Cases considered.

Change Cases Considered

	ENERGY GATEWAY	BOARDMAN TO HEMINGWAY	SWIP NORTH	ALTERNATIVE PROJECT
INITIAL REGIONAL PLAN	X	X		
CHANGE CASE 1				
CHANGE CASE 2		X	X	
CHANGE CASE 3				X
CHANGE CASE 4	X	X	X	
CHANGE CASE 5	X		X	
CHANGE CASE 6			X	X
CHANGE CASE 7[1]		X		X

[1] Change Case 7 Alternative Project is a similar but larger project than the other Change Cases Alternative Project.

The Alternative Projects used in the Change Cases could add to or displace (either defer or replace) one or more non-committed projects in the Initial Regional Plan. All Change Cases met all regional transmission needs, reliability standards and Public Policy Requirements. The projects—either from the Initial Regional Plan or a Change Case plan—that defined the more efficient or cost-effective regional transmission plan, as measured by the three benefit metrics (capital related cost, losses and reserves), adjusted by their effects on neighboring regions, were included in the RTP.

Boardman to Hemingway Project

A Change Case was created with this project removed (i.e., removed from each of the stressed-hour conditions studied) and no Alternative Project added. There were no Alternative Projects submitted during the Q1 data-submittal period, nor did the TWG identify an Alternative Project to replace this project during the technical analysis. The results of the Change Case power-flow analyses for system-normal analysis and contingency analysis did not identify any voltage or thermal-overload violations.

Energy Gateway/Boardman to Hemingway Project

A Change Case was created with the combined Energy Gateway and Boardman to Hemingway project removed and no Alternative Project added. There were no Alternative Projects submitted during the Q1 data submittal period to replace these projects. As described below, the reliability analysis identified a significant number of reliability violations.

Southwest Intertie Project North (SWIP North)

Great Basin Electric submitted the Southwest Intertie Project North (SWIP North) as a Sponsored Project to be considered for regional cost allocation, if it were to be selected in the RTP. This Alternative Project consisted of a new 500-kV line from Midpoint substation, north of Jerome, Idaho, to the Robinson Substation near Ely, Nevada. In addition, a 500-kV line from Harry Allen Substation, northeast of Las Vegas, to the Eldorado Substation in southern Nevada, was added to this case. Change Cases with the SWIP North project added to various stressed-condition cases were developed. These Change Cases were then analyzed using power-flow analysis. A comparison of the study results with and without the SWIP North project showed some improvement in the post-contingency voltages. However, voltage levels before adding the SWIP North project were already within acceptable voltage- and thermal-overload performance ranges in the cases. Also, Change Cases 2 and 5 found that the SWIP North project did not yield a transmission plan that was more efficient or cost-effective than a plan without the SWIP North project. Therefore, the SWIP North project was not selected in the Regional Transmission Plan.

Reliability analysis identifies Change Case 7

The reliability analysis of the Initial Regional Plan found that each of the stressed cases for the selected hours met system performance criteria at steady-state and contingency conditions. Thus the question became whether the non-committed projects in the Initial Regional Plan (i.e., Boardman to Hemingway project and Energy Gateway/Boardman to Hemingway project) were needed or if an Alternative Project (including the SWIP North project) would yield a more efficient or cost-effective regional plan. The analysis looked at two Change Cases with the non-committed projects removed as well as a Change Case for SWIP North.

As noted above, the reliability analysis for Change Case 1 studied the existing transmission system by removing the non-committed Energy Gateway and Boardman to Hemingway projects from the Initial Regional Plan. The Quarter 3-4 reliability analysis determined that the transmission plan was reliable except in the export stress condition. In this instance, an overloaded line from NTTG to WAPA was resolved by an unsponsored Alternative Project. However, the Initial Regional Plan was updated in Quarter 5 with higher loads and additional wind resources in the PACE area, and additional reliability studies were performed. Results of these studies showed an increase in the number of reliability violations. This increase prompted several Alternative Projects (i.e., variants of the Quarter 3-4 Alternative Project) to be studied in Change Cases to define the Regional Transmission Plan that was more efficient or cost effective than the other Change Case regional transmission plans studied. Thus, the reliability analysis found the need for improvements to the existing transmission system to meet 2024 transmission needs.

The reliability analyses of Change Cases 2-6 tested whether an Alternative Project would yield a more efficient or cost-effective transmission plan than the Initial Regional Plan's non-committed projects. If a Change Case proved unreliable for any stressed condition and needed mitigation (system fixes) to correct an overload or voltage violation under system normal or contingency analysis, then the cost of this mitigation was added to the capital cost of the Alternative Projects in the Change Case. There were no impacts to neighboring Planning Regions for any of these mitigated Change Cases.

Change Case 7 was the result of the reliability work described above and the Available Transmission Capacity analysis (described below) that was completed after the benefit metric analysis (also described below). This analysis determined if the existing transmission path had adequate capacity to meet the transmission service obligation. The study demonstrated the need for the Boardman to Hemingway Project in the RTP to satisfy firm transmission-service obligations. There were no impacts to neighboring Planning Regions for this Change Case. Change Case 7 ultimately became the RTP.

Transmission Needs and Available Capacity Analysis

During the course of developing the RTP, the TWG recognized that the technical analysis did not adequately account for the transmission needs associated with the Transmission Providers' firm transmission-service obligations. The resolution was to conduct an analysis of the relevant transmission path's Available Transmission Capacity (ATC). This analysis examined whether Idaho Power's firm transmission-service obligation, which designated the use of existing Path 14 (see table below) from the Pacific Northwest to Idaho, could be met in 2024 without the Boardman to Hemingway project added. The following table shows the results of this analysis.

The existing Idaho to Northwest path has 0 MW west-to-east available transfer capability. This means that current firm transmission-service obligations could not be met by the existing Idaho to Northwest transmission path.

Transmission Needs

PATH NAME	EXISTING PATH RATING (MW)	AVAILABLE TRANSFER CAPABILITY (2015)
8 – MONTANA TO NORTHWEST	E–W: 220 | W–E: 1350	E–W: 724 | W–E: 706
14 – IDAHO TO NORTHWEST	W–E: 1350 | E–W: 2400	W–E: 0 | E–W: 514
16 – IDAHO – SIERRA	N–S: 500 | S–N: 360	N–S: 168 | S–N: 0
17 – BORAH WEST	E–W: 2557 | W–E: 1600	E–W: 0 | W–E: 1445
19 – BRIDGER WEST	E–W: 2400 | W–E: 600	E–W: 60 | W–E: 200
20 – PATH C	N–S: 1600 | S–N: 1250	N–S: 0 | S–N: 0
37 – TOT 4A	NE–SW: 960	NE–SW: 0 | SW–NE: 761
38 – TOT 4B	SE–NW: 880	SE–NW: 33 | NW–SE: 104
75 –HEMINGWAY – SUMMER LAKE	E–W: 1500 | W–E: 550	E–W: 0 | W–E: 0

The results of this comparison demonstrated the need for the Boardman to Hemingway Project in the RTP to satisfy the transmission needs of Idaho Power. As a result of this study, the Change Cases that did not include the Boardman to Hemingway transmission project were deemed unacceptable.

The technical study results were then applied to three benefit metrics to analyze the Initial Regional Plan and the Change Case plans. The benefit metrics, derived from the Biennial Study Plan, included capital-related costs, line losses and reserves. The combination of some or all of the Initial Regional Plan's non-committed projects or Alternative Projects that provided the most efficient or cost-effective transmission plan were included in the RTP. The economic evaluations for the Initial Regional Plan and the Change Cases are discussed below.

Capital-related Cost Metric

Development of the capital-related cost metric required three steps: 1) validate the Project Sponsor's Q1 submitted project capital cost, 2) calculate the annual capital-related costs, and 3) compute the total present value of annual capital-related costs for the Initial Regional Plan and the Change Case plans. A change in annual capital-related costs between a Change Case and the Initial Regional Plan captures benefits related to transmission needs driven by both reliability and Public Policy Requirements. This benefit metric reflects the extent that a project in the Initial Regional Plan can be displaced while the plan meets all regional transmission needs and reliability standards. The capital cost of the transmission projects was converted to annual capital-related costs representing the sum of annual return (both debt and equity related), depreciation, operation and maintenance expense, and income and other taxes.

Change in System Losses

The energy-loss metric captured the change in energy generated, based on system topology, to serve a given amount of load. Using power-flow software, NTTG footprint losses were evaluated with and without a given non-committed or Alternative Project in service. A reduction in losses after a project was added represented a benefit, because less energy was required to serve the same load.

Five NTTG stressed-hour-conditioned cases were evaluated with and without a project in service. The net change in energy losses was determined for each case. The net losses for the five cases were then averaged to determine an average MW loss value. Next, the average MW loss value was annualized and multiplied by a 2024 nodal energy price extracted from the WECC 2024 TEPPC model to produce an annualized energy-loss benefit in dollars.

Change in Location of Reserves

The reserve metric evaluated the opportunities for two or more parties to economically share a generation resource that would be enabled by transmission. The metric provided a 10-year incremental look at the increased load and generation additions in the NTTG footprint and the incremental transmission additions that may be included in the RTP.

In the study cycle, Gateway West, Gateway South, Boardman to Hemingway, SWIP North and a Montana-NW upgrade were included in the analysis. To evaluate these projects, the NTTG footprint was segmented into five zones, and a sixth external zone was included to study SWIP North. Of the 34 viable power-sharing combinations, the analysis of the annual net savings over the standalone alternative suggested that only six viable combinations were economic. The viable combinations were further cut by half, to three, after the costs associated with SWIP South, the most likely location for a reserve resource, were included. This metric included generation capital costs in its evaluation. As such, the metric may only be appropriate for cost allocation and should not drive the selection of a base plan. Whether these cost savings warrant jointly sharing the costs of reserve capacity would be left to the parties to decide.

Metric Analysis Conclusion

The sum of the annual capital-related cost metric, loss metric (monetized) and reserve metric (monetized) calculated an incremental cost for the Initial Regional Plan and the Change Case plan. The set of projects (either the Initial Regional Plan or a Change Case plan) with the lowest incremental cost, after adjustment by the plan's effects on neighboring regions, were incorporated within the RTP. As described earlier, the Change Cases that did not include the Boardman to Hemingway project were not viable plans because there was insufficient available transmission capacity on the designated transmission path to meet the firm transmission service obligation. The following table shows the results of the metric analysis, which concludes that Change Case 7 has a lower annual increment cost than the Initial Regional Plan and as such was deemed the more efficient or cost-effective regional plan. Thus, Change Case 7 was deemed to be NTTG's RTP.

Metric Analysis Incremental Cost

	LEVELIZED CAPITAL RELATED COST	ANNUAL MONETIZED NTTG LOSSES	ANNUAL MONETIZED RESERVE	ANNUAL INCREMENTAL COST
INITIAL REGIONAL PLAN	$521,402,647	$87,882,729	$0	$609,285,376
REGIONAL TRANSMISSION PLAN (CHANGE CASE 7	$360,580,734	$88,893,318	$0	$449,474,052

Robustness Analysis

A robustness analysis of the RTP using the four cost-allocation scenarios (described below) was completed. Two of these scenarios varied the load in the NTTG footprint by +/- 1000 MW. The two other scenarios looked at different system conditions by displacing wind or coal generation with other renewable resources. The results of the robustness analysis suggested no change was needed to the non-committed regional transmission projects in the RTP. That is, these additional studies demonstrated the robustness of the RTP to reliably meet the transmission needs of a variety of load and resource alternatives in the future.

Projects Selected for the Regional Transmission Plan

Results of the technical planning studies showed that one Alternative Project, along with the Boardman to Hemingway 500-kV project, produced a more efficient or cost-effective regional transmission plan than the Initial Regional Plan.

The Alternative Project comprises the following transmission elements:

- 230-kV line from Windstar to Aeolus in central Wyoming and reinforcements to existing underlying transmission facilities
- 500-kV line from Aeolus to Clover near Mona, Utah
- 500-kV line from Aeolus to Anticline (Bridger) to Populus
- 345-kV line from Anticline to Bridger

Since the unsponsored Alternative Project was identified through the technical analysis, it was eligible to be considered for regional cost allocation.

The sponsored Boardman to Hemingway 500-kV project did not request regional cost allocation.

Cost Allocation Process

The NTTG Cost Allocation Committee (CAC) is charged with the task of allocating costs of selected projects to Beneficiaries. The RTP included one unsponsored Alternative Project for purposes of regional cost allocation. This project met the required minimum estimated cost of $20 million.

Projects Submitted for Cost Allocation

During NTTG's 2014-2015 biennial planning cycle, two transmission projects were considered for selection into the Draft Final RTP for purposes of regional cost allocation:

- A sponsored project submitted by Great Basin Transmission, LLC, an affiliate of LS Power, for its SWIP North transmission project. Reliability and economic analyses indicated that SWIP North failed to meet the more-efficient or cost-effective criteria and was not selected into the Draft Final RTP. This project was ineligible for cost allocation.
- The second project, the unsponsored Alternative Project, was identified by NTTG in the planning process and selected in the RTP for purposes of regional cost allocation. The regional cost allocation methodology was applied to this unsponsored Alternative Project, but ultimately the project did not receive cost allocation for the reason described below.

Cost Allocation Scenarios

Four cost allocation scenarios were developed by the Cost Allocation Committee for those parameters that likely affect the amount of total benefits of a project and their distribution among Beneficiaries. The variables in the cost allocation scenarios include, but are not limited to, load levels by load-serving entity and geographic location, fuel prices, and fuel and resource availability. The potential impact of uncertainties is estimated and incorporated in the calculation of net benefits used in cost allocation. This process is intended to provide an overall range of future costs used in determining a project's benefits and Beneficiaries.

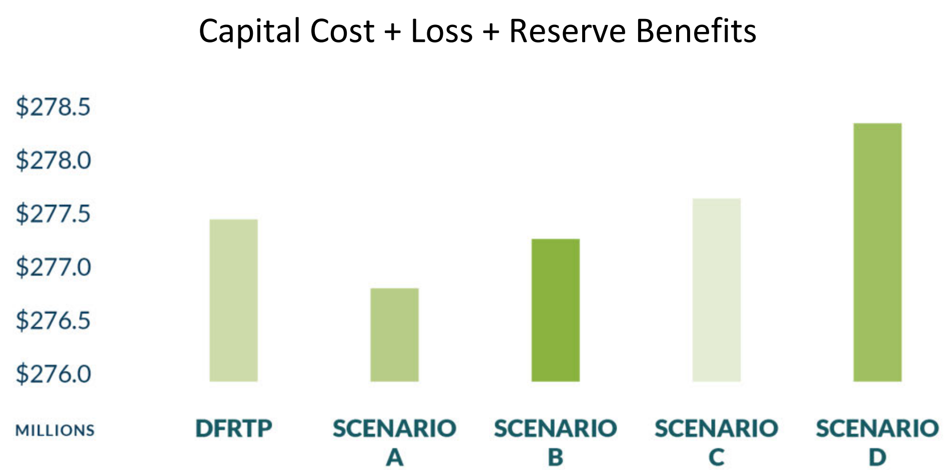
Scenario A: Add 1,000 MW of NTTG load in the NTTG footprint for a high-load scenario. Allocate the 1,000 MW to each Balancing Authority Area (BAA) based on the 2013/2014 actual peak demand and the projected 2024 peak demand.

Scenario B: Subtract 1,000 MW of NTTG load in the NTTG footprint for a low-load scenario. Allocate the 1,000 MW to each BA based on the 2013/2014 actual peak demand and the projected 2024 peak demand.

Scenario C: Remove 1,600 MW of wind capacity (2024 Q1 data projection, less the 3,000 MW wind project capacity submitted by Power Company of Wyoming), cut wind by 50 percent and replace with solar energy.

Scenario D: Subtract 1,000 MW of coal and presume units that are not retired in the 2024 case can be reduced pro rata and replaced with an equivalent amount of energy in equal shares of wind in Wyoming and Montana and solar in Idaho and Utah.

After the Cost Allocation Committee defined the cost allocation scenarios, the Planning Committee conducted N-0 power-flow analysis to validate the need for the Alternative Project in each scenario and to ensure that each scenario remained reliable. The TWG followed the Cost Allocation Study Plan and used the results from the power-flow analysis to calculate three metrics—capital cost benefit, line loss benefit and reserve margin benefit – for each cost allocation scenario.



These metric results were used by the Cost Allocation Committee's cost allocation methodology to allocate the Alternative Project costs to its Beneficiaries. Each metric was expressed as an annual dollar change in costs (or revenue). A common year was selected for net present value calculations for all cases to enable a comparative analysis between the RTP and the four cost allocation scenarios. As described above, these cost allocation scenario results were also used by the Planning Committee to test the robustness of the RTP.

Cost Allocation Results

The Cost Allocation Committee initially identifies Beneficiaries as entities that may be affected by a project based on application of the analysis criteria and cost allocation scenarios. For projects eligible to receive a cost allocation, the Cost Allocation Committee starts with the benefit and Beneficiary calculations provided by the Planning Committee (shown above) and removes those entities that do not receive a benefit from the project being evaluated.

Next, the Cost Allocation Committee adjusts the calculated initial benefits for each Beneficiary based on the Attachment K methodology and criteria. The adjusted net benefits as defined by the Attachment K methodology are used for allocating project costs proportionally to

Beneficiaries, but the cost allocation methodology has a benefits-cost threshold test that may result in some costs not being allocated to beneficiaries (e.g., remaining costs). These remaining costs are reallocated among the remaining Beneficiaries, if possible. Reallocation continues among regional Beneficiaries until either all remaining costs are allocated or there are no Beneficiaries above the benefit-cost threshold outlined in the Attachment K. The applicant (i.e., a project sponsor or stakeholder that submits an unsponsored project) may voluntarily accept any remaining project costs. Otherwise, if the thresholds prevent all costs from being reallocated among Beneficiaries and the remaining costs are not accepted by the applicant, the project is no longer eligible for cost allocation.

Cost Allocation Results

The cost allocation analysis for the unsponsored Alternative Project resulted in no cost allocation of the Alternative Project. Since the Alternative Project was identified by the Planning Committee during the development of the RTP, there was no Applicant to accept the remaining costs of the project. As a result, since all project costs could not be allocated to Beneficiaries, the Alternative Project was ineligible for cost allocation.

Next Steps

Publication of the NTTG Regional Transmission Plan completes the two-year planning process begun in January 2014. The 2014-2015 NTTG RTP identified a need for new transmission capacity to serve forecasted load in 10 years. The plan also identified two transmission projects as more efficient and cost-effective means to meet that need. While the RTP is not a construction plan, it provides valuable insight and information for all stakeholders (including developers) to consider and use in their respective decision-making processes.

The next biennial transmission planning cycle for NTTG started Oct. 1, 2015 and will culminate with the publication of the 2016-2017 RTP in December 2017.

NTTG 2014-2015 Regional Transmission Plan Supporting Materials

The supporting materials referenced in this report have been posted on the NTTG website and can be found using the following link:

> http://www.nttg.biz/site/index.php?option=com_docman&view=list&slug=appendices&Itemid=31.

A list and link to each of the individual supporting documents is also provided below:

1. NTTG 2014-2015 Draft Final Regional Transmission Plan 06-30-2015
2. Revised NTTG Biennial Study Plan Approved 3-9-2015
3. Quarter 5 Additional Study Report - Evaluating Transmission Segments Similar to Energy Gateway
4. NTTG Study Plan for the 2014-2015 Public Policy Consideration Scenario - Final 02-11-15
5. NTTG Report for the 2014-2015 Public Policy Consideration Scenario – Final 05-03-15
6. NTTG Revised Cost Allocation Study Plan Approved 06-03-15
7. Cost Allocation Calculation Workbook Final 06-29-2015

NTTG 2016-2017

REGIONAL TRANSMISSION PLAN

NORTHERN TIER
TRANSMISSION GROUP

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NTTG MISSION

To ensure efficient, effective, coordinated use and expansion of the members' transmission systems in the Western Interconnection to best meet the needs of customers and stakeholders.

Northern Tier Transmission Group

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FRONT COVER
Idaho Power double circuit 230-kV tower.
Photo courtesy of Idaho Power

Repair of insulator on 345-kV tower Bonanza- Mona line.
Photo courtesy of Deseret Power Electric Cooperative

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EXECUTIVE SUMMARY

Would it be more efficient or cost-effective to meet future transmission needs in the Northern Tier Transmission Group (NTTG) footprint through a regional planning framework rather than the aggregate of local planning processes[1]?

The NTTG 2016-2017 Regional Transmission Plan (RTP) poses this question and seeks to answer it. Developed in accord with NTTG Transmission Providers' Attachment K, which includes FERC Order 1000 regional and interregional transmission planning requirements, the plan analyzes whether NTTG's transmission needs in 2026 could best be satisfied with projects of a regional or interregional scope.

To arrive at a conclusion, NTTG used a two-year process of identifying transmission requirements and performing reliability and economic analyses on several collections of transmission projects, or plans: the prior (2014-2015) RTP, an Initial RTP[2] made up of projects from the prior RTP and projects included in the Full Funders' Local Transmission Plans, and a number of Change Case plans. A null Change Case (null case), which tests the NTTG footprint's current transmission system stressed by the addition of loads and resources projected for 2026, showed that the NTTG system performed acceptably in only one of seven stressed conditions studied. All the other conditions suffered performance issues that required correction.

A technical study found that the 2014-2015 prior RTP, which included two Non-Committed Projects (Boardman to Hemingway and portions of Energy Gateway), was not fully reliable with the 2026 load and resource projections. The study then evaluated 23 Change Cases that explored ways to reliably meet the transmission system needs through various combinations of the Non-Committed Projects in the Initial RTP or three proposed Interregional Transmission Projects, or both. These Change Cases were created to explore the relationship of a build-out of wind generation in Wyoming to meet NTTG load with its impact on the transmission system west of Wyoming and a potential expansion of the transmission system (i.e., the Gateway West and Gateway South projects).

The study also examined three Interregional Transmission Projects as Alternative Projects to determine whether these projects would yield a more efficient or cost-effective regional transmission plan for NTTG and as a part of interregional coordination and planning.

The analysis found, however, that none of the Interregional Transmission Projects could replace or enhance the Non-Committed Projects more efficiently or cost effectively to satisfy NTTG's regional transmission needs.

Reliability analyses narrowed the potentially acceptable solutions to the Initial RTP and two Change Cases. Subsequent economic analyses identified one of the

[1] NTTG's regional transmission planning process is not intended to be a replacement for local transmission or resource planning.
[2] Terms are capitalized to be consistent with Attachment K. All capitalized terms are defined in the glossary.

Change Cases as the more-efficient or cost-effective case. Known in the study as Change Case 23, this case includes Boardman to Hemingway, Gateway South, portions of Gateway West, and the Antelope projects. See the figure below for a map of those projects.

FIGURE 1
These projects comprise NTTG's 2016-2017 Regional Transmission Plan.

Stakeholder input on the RTP was accepted and evaluated throughout the biennial planning cycle. NTTG posted the Draft RTP in December 2016 (Quarter 4) for stakeholder comment and the Draft Final RTP in Quarter 6 for public comment. The revised Draft Final RTP was made available for public comment in Quarter 7. The Planning Committee recommended submittal of the RTP to the NTTG Steering Committee in Quarter 8. The Steering Committee approved the RTP in Quarter 8.

PLAN ASSUMPTIONS AND CAVEATS

The NTTG 2016-2017 Regional Transmission Plan (RTP) is meant to inform local transmission planning processes and is not a construction plan. NTTG relies on the load and resource data submittals of its members and does not consider the re-dispatch or re-optimization of resource assumptions. The RTP studies are completed pursuant to the NTTG Transmission Provider's Attachment K.

NTTG's transmission plan assumes that its members' submissions are reasonable and cost-effective. The transmission plan is not an attempt to design an optimal portfolio of resources to meet the expected demand of the region's consumers. Instead, it is an attempt to design a reliable and cost-effective portfolio of transmission around the inputs of NTTG Members. The RTP is the result of the assumptions outlined in the report and solely represents a lower-cost transmission plan than one represented by a rollup of the combined Transmission Provider's plans.

To the degree that those NTTG Transmission Providers' inputs are not realistic or cost-effective, the resulting NTTG Transmission Plan will likely be affected. However, NTTG regards correcting such potential errors as work to be undertaken in the context of integrated resource plans conducted by individual load-serving entities in their respective states.

THE NORTHERN TIER TRANSMISSION

The Northern Tier Transmission Group (NTTG) was formed in 2007 to provide a forum where all interested stakeholders, including Transmission Providers, customers and state regulators, can participate in an open, transparent, coordinated regional transmission planning process. The process is intended to promote effective planning and use of the multi-state electric transmission system within the NTTG footprint.

NTTG fulfills requirements of the Federal Energy Regulatory Commission (FERC) Order 1000 for each public utility transmission provider to participate in a regional transmission planning process that produces a regional transmission plan and, if appropriate, includes a regional cost-allocation method.

NTTG evaluates transmission projects that move power across the regional bulk electric transmission system, serving load in its footprint and delivering electricity to external markets. The transmission providers belonging to Northern Tier serve more than 4 million retail customers with more than 29,000 miles of high-voltage transmission lines. The NTTG footprint covers portions of seven Western states. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, and parts of Washington and California.

NTTG works with other entities—the Western Electricity Coordinating Council (WECC) for reliability data and neighboring Planning Regions (e.g., ColumbiaGrid, WestConnect and California Independent System Operator (CAISO)) for interregional project coordination.

NORTHERN TIER MEMBERS

Deseret Power Electric Cooperative

Idaho Power Company

Idaho Public Utilities Commission

MATL LLP

Montana Consumer Counsel

Montana Public Service Commission

NorthWestern Energy

Oregon Public Utility Commission

PacifiCorp

Portland General Electric

Utah Associated Municipal Power Systems (UAMPS)

Utah Office of Consumer Services

Utah Public Service Commission

Wyoming Office of Consumer Advocates

Wyoming Public Service Commission

The NTTG footprint covers portions of seven Western states.

PURPOSE OF THE PLAN

The NTTG Regional Transmission Plan (RTP) aims to produce, if possible, a more efficient or cost-effective regional plan to transmit energy compared with a plan that rolls up the local Transmission Providers' transmission plans and other Change Case transmission plans studied. This study process complies with FERC Order No. 1000, Attachment K—Regional Planning Process. This planning cycle marks the first time that NTTG implemented FERC Order 1000 interregional project coordination with the other western regional transmission planning organizations.

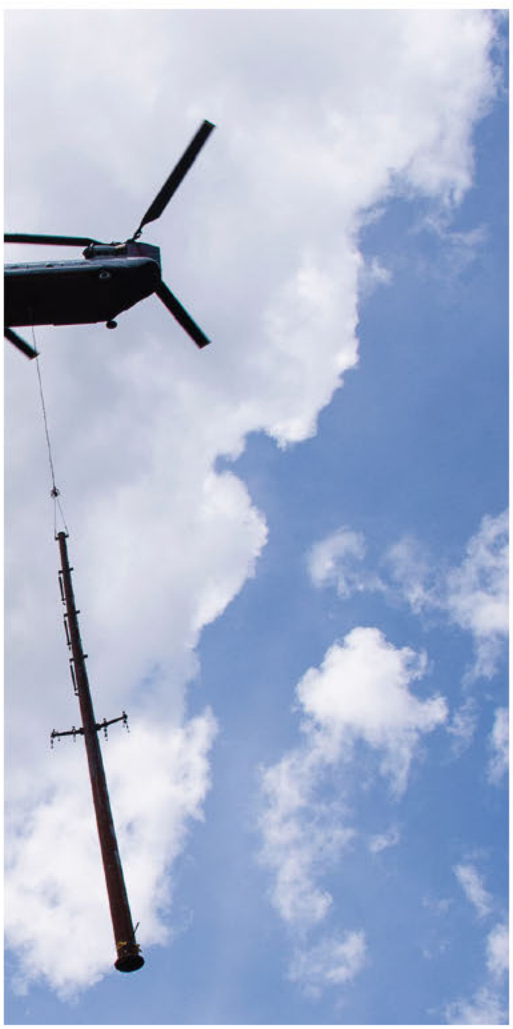
Journeyman lineman prepares equipment for upgrade of NorthWestern Energy's Jack Rabbit-Big Sky Project.
Photo courtesy of Susan Malee, NorthWestern Energy

PLAN DEVELOPMENT PROCESS

THE REGIONAL TRANSMISSION PLAN IS DEVELOPED THROUGH A TWO-YEAR PROCESS:

1. Identification of the transmission requirement for the NTTG footprint, derived from the data submissions
2. Reliability analysis and evaluation of the Initial RTP and Alternative Projects (including interregional projects) through Change Cases
3. Economic analysis and evaluation comparing the annualized incremental costs of the Initial RTP and the Change Cases that perform acceptably (two cases this study cycle)
4. Selection of the project or projects that yield a regional transmission plan that is more efficient or cost-effective than the other regional transmission plans studied
5. Any projects that were submitted for the purposes of cost allocation and selected into the RTP will go through the cost allocation process if they are deemed to be eligible for cost allocation

A Chinook helicopter transports a steel transmission tower above the Gallatin River south of Bozeman, Mont., as part of NorthWestern Energy's Jack Rabbit-Big Sky project.
Photo courtesy of Susan Malee, NorthWestern Energy



Line crew installs single-pole structures for NorthWestern Energy's new 100-kV transmission line north of Reed Point, Mont., with Beartooth Mountains in the background.
Photo courtesy of Susan Malee, NorthWestern Energy

BIENNIAL CYCLE

NTTG follows a two-year, eight-quarter planning cycle to produce the 10-year Regional Transmission Plan. In the first step, the Planning and Cost Allocation Committees pre-qualify[3] Transmission Developers who properly submit their transmission project to be considered for regional cost allocation (should the sponsor's project be selected in the Regional Transmission Plan for cost allocation). The biennial cycle includes steps to collect, evaluate and analyze transmission and non-transmission data, produce and publish a draft plan, gather stakeholder and public input, update the plan and complete the cycle with the publishing of a RTP.

NORTHERN TIER TRANSMISSION GROUP
EIGHT-QUARTER BIENNIAL PROCESS

FIGURE 2

NTTG uses an eight-quarter biennial planning cycle.

[3]Pursuant to Attachment K, Section Pre-qualify for Cost Allocation, a Project Sponsor that intends to submit a project for cost allocation must be pre-qualified before the beginning of the 2016-2017 biennial planning cycle (i.e., the last quarter of the prior planning cycle).

BIENNIAL STUDY PLAN

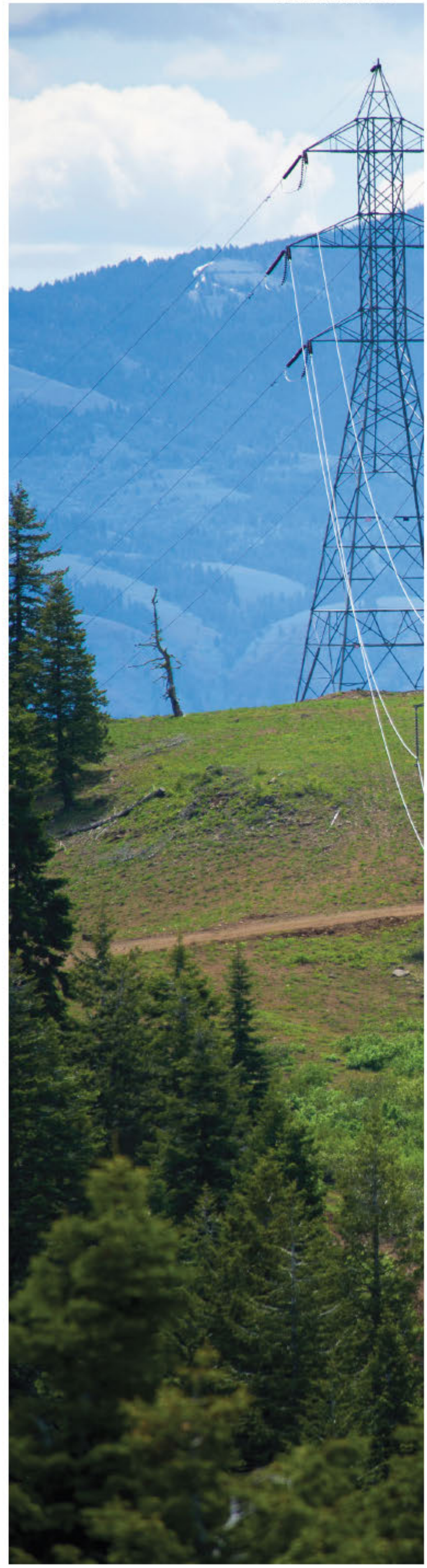
The biennial study plan outlines the process that NTTG follows to develop its 10-year RTP. It provides the framework to guide plan development. It also describes NTTG's process to determine if a properly submitted Interregional Transmission Project (ITP) would yield a transmission plan that is a more cost-effective or efficient solution to NTTG's regional transmission needs.

The NTTG Planning Committee manages the study plan. The Planning Committee establishes the Technical Work Group (TWG) subcommittee to develop the study plan. The TWG also performs the necessary technical evaluations for the RTP and assesses any projects, including ITPs, submitted to NTTG. TWG members are NTTG Planning Committee members or their designated technical representatives. They have access to and expertise in power-flow analysis for power systems or production-cost modeling, or both.

Developed during Quarter 2 of the biennial planning cycle, the study plan establishes the:

- **Study methodology and criteria**
- **Study assumptions based on the loads, resources, point-to-point transmission requests, desired flows, constraints and other technical data submitted in Quarter 1 and updated in Quarter 5 of the regional planning cycle**
- **Software analysis tools**
- **2026 production-cost-model database and hours to be selected for reliability analysis**
- **Evaluation criteria for reliability and transmission service obligations**
- **Capital cost, energy losses and reserve-sharing metric calculations**
- **Public Policy Requirements and Public Policy Considerations**

The study plan was posted for stakeholder comment, recommended for approval by the Planning Committee and approved by the Steering Committee during Quarter 2 of the biennial cycle. Due to data submission updates provided in Quarter 5, the study plan was revised in Quarter 6. Any differences between what is stated in the study plan and the process stated in the NTTG Transmission Providers' FERC Order 1000 Attachment K defer to Attachment K.



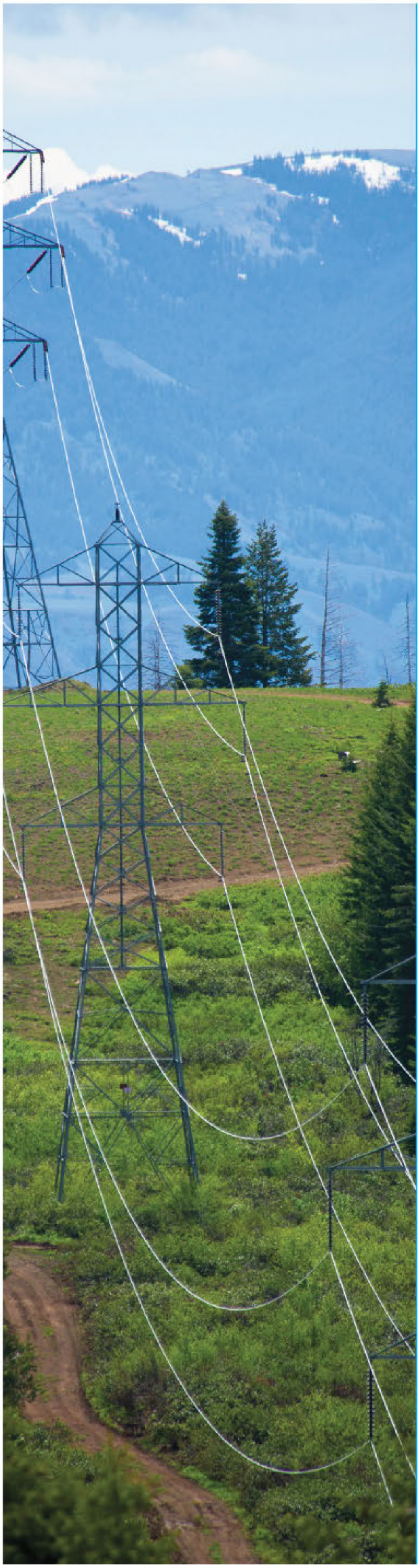
STUDY METHODOLOGY

To determine the more efficient or cost-effective transmission plan, the TWG subcommittee conducted reliability and economic studies in accordance with the 2016-2017 Study Plan. The Study Plan and ultimately the RTP reflect the NTTG Transmission Providers' Attachment K requirements to satisfy its transmission needs. NTTG's regional transmission planning does not investigate local transmission planning or generation decisions related to integrated resource planning. Rather, NTTG's methodology uses a regional perspective to question the Initial RTP's roll-up of Non-Committed regional transmission project(s) to identify, if possible, a regional transmission plan that is more efficient or cost effective than the aggregated Full Funder's transmission plans. In conducting its regional studies, NTTG uses regional transmission and non-transmission alternatives (if any) to honor the local transmission needs. As part of the study, NTTG assumed that the local existing and new generation additions have (or will have) firm transmission rights to move their power from the generator to load. NTTG's reliability studies did not re-dispatch existing generation down to relieve congestion such that the new generation additions could move their power to load without potentially creating congestion.

The reliability studies used production-cost modeling and power-flow studies. The production-cost and power-flow models represent data for the western interconnection load, resource and transmission topology. In developing the data for these two models, NTTG started with a WECC production cost model (version TEPPC CC1.3) and WECC power-flow model (version 25hs1a) and modified the modeling data in NTTG's footprint for its regional studies. For the studies including one or more interregional transmission projects that relied on increased wind generation within NTTG's footprint (e.g., adding new wind resource in Wyoming), NTTG adjusted generation levels down in the region receiving the power. The goal of the adjustments was to ensure western interconnection load and resource balance. NTTG consulted with the planning region receiving the power (i.e., California ISO) for their generation reductions.

The results of the production-cost modeling were used to identify seven hours of high stress on the transmission system. These seven hours were then subjected to reliability analysis using a power-flow model. The input and output data for these selected hours were transferred from the production-cost model (i.e., GridView) to a power-flow model (i.e., PowerWorld) to perform the technical reliability analysis. By taking these steps, a consistent set of analysis tools and data can be engaged to evaluate the reliability performance.

Next, economic studies employed the Attachment K's three metrics—capital-related costs, energy losses, and reserves—to analyze Change Case plans that were deemed reliable to further determine the cost effectiveness of the NTTG transmission plan.



Production-Cost Modeling

The TWG examined 8,760 hours of data using GridView[4] production-cost software to establish stressed conditions within the NTTG footprint. To set the stressed conditions, the TWG used and modified a dataset from the Transmission Expansion Planning Policy Committee (TEPPC) of the WECC. The TEPPC case included a representation of the load, generation and transmission topology of the WECC interconnection-wide transmission system 10 years into the future.

The study plan identified seven stressed conditions that affect the NTTG area for study. After all hours of data were run through the GridView production-cost program, the results were analyzed and the hours representative of the seven stressed conditions were identified. For a more detailed discussion of the conditions and hours, see the section on stress-conditioned case study results.

Power-Flow Cases

For the next step in the process, the TWG used PowerWorld[5] simulation software to convert the production-cost model for the seven stressed hours into power-flow cases. Each of the stressed cases was then reviewed by the TWG to ensure that the case met steady-state system performance criteria (no voltage issues or thermal overloads). Bubble diagrams showing the inter-area flows for each of the stressed cases are included in the Draft Final RTP, available on the NTTG website.

DATA SUBMISSION

Information flows into NTTG during Quarter 1 and Quarter 5 of the biennial cycle. Transmission Providers and stakeholders may supply data on forecasted firm energy obligations and commitments required to support the transmission system within the NTTG footprint. The data may include load forecasts, resources, transmission topology, transmission service and Public Policy Requirements submissions. Regional transmission projects submitted in Quarter 1 are shown in Table 1 and include those from the prior Regional Transmission Plan, Transmission Provider Local Transmission Plans (LTP), Sponsored Projects, unsponsored projects and Merchant Transmission Developer projects. No projects that were eligible for cost allocation were submitted into NTTG's 2016-17 regional planning process.

230-kV double-circuit transmission line between Idaho Power's Oxbow and Hells Canyon hydroelectric projects.
Photo courtesy of Idaho Power

[4]GridView is a registered ABB product
[5]PowerWorld is a registered trademark of PowerWorld Corp.

SPONSORED TRANSMISSION PROJECTS

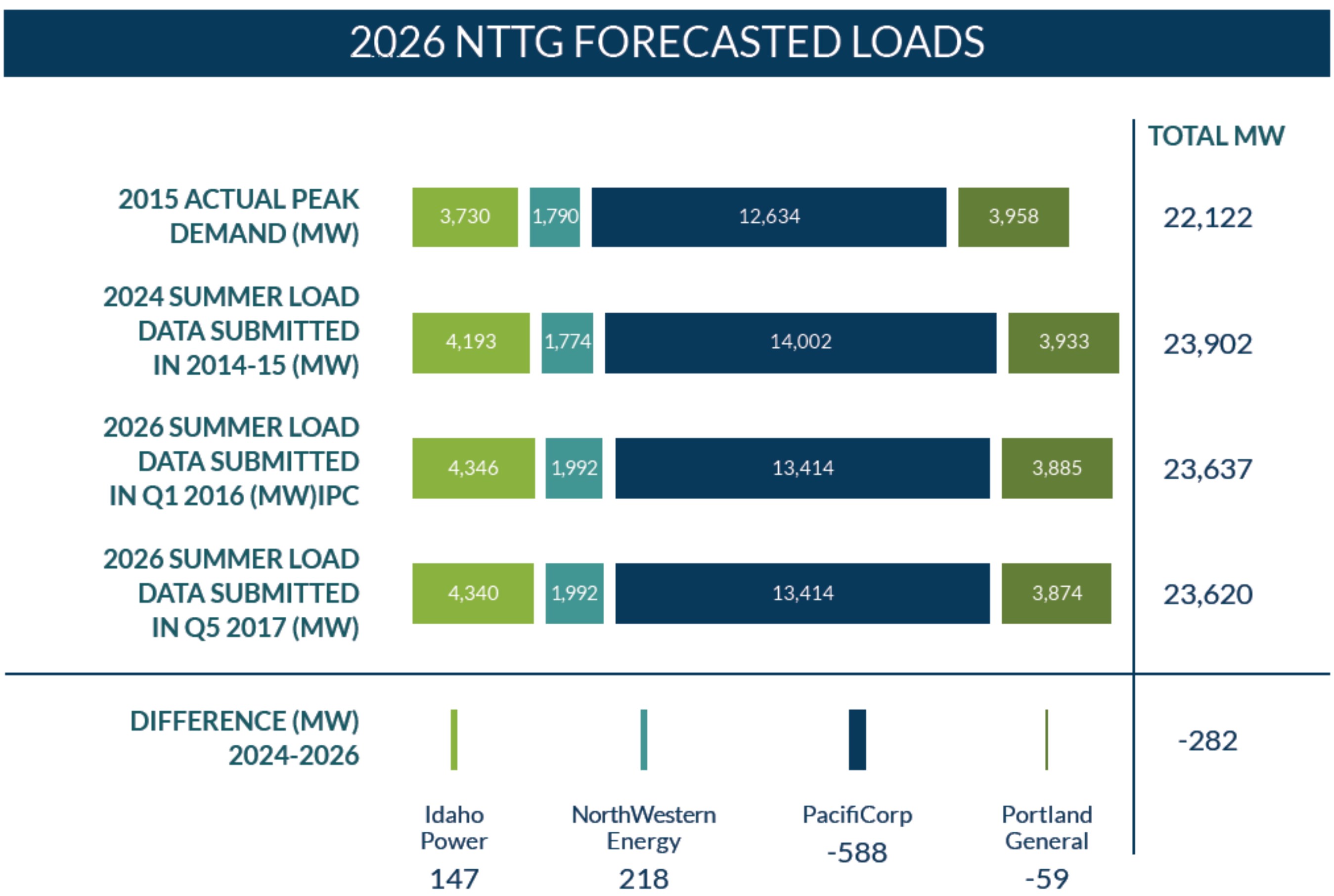
SPONSOR	FROM	TO	VOLTAGE	CIRCUIT	TYPE	REGIONALLY SIGNIFICANT[6]	COMMITTED	PROJECTS
DESERET G&T	Bonanza	Upalco	138 kV	2	LTP	No	No	New Line
IDAHO POWER	Longhorn	Hemingway	500 kV	1	LTP & pRTP[7]	Yes	No	Boardman to Hemingway (B2H) Project
	Hemingway	Bowmont	230 kV	2	LTP	Yes	No	New Line (associated with Boardman to Hemingway)
	Bowmont	Hubbard	230 kV	1	LTP	Yes	No	New Line (associated with Boardman to Hemingway)
	Cedar Hill	Hemingway	500 kV	1	LTP	Yes	No	Gateway West Segment #9 (joint with PacifiCorp East)
	Cedar Hill	Midpoint	500 kV	1	LTP	Yes	No	Gateway West Segment #10
	Midpoint	Borah	500 kV	1	LTP	Yes	No	(convert existing from 345 kV operation)
	King	Wood River	138 kV	1	LTP	No	No	Line Reconductor
	Willis	Star	138 kV	1	LTP	No	No	New Line
MATL	SE Alberta		DC	1	LTP	Yes	No	MATL 600 MW Back to Back DC Converter
PACIFICORP EAST	Aeolus	Clover	500 kV	1	LTP & pRTP	Yes	No	Gateway South Project – Segment #2
	Aeolus	Anticline	500 kV	1	LTP & pRTP	Yes	No	Gateway West Segments 2&3
	Anticline	Jim Bridger	500 kV	1	LTP & pRTP	Yes	No	345/500 kV Tie
	Anticline	Populus	500 kV	1	LTP & pRTP	Yes	No	Gateway West Segment #4
	Populus	Borah	500 kV	1	LTP	Yes	No	Gateway West Segment #5
	Populus	Cedar Hill	500 kV	1	LTP	Yes	No	Gateway West Segment #7
	Antelope	Goshen	345 kV	1	LTP	Yes	No	Nuclear Resource Integration
	Antelope	Borah	345 kV	1	LTP	Yes	No	Nuclear Resource Integration
	Windstar	Aeolus	230 kV	1	LTP & pRTP	Yes	No	Gateway West Segment #1W
	Oquirrh	Terminal	345 kV	2	LTP	Yes	Yes	Gateway Central
	Cedar Hill	Hemingway	500 kV	1	LTP	Yes	No	Gateway West Segment #9 (joint with Idaho Power)
PACIFICORP WEST	Wallula	McNary	230 kV	1	LTP	Yes	Yes	Gateway West Segment A
PORTLAND GENERAL	Blue Lake	Gresham	230 kV	1	LTP	No	No	New Line
	Blue Lake	Troutdale	230 kV	1	LTP	No	No	Rebuild
	Blue Lake	Troutdale	230 kV	2	LTP	No	No	New Line
	Horizon	Springville Jct	230 kV	1	LTP	No	No	New Line (Trojan-St Marys-Horizon)
	Horizon	Harborton	230 kV	1	LTP	No	No	New Line (re-terminates Horizon Line)
	Trojan	Harborton	230 kV	1	LTP	No	No	Re-termination to Harborton
	St Marys	Harborton	230 kV	1	LTP	No	No	Re-termination to Harborton
	Rivergate	Harborton	230 kV	1	LTP	No	No	Re-termination to Harborton
	Trojan	Harborton	230 kV	2	LTP	No	No	Re-termination to Harborton

[6]Regionally significant transmission projects are generally those that effect transfer capability between areas of NTTG. Projects that are mainly for local load service are not regionally significant. Projects that are not regionally significant will be placed into all change cases and not tested for impact on the Regional Transmission Plan. The future facilities submitted in the LTP's will be removed in the null case.
[7]Prior RTP.

TABLE 1
January 2016 data submittal—transmission additions by 2026.

Forecasted Loads

Participating load-serving entities provide forecasts of loads for balancing authority areas internal to the NTTG footprint. These loads are generally the same as those found in the participants' official load forecasts (such as those in integrated resource plans) and are similar to those provided to the Load and Resource Subcommittee of the WECC Planning Coordination Committee. Figure 3 summarizes the load forecast used in the 2016-2017 planning cycle.



NTTG received 3,200 MW of proposed new generation resources from its funding Transmission Providers for consideration in the RTP. Figure 4 displays these incremental resources within the NTTG footprint and compares submissions from the prior RTP with submissions for Quarter 1 and Quarter 5 of the current cycle.

FIGURE 3
2026 NTTG forecasted loads. Loads for Deseret G&T and UAMPS are included in PacifiCorp East.

COMPARISON OF FORECASTED RESOURCES (MW)

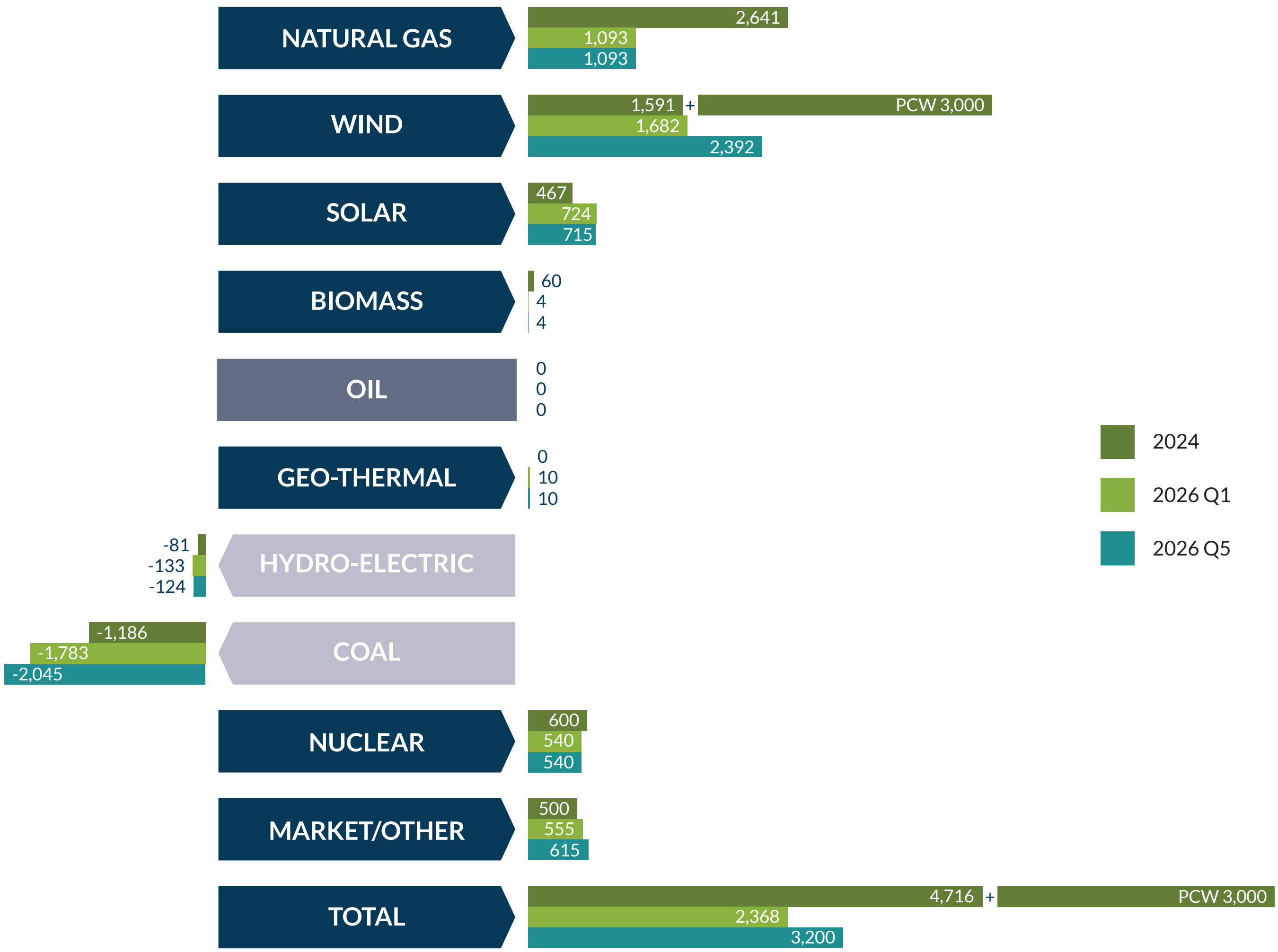


FIGURE 4. Comparison of forecasted resources.

In the 2014-15 study cycle, Power Company of Wyoming (PCW) submitted 3,000 MW of wind resources associated with the TransWest Express project. PCW asked that those resources not be included in the NTTG 2014-15 Regional Plan, and those resources have been shown separately in Figure 4. For the 2016-17 study cycle, the 3,000 MW has been excluded from the NTTG totals. Those resources, to serve loads outside the NTTG footprint in California, have been submitted with an Interregional Transmission Project in the 2016-17 study cycle.

In Quarter 5, NorthWestern submitted 550 MW of new Montana wind generation. Also PacifiCorp indicated that its recently submitted integrated resource plan increased the amount of Wyoming wind power from 887 MW to 1,100 MW. As shown in Figure 4, the total resource forecast of 3,200 MW submitted this cycle was reduced by 1,516 MW, or 32.1 percent, from the 4,716 MW forecast in 2024. Following the Quarter 1 data submittal, the owners of the Colstrip 1 and 2 coal-fired plants announced a plan to retire the units before 2026. The owners of the Valmy 1 and 2 coal plants in Nevada also plan to decommission the plants by 2025, a decade earlier than originally planned. Both sets of retirements were assumed in the 2016-2017 studies and are reflected in Quarter 5 values shown in Figure 4.

In support of the proposed transmission additions or upgrades, NTTG received four firm transmission-service-obligation submissions (contractual requirements to provide service)—two each from Idaho Power and PacifiCorp. These are shown in the following map.

FIGURE 5
Transmission Service Obligations.

PUBLIC POLICY CONSIDERATION SCENARIO REQUESTS

In Quarter 1, Renewable Northwest (RNW) and the Northwest Energy Coalition (NWEC) jointly submitted a Public Policy Consideration request for a scenario analysis study. The group asked NTTG to study a faster phase-out of coal plants while developing utility-scale renewable resources and replacing Colstrip units 1, 2 and 3 with either wind only or a combination of wind and natural gas simple/combined cycle resource.

Members of the TWG and representatives from RNW and NWEC reviewed the request and agreed to some modifications. These modifications, and the associated study assumptions, are documented in the NTTG 2016-2017 Study Plan, Attachment 3 of the Draft Final RTP.

The study results suggested that a replacement of wind or a combination of wind and gas for coal may be feasible. This study, however, neither constituted a path study nor conveyed or implied transmission rights. Additional analysis would be required to understand the full impacts of coal plant decommissioning.

Public Policy Considerations are considered to be relevant factors not established by local, state or federal laws or regulations. The results of PPC analysis may inform the RTP but do not result in the inclusion of additional projects in the RTP.

A full report of the study can be found in Appendix D of the NTTG 2016-2017 Draft Final RTP.

REGIONAL ECONOMIC STUDY REQUESTS

NTTG received no regional economic study requests.

INITIAL REGIONAL TRANSMISSION PLAN DEVELOPMENT

The starting point for the biennial planning process was development of the Initial RTP. This exercise used a bottom-up approach to merge the projects in the prior RTP (2014-2015) and the NTTG Transmission Providers' local transmission plans into a single regional transmission plan. Next, the TWG analyzed the Initial RTP through Change Case plans, which included or excluded Non-Committed regional projects and Interregional Transmission Projects. These Change Case plans helped to determine whether Alternative Projects could be added or substituted, or if one or more Non-Committed Projects could be deferred, or both, to yield a regional transmission plan more efficient or cost effective than the Initial RTP. The results of this analysis led to the formation of the Draft RTP.

FIGURE 6

2014-2015 Prior Regional Transmission Plan: The turquoise and green lines represent the projects comprising the prior RTP from 2014-2015. These include Boardman to Hemingway, in the northwest sector of the map, and an Alternative Project with four transmission elements across four states.

FIGURE 7

Map showing Non-Committed regional projects comprising the 2016-2017 Initial RTP.

- Boardman to Hemingway
- Gateway West
- Gateway South
- Antelope

INTERREGIONAL PROJECT COORDINATION

As part of interregional coordination, NTTG and the other regional entities in the Western Interconnection collaborate during their transmission planning processes to coordinate their interregional transmission planning data. These coordination efforts inform each planning region's transmission plans. A properly submitted Interregional Transmission Project is evaluated as an Alternative Project in NTTG's regional planning process. The set of uncommitted projects (regional, interregional or both) that result in the more efficient or cost-effective plan forms the Regional Transmission Plan.

SUMMARY OF Q1-2016 INTERREGIONAL PROJECTS SUBMITTED TO NTTG

PROJECT NAME	COMPANY	RELEVANT PLANNING REGION(S)	TERMINATION FROM	TERMINATION TO	STATUS	IN SERVICE DATE
CROSS-TIE TRANSMISSION PROJECT	TransCanyon, LLC	NTTG, WestConnect	Clover, UT	Robinson Summit, NV	Conceptual	2024
SWIP-NORTH	Great Basin Transmission LLC	NTTG, WestConnect	Midpoint, ID	Robinson Summit, NV	Permitted	2021
TRANSWEST EXPRESS TRANSMISSION PROJECT	TransWest Express, LLC	NTTG, WestConnect and CAISO	Sinclair, WY	Boulder City, NV	Conceptual	2020

TABLE 2

Three Interregional Transmission Projects were submitted for consideration during formation of the Initial RTP in Quarter 1 of the biennial cycle.

FIGURE 8
Three Interregional Transmission Projects were evaluated during the planning cycle.

Southwest Intertie Project (SWIP)

Great Basin Transmission, LLC (GBT), an affiliate of LS Power, submitted the 275-mile northern portion of the Southwest Intertie Project (SWIP) as an ITP. SWIP-North would connect the Midpoint 500-kV substation in NTTG's planning area to the Robinson Summit 500-kV substation in the WestConnect area with a 500-kV single-circuit AC transmission line. The SWIP is expected to have a bi-directional WECC-approved path rating of approximately 2,000 MW. If GBT is selected to build SWIP-North, development, final design and construction activities could be completed to support energizing the project within an estimated 36-42 months.

Cross-Tie Transmission Line

TransCanyon submitted the 213-mile Cross-Tie Transmission Line for consideration as an ITP. TransCanyon proposes to build a 1500-MW, 500-kV high-voltage alternating current (HVAC) line between central Utah and east-central Nevada. The line would connect PacifiCorp's proposed 500-kV Clover substation with the existing 500-kV Robinson Summit substation. TransCanyon expects the project to be in-service by the end of 2024.

TransWest Express Transmission Project

TransWest proposed a 730-mile, phased 1,500/3,000 MW, ±600 kV, high-voltage direct current (HVDC) transmission system with terminals in south-central Wyoming and southeastern Nevada. The federal Bureau of Land Management and Western Area Power Administration published the Final Environmental Impact Statement (FEIS) for the TWE Project in May 2015.

STRESS-CONDITIONED CASE STUDY RESULTS

Stressed Hours for Study with Production-Cost Modeling

The TWG used GridView production-cost software to review 8,760 hours of data to identify stressed conditions within the NTTG footprint. A case representing the year 2026 was obtained from the WECC TEPPC. This case included a representation of the load, generation and transmission topology of the WECC interconnection-wide transmission system 10 years in the future. The TWG identified corrections to the data needed to align with data submitted in the first quarter of the biennial planning cycle. The TWG shared these changes with the other regional planning entities and WECC to include in their future studies. The TWG then agreed to use this modified TEPPC case in creating the stressed cases discussed below.

After processing all 8,760 hours through the production-cost program, the TWG analyzed the data and identified seven stressed conditions to study, as shown in Table 3.

2026 SELECTED HOURS

STRESSED CONDITION	DATE	HOUR	TWG LABEL
MAX. NTTG SUMMER PEAK	July 22, 2026	16:00	A
MAX. NTTG WINTER PEAK	December 8, 2026	19:00	B
MAX. MT TO NW	September 10, 2026	Midnight	C
HIGH SOUTHERN IDAHO IMPORT	June 11, 2026	14:00	D1
HIGH SOUTHERN IDAHO EXPORT	September 17, 2026	2:00	D2
HIGH TOT2 FLOWS	November 11, 2026	17:00	E
HIGH WYOMING WIND	September 17, 2026	2:00	F

TABLE 3
Hours selected from 2026 WECC TEPPC case to represent different NTTG system stresses.

SEVEN STRESSED CASES

Time
Demand
Supply
Import
Export

HIGH SUMMER PEAK (NTTG CASE A)

4PM, 07/22/2026
24,100 MW
17,851 MW
6,250 MW

This case showed a need to import energy during high summer air-conditioning loads. The transmission projects in the Initial RTP performed reasonably well; however, system performance proved inadequate without transmission system additions by 2026 to meet NTTG's summer peak load. This case accounted for wind resources of 2,175 MW to check the performance of the set of projects comprising the Draft RTP.

HIGH WINTER PEAK (NTTG CASE B)

7PM, 12/08/2026
22,468 MW
19,261 MW
3,208 MW

A few local system violations occurred when tested against the transmission projects comprising the Initial RTP. This case puts less stress on the NTTG system than did the summer peak. This case also accounted for wind resources of 2,175 MW to check the performance of the Draft RTP projects.

HIGH MONTANA-NW (PATH 8) FLOWS (NTTG CASE C)

12AM, 09/10/2026
13,097 MW
12,138 MW
959 MW

This case tested transmission system capabilities with high electricity flows from Montana to the Northwest. This scenario was used for the Public Policy Consideration study, which analyzed the impact of an accelerated phase-out of Colstrip units 1, 2 and 3 with either wind only or a combination of wind and gas. See the Public Policy Consideration Scenario Requests section for results of the study.

HIGH SOUTHERN IDAHO IMPORT (NTTG CASE D1)

2PM, 06/11/2026
16,382 MW
9,159 MW
7,223 MW

Under conditions with the eastbound path from the Northwest to Idaho operating at a 2,244 MW deficit, and the NTTG system importing 7,223 MW, the NTTG transmission topology could not import enough power to support load service obligations in southern Idaho. With the addition of transmission projects comprising the Initial RTP, however, the NTTG system would perform well, with a few local violations.

HIGH SOUTHERN IDAHO EXPORT (NTTG CASE D2)

2AM, 09/17/2026
11,935 MW
14,683 MW
2,748 MW

In this export scenario, with the Idaho to Northwest Path 8 flow at 3,391 MW, the existing NTTG system would be incapable of supporting expected transfers and meeting transmission requirements in 2026. Adding in the projects from the Initial RTP, the system performed well, with one contingency that caused a series capacitor bank to overload. That bank, however, has reached the end of its useful life and is likely to be replaced before 2026.

HIGH NE-SE (PATH TOT2) FLOWS (NTTG CASE E)

5PM, 11/11/2026
16,625 MW
16,620 MW
5 MW

This case evaluated the performance of the Interregional Transmission Projects in supporting transfers between regions. These additional interregional transfers were not identified in Q1 to meet or defer NTTG's 2026 footprint resource requirements. The case showed near balance in the NTTG footprint between loads and resources, with a small 5 MW import, along with a Tot2 flow of 1,566 MW. This case accounted for wind resources of 2,175 MW to check the performance of the Draft RTP.

HIGH WYOMING WIND PRODUCTION (NTTG CASE F)

2AM, 09/17/2026
15,015MW
11,935 MW
3,081 MW

This case, as others, was studied at the 2,175-MW wind level, which includes the addition of 1,100 MW of wind capacity. The thermal dispatch in this case was at a typical high level of 3,580 MW. The added wind generation in the Wyoming area worsened reliability issues observed in Wyoming and confirmed the need for additional transmission to use these resources to their fullest extent. The RTP addresses these reliability concerns and relieves the transmission constraints.

DEVELOPMENT OF CHANGE CASES

For each of the seven stress-conditioned cases, the TWG prepared a null Change Case and analyzed reliability results. The null case represents roughly today's transmission topology made to serve loads and resource requirements in 2026. Only the Heavy Winter case performed acceptably. All the other conditions revealed performance issues that required varying degrees of correction, with the heavy summer case needing the least correction and the high Wyoming wind case needing the most. In instances where the transmission system was not adequately stressed to historical norms, the TWG slightly modified system conditions to ensure that the transmission system was studied under reasonably stressed conditions.

CHANGE CASE RESULTS

To efficiently study the wide range of potential combinations of Non-Committed Projects, the TWG proposed a Change Case matrix in the study plan. Once the stressed power-flow cases had been selected and developed, the TWG modified the matrix to better reflect the recommended analysis. The TWG provided stakeholders with the opportunity for input on whether a particular combination of uncommitted regional or interregional projects should be analyzed. No comments were received. The matrix was subsequently vetted through the Planning Committee and the Steering Committee.

Figure 9 is the Change Case matrix used by the TWG.

Trucks haul wind turbine blades to PacifiCorp's 111-MW Dunlap Wind Project near Medicine Bow, Wyo. Photo courtesy of PacifiCorp

CHANGE CASE MATRIX

CASE	B2H	GATEWAY S*	GATEWAY W*	ANTELOPE PROJECTS	SWIP N	CROSS-TIE	TWE	STRESSED CONDITIONS
null								A B D1 D2 F
pRTP	X	X	d					A B D1 D2 F
iRTP	X	X	X	X				A B D1 D2 E F
CC1	X							A B D1 D2 F
CC2		X		X				A D2 E F
CC3		X	X					A B D1 D2 E F
CC4	X		X	X				A B D1 D2 E F
CC5							X	A B D1 D2 F
CC6						X		A B D1 D2 F
CC7					X			A B D1 D2 F
CC8							X	E+RPS
CC9		X					X	E+RPS
CC20		X	X				X	E+RPS
CC10						X		E+RPS
CC11		X				X		E+RPS
CC18		X	X			X		E+RPS
CC12					X			E+RPS
CC13			X		X			E+RPS
CC19		X	X		X			E+RPS
CC14		X	X		X	X		E+RPS
CC15			X		X		X	E+RPS
CC16		X				X	X	E+RPS
CC17		X	X		X	X	X	E+RPS
CC21	X	X	a	X				D2 F
CC22	X	X	b	X				D2 F
CC23	X	X	c	X				A B D1 D2 E F

*B2H and Alternate Project in the pRTP are similar to B2H, Gateway S and Gateway W in the 2016-17 Q1 data submittals

The change case does not include the non-Committed Project

X The change case includes the non-Committed Project

a Gateway West without Midpoint-Hemingway #2 and Cedar Hill-Midpoint

b Gateway West without Borah-Midpoint Uprate and Populus-Borah

c Gateway West without Midpoint-Hemingway #2, Cedar Hill-Midpoint and Populus-Borah

d Gateway West without Midpoint-Hemingway #2, Cedar Hill-Midpoint and Populus-Cedar Hill-Hemingway, Populus-Borah and Midpoint-Borah Uprate

The change case was run with and without B2H

FIGURE 9
Change Case matrix used in the development of the RTP.

In all, the TWG performed more than 100 reliability studies with more than 410 contingencies in each study. To better communicate the results of these studies, the TWG created heat maps, which present a weighted[8] graphical performance of a Change Case on a specific flow condition. A full heat map analysis of the Change Cases is included in the final Draft RTP.

Figure 10, for example, shows the general location where performance issues (e.g., an overloaded transmission line) occurred for a contingency. The accumulation of overloads and voltage issues are represented by the color spectrum from blue to red, or "cooler" to "hotter." These violations occur when transmission systems cannot handle anticipated transfers across that area's transmission lines. In particular, this heat map, using existing Wyoming wind resources dispatched at about 600 MW, indicates that transmission additions are necessary to integrate the projected wind resources.

The heat map in Figure 11 shows how the addition of the Initial RTP projects produced a dramatic improvement of transmission performance when compared with the null case.

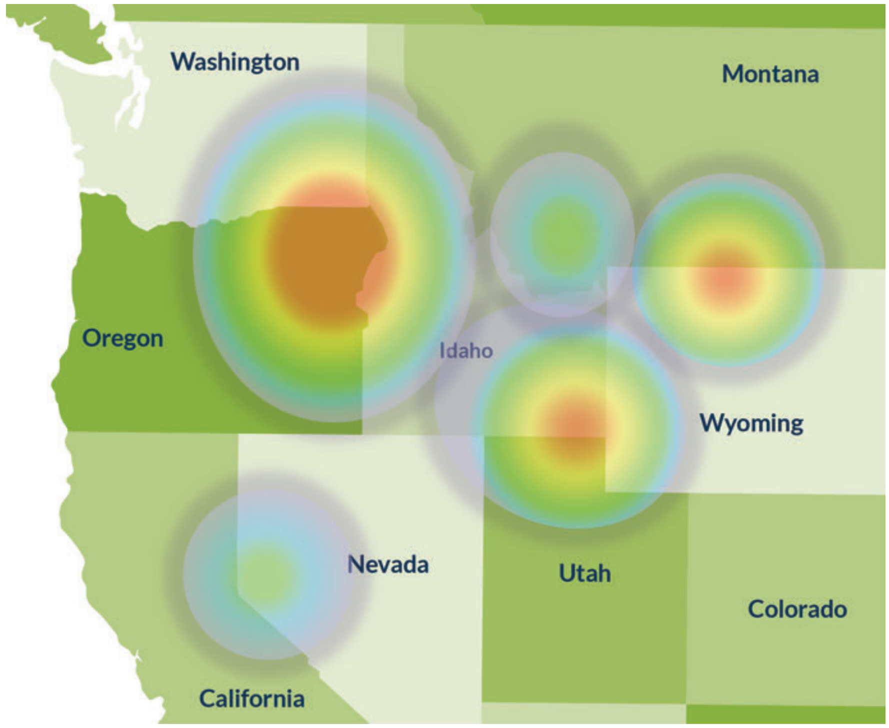


FIGURE 10
Heat map of the D2-Null Case.

FIGURE 11
Heat map of the High Southern Idaho export case with the Initial RTP facilities included.

[8]High voltage conditions had a weighting of 1; low-voltage conditions had a weighting of 3; and overloads of branches had a weighting of 5. For example, a zone in which 10 contingencies caused an overload of one branch in that zone would receive a total weight of 50 (i.e., 10 x 5), which would then be translated into a color on the map. A blue color represents a weighted total of about 10, green is a count up to 30, yellow is a count up to 50 and red is for a weighted count exceeding about 70.

High Southern Idaho Import Case

Combining the Boardman to Hemingway project with the Gateway West and Gateway South Non-Committed Projects eliminated violations in flow conditions visible in the null case. Change Case 3 tested whether Gateway West or Gateway South, or both, could replace or compare with the Boardman to Hemingway line. They couldn't. The projects contained in the prior RTP also failed to alleviate the violations.

High Southern Idaho Export Case

Adding the Boardman to Hemingway project relieved stress across the Idaho-Northwest cutplane, but significant issues remained east of Hemingway. Adding the eastern portion of Gateway West and Gateway South outlined in the prior RTP eliminated the performance issues in Wyoming and between Idaho and Montana, but those additions increased the stress across southern Idaho. The Initial RTP and Change Cases 21 and 23 resolved these issues.

High Wyoming Wind Case

Without significant reinforcements, the transmission system in Wyoming could not handle both existing and future planned wind resources while maintaining all other Wyoming area generating resources at their typical high capability in an export scenario.

With wind production at the 1,300-MW level in the null case (no new transmission supporting 2026 loads), the system performed poorly. Nor did the projects in the prior RTP solve problems. Adding the Initial RTP projects resolved all violations except for a series capacitor bank. That bank has reached the end of its useful life, however, and is due for replacement.

In Quarter 6, the case was tested to see if Change Cases 1 through 4 would support the increased level of Wyoming wind. The null case (no new transmission) was unable to be solved with wind above 1,800 MW. Testing Change Case 4 required adding the Aeolus-Anticline 500-kV line (Case 4a) to eliminate a number of contingencies that failed to solve in Wyoming. Change Case 23, which is essentially Change Case 4a with Gateway South added, performed well with Wyoming wind modeled at 2,175 MW.

Interregional Transmission Projects

Change Cases 5 through 20 tested whether the three Interregional Transmission Projects (ITP)—alone, in combination with other ITPs or in combination with the Non-Committed Projects—could satisfy NTTG's transmission needs on a regional or interregional basis more efficiently or cost effectively than through local planning processes. The ITPs were added to the null cases without any additional resources to serve NTTG load beyond those resources identified in the Quarter 1 and Quarter 5 data submittals. Testing showed the ITPs did not provide the NTTG footprint with regional benefits either by significantly reducing performance issues or by displacing NTTG Non-Committed Projects.

The Initial RTP also was analyzed to determine whether it would be capable of supporting the interregional resource transfers proposed by the ITPs. Given the relatively long distances of the ITPs, the local integration performance issues identified in Wyoming were solvable.

RELIABILITY CONCLUSIONS

Based on the above study results, the TWG concluded that the Initial RTP shown in Figure 7 and two variants, Change Cases 21 and 23, satisfy NTTG reliability criteria. In Quarter 5, the TWG tested Change Case 23 and the wind resource additions at various load and flow levels on the Heavy Summer, Heavy Winter, High Tot2 and High Wyoming wind cases. The TWG study found the NTTG area would be reliably served in the year 2026 only by including the following Non-Committed regional projects:

Boardman to Hemingway

The Energy Gateway projects including segments:

- **Windstar–Aeolus 230 kV**
- **Aeolus–Clover 500 kV**
- **Aeolus–Anticline 500 kV**
- **Anticline–Populus 500 kV**
- **Populus–Cedar Hill–Hemingway 500 kV**
- **Borah-Midpoint 345 kV uprate to 500kV**

Antelope Transmission Project including:

- **Antelope–Borah 345 kV**
- **Antelope–Goshen 345 kV**
- **Antelope 345/230 kV transformers and interconnection facilities**

The ITPs were evaluated to determine whether one or more of them could defer or replace NTTG's Non-Committed Projects. The TWG concluded that none of the ITPs resolved NTTG's reliability performance issues and, thus, were not included in the Draft Final NTTG RTP.

ECONOMIC EVALUATIONS

To determine whether the Initial RTP or a Change Case transmission plan was more cost effective, the TWG used three economic metrics, as determined in the biennial study plan. The three metrics—capital-related costs, power flow losses and reserves—and results are discussed below.

Capital-related Cost Metric

Development of the capital-related cost metric required three steps. The first step validated the capital cost of the Project Sponsor's Quarter 1 submitted project. The second step used those results to estimate the annual capital-related costs. The third step levelized the net present value annual capital-related costs for the Initial RTP and the Change Case plans.

Energy-loss Metric

The energy-loss metric captures the change in energy generated, based on system topology, to serve a given amount of load. A reduction in losses for a Change Case would represent a benefit, since less energy would be required to serve the same load. The two Change Cases with fewer Gateway West transmission segments—Change Cases 21 and 23—had losses higher than, or in some cases equal to, the Initial RTP. Losses were higher in the two Change Cases because the electrical flows in the Initial RTP were redistributed to fewer lines. From a loss perspective alone, the Initial RTP case had fewer losses and as such was the more efficient case.

Reserve Metric

The reserve metric evaluates the opportunities for two or more parties to save money by sharing a generating resource that would be enabled by transmission. The metric is a 10-year look at the increased load and generation additions in the NTTG footprint and the incremental transmission additions that may be included in the RTP.

In the study cycle, the TWG analyzed Gateway West, Gateway South, Boardman to Hemingway, SWIP North and the Cross-Tie projects. To evaluate these projects, the NTTG footprint was segmented into five zones, and a sixth external zone was included to study the SWIP North and the Cross-Tie projects. The six zones produced 122 viable sharing combinations. Of those, the analysis of the annual net savings over each theoretical participant's standalone alternative suggested that only 34 viable combinations were economic.

Note that this metric includes generation capital costs in its evaluation and, as such, may only be appropriate for cost allocation purposes. It should not drive the selection of a RTP. Whether these cost savings warrant jointly sharing the costs of reserve capacity is up to the parties to decide.

For the NTTG metric analysis, the Initial RTP and the two alternative Change Cases each supported viable economic combinations. Since these Change Cases could contain the same benefit value, the Change in Reserve metric did not factor into the RTP selection decision.

Economic Metric Analysis Conclusion

The sum of the annual capital-related cost metric, loss metric (monetized) and reserve metric (monetized) yielded an incremental cost for the Initial RTP and the Change Case plans. The set of projects with the lowest incremental cost, after adjustment by the plan's effects on neighboring regions—Change Case 23 (see Figure 12, below)—was then incorporated into the RTP. Note that the incremental cost was computed as the levelized annual capital-related cost, minus NTTG loss benefit, minus monetized reserve benefit.

FIGURE 12
Change Case 23, comprising Boardman to Hemingway, Gateway South, portions of Gateway West, and the Antelope projects, produced the lowest incremental cost.

PLANNING PROCESS FLOW MAP

INITIAL REGIONAL PLAN (IRP)
NON-COMMITTED PROJECTS

- Boardman to Hemingway (B2H)
- Energy Gateway South (Gateway S)
- Energy Gateway West (Gateway W)
- Antelope Projects

INTERREGIONAL TRANSMISSION PROJECTS

- SWIP North (SWIPN)
- Cross Tie
- TransWest Express (TWE)

CHANGE CASES CONSIDERED

CASE	B2H	GATEWAY S*	GATEWAY W*	ANTELOPE PROJECTS	SWIPN	CROSS-TIES	TWE
null							
pRTP	X	X	D				
iRTP	X	X	X	X			
CC1	X						
CC2		X		X			
CC3		X	X				
CC4	X		X	X			
CC5							X
CC6						X	
CC7					X		
CC8							X
CC9		X					X
CC20		X	X				X
CC10						X	
CC11		X				X	
CC18		X	X			X	
CC12					X		
CC13			X		X		
CC19		X	X		X		
CC14		X	X		X	X	
CC15			X		X		X
CC16		X				X	X
CC17		X	X		X	X	X
CC21	X	X	A	X			
CC22	X	X	B	X			
CC23	X	X	C	X			

FINAL REGIONAL TRANSMISSION PLAN

Based on the study assumptions and reliability and economic conclusions discussed above, the more efficient or cost-effective plan is Change Case 23. Change Case 23 is a staged variant of the Initial RTP. For the transfers submitted in Quarter 1 and Quarter 5, the facility segments shown in Figure 13, below, were not necessary for the transfers studied in the Change Cases. These segments would likely be necessary at higher transfer levels.

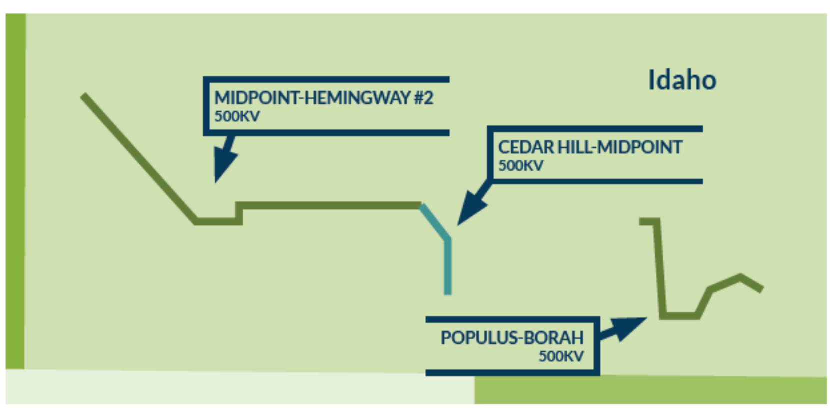
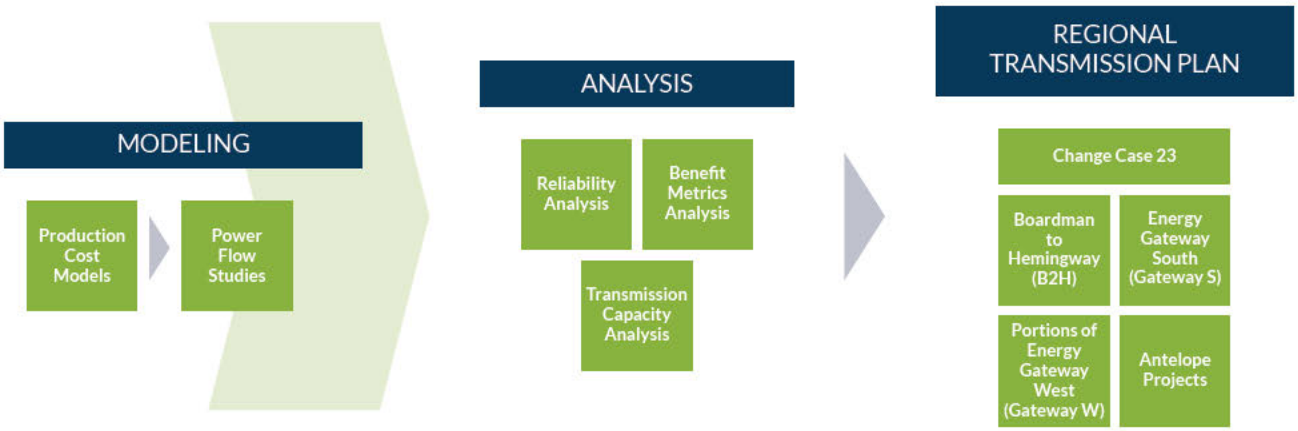


FIGURE 13
These transmission line segments from the Initial RTP were not included in the final RTP.



NTTG's final RTP emerged after a rigorous reliability analysis of the NTTG Transmission Providers' rollup of their local area plans and assumption of Non-Committed regional transmission projects, augmented with stakeholder Interregional Transmission Projects. This technical analysis was followed by an economic metric analysis that selected NTTG's more efficient and cost-effective regional transmission plan, shown below in Figure 14.

FIGURE 14
These projects comprise NTTG's final RTP.

COST ALLOCATION

The SWIP-North Project Sponsors were the only Project Sponsors to request cost allocation; however, they failed to comply with the requirement to submit pre-qualification data by Oct. 31, 2015. As a result, no projects that were eligible for cost allocation were submitted into NTTG's 2016-17 regional planning process.

NEXT STEPS

Publication of the NTTG Regional Transmission Plan completes the two-year planning process begun with pre-qualification of Project Sponsors in Quarter 8 2015 and continued with project data submittal in Quarter 1 of 2016. The NTTG 2016-2017 RTP identified a need for new transmission capacity to serve forecasted load in 10 years. The plan also identified a set of transmission projects known in this report as Change Case 23 as the more efficient or cost-effective transmission plan to meet that need. While the RTP is not a construction plan, it provides valuable regional insight and information for all stakeholders (including developers) to consider and use in their respective decision-making processes.

The next biennial regional transmission planning cycle for NTTG started Oct. 1, 2017 with Project Sponsor pre-qualification and will culminate with the publication of the 2018-2019 RTP in December 2019.

NTTG 2016-2017 REGIONAL TRANSMISSION PLAN SUPPORTING MATERIALS

The supporting materials referenced in this report have been posted on the NTTG website and can be found using the following link:

https://www.nttg.biz/site/index.php?option=com_docman&view=list&slug=supporting-documents-regional-transmission-plan&Itemid=31

A list of each of the individual supporting documents is also provided below:

1. Amended Quarter 6 NTTG 2016-17 Biennial Study Plan Approved – 08-02-2017
2. NTTG Draft Final Regional Transmission Plan – 06-30-2017
3. NTTG 2016-2017 Public Policy Consideration Scenario Report

GLOSSARY

Note: This Glossary is for the benefit of readers and neither supplements nor modifies any defined terms contained in any entity's filed Open Access Transmission Tariff (OATT), including the Attachment K to that tariff. To the extent that a term diverges from any entity's OATT, the OATT takes precedence.

Alternative Project Alternative Project refers to Sponsored Projects, projects submitted by stakeholders, projects submitted by Merchant Transmission Developers and unsponsored projects identified by the Planning Committee (if any).

Change Case A Change Case is a scenario where one or more of the Alternative Projects is added to or replaces one or more Non-Committed projects in the Initial RTP. The deletion or deferral of a Non-Committed Project in the Initial RTP without including an Alternative Project can also be a Change Case.

Committed Project A Committed Project is a project that has all permits and rights of way required for construction, as identified in the submitted development schedule, by the end of Quarter 1 of the current regional planning cycle.

Draft Regional Transmission Plan Draft Regional Transmission Plan refers to the version of the Regional Transmission Plan that is produced by the end of Quarter 4 and presented to stakeholders for comment in Quarter 5.

Draft Final Regional Transmission Plan Draft Final Regional Transmission Plan refers to the version of the Regional Transmission Plan that is produced by the end of Quarter 6, presented to stakeholders for comment in Quarter 7 and presented, with any necessary modifications, to the Steering Committee for adoption in Quarter 8.

Initial Regional Transmission Plan Initial Regional Transmission Plan comprises projects included in the prior Regional Transmission Plan and projects included in the Full Funders Local Transmission Plans and accounts for future generation additions and deletions (e.g., announced coal retirements).

Interregional Transmission Project An Interregional Transmission Project is a proposed new transmission project that would directly interconnect electrically to existing or planned transmission facilities in two or more planning regions and that is submitted into the regional transmission planning processes of all such planning regions.

Merchant Transmission Developer Merchant Transmission Developer refers to an entity that assumes all financial risk for developing and constructing its transmission project. A Merchant Transmission Developer recovers the costs of constructing the proposed transmission project through negotiated rates instead of cost-based rates.

Non-Committed Project A project that is not a Committed Project

Project Sponsor A Project Sponsor is a Nonincumbent Transmission Provider or Incumbent Transmission Provider intending to develop the project that is submitted into the planning process.

Public Policy Consideration Those public policy considerations that are not established by local, state, or federal laws or regulations.

Public Policy Requirements Those public policy requirements that are established by local, state or federal laws or regulations, meaning enacted statutes (i.e., passed by the legislature and signed by the executive) and regulations promulgated by a relevant jurisdiction.

Sponsored Project A Sponsored Project is a project proposed by a Project Sponsor.

BACK COVER
Photo courtesy of Idaho Power

NORTHERN TIER
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