PRELIMINARY GEOTECHNICAL AND GEOLOGIC HAZARDS REPORT

San Juan Headwaters Reservoir

Pagosa Springs, Colorado

Yeh Project No.: 224-459

May 15, 2025

Prepared for:

San Juan Water Conservancy District
6 Eaton Drive, Suite 5
Pagosa Springs, CO 81147
Attn: Ms. Candace Jones

Prepared by:

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San Juan Water Conservancy District
6 Eaton Drive, Suite 5
Pagosa Springs, CO 81147

Attn: Ms. Candace Jones

Subject: Preliminary Geotechnical and Geologic Hazards Report, Feasibility Study of the San Juan Headwaters Reservoir Project, Pagosa Springs, Colorado

Dear Ms. Jones:

Yeh and Associates, Inc. is pleased to submit this Preliminary Geotechnical and Geologic Hazards Report for the San Juan Headwaters Reservoir project in the Dry Gulch basin in Pagosa Springs, Colorado. This report was prepared to provide preliminary geotechnical and geologic hazard considerations as input to the District's project feasibility study. This report was prepared in accordance with our *Professional Consulting Agreement* dated January 21, 2025.

The evaluation consisted of reviewing existing project studies, publicly available geologic maps and historical aerial photographs, and preliminary geotechnical analyses. Historic aerial photographs collected for this study are appended. Graphics showing the regional geology, anticipated soil and rock conditions, and historic seismicity and faulting in the site vicinity are presented on plates attached to this report. The following is a summary of key geologic hazards and geotechnical considerations for the project feasibility study:

- Subsurface conditions are anticipated to consist of predominantly fine-grained alluvial deposits and weathered shale overlying interbedded sandstone and shale bedrock of the Mesa Verde and Lewis Shale formations. Alluvial soil types within the proposed reservoir limits are anticipated to predominantly consist of clay or silt based on mapping by NRCS (2025).
- Groundwater measured by previous studies ranged from approximately 13 to 30 feet below the ground surface. There is limited groundwater data available at the proposed embankment site, but groundwater elevations are likely seasonal and influenced by the elevation of water in Dry Gulch. The new embankment will likely be founded on bedrock underlying predominantly fine-grained soil. Wet soil conditions should be anticipated and dewatering to

lower groundwater levels for construction will likely be needed for excavations associated with the embankment.

- Geologic hazards that will likely need to be addressed by the project design include strong ground motion associated with the design earthquake, soil erosion, expansive soil, and reservoir-triggered seismicity. Further evaluation of the potential for landslides and debris flows should also be performed. Preliminary recommendations to address the geologic hazards in a design-level investigation are provided.
- Seepage and slope stability analyses should be performed for the reservoir design to provide a basis for the design of the reservoir slopes, embankment, drainage systems and seepage controls. The design of dam embankments typically involves an evaluation of the potential for seepage beneath the embankment, referred to as underseepage, and seepage through the embankment, referred to as through-seepage. Slope stability analyses should be performed for the embankment and reservoir rim slopes in accordance with CDWR (2020). The design typically involves slope stability analyses that consider static and seismic conditions.
- Existing geotechnical data within the proposed reservoir site are limited and not considered suitable for the design of the proposed reservoir project. Recommendations for additional subsurface exploration are provided in this report.
- Geotechnical site exploration should be performed for the reservoir's design. The exploration program should include mapping and subsurface exploration to measure the orientation of rock bedding and discontinuities, such as test pits that expose relatively fresh (aka unweathered) bedrock and borings to obtain soil and rock samples. The field exploration program will provide a basis for evaluating seepage and slope stability for the proposed embankment.

We appreciate the opportunity to be of service. Please contact Gresh Eckrich at 805-616-0399 or geckrich@yeh-eng.com if you have questions or require additional information.

Sincerely,

YEH AND ASSOCIATES, INC.

Melissa Boyd
Senior Project Geologist

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Reviewed by: COLORADO LICENSED PROFESSIONAL ENGINEER TODD M. SCHLITTENHART 39389 5/15/2025

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1. Purpose and Scope of Study

Yeh and Associates was retained by the San Juan Water Conservancy District (SJWCD) to provide geotechnical services as input to the feasibility study for the San Juan Headwaters Reservoir project in the Dry Gulch basin in Pagosa Springs, Colorado (see Figure 1). The evaluation consisted of a review of existing previous studies, publicly available geologic maps and historical aerial photographs, and preliminary geotechnical analyses. This report provides a discussion of preliminary findings and recommendations regarding regional and site geology, potential for geologic hazards to impact the project, and preliminary geotechnical and construction considerations. This report is not intended to serve as a design-level report for the project.

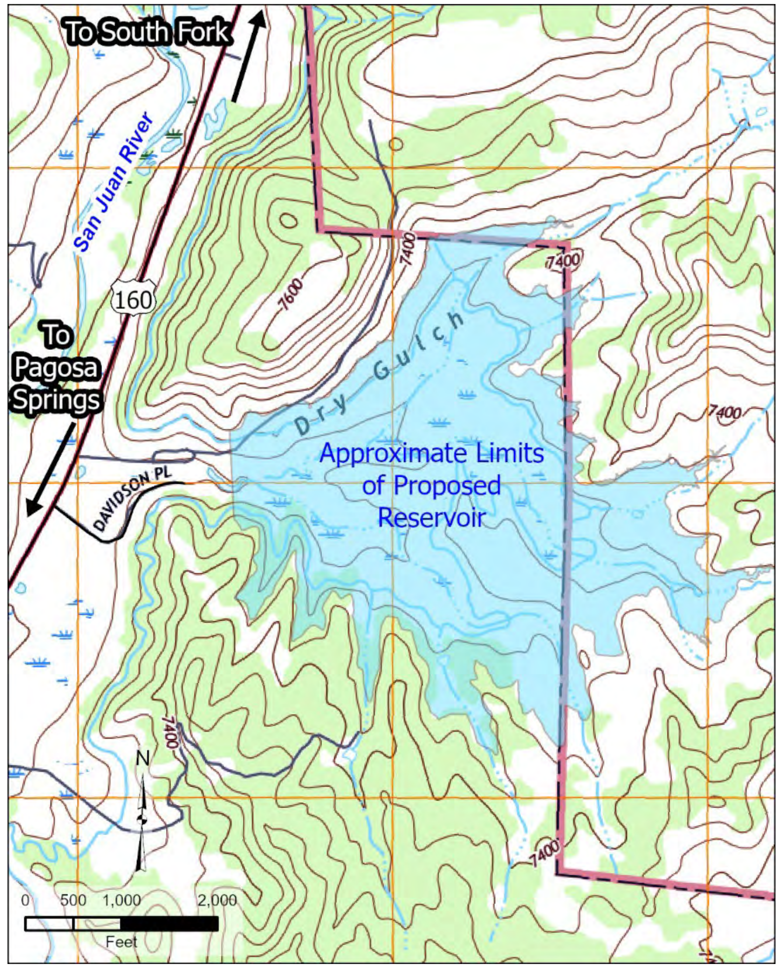

Figure 1. Vicinity Map

2. Project Understanding

2.1 Project Description

The project will consist of a new water supply reservoir that will store approximately 11,000 acre-feet (ac-ft) of water in the Dry Gulch basin northeast of Pagosa Springs. The approximate limits of the proposed reservoir are shown in Figure 1. The West Fork of the San Juan River parallels US Highway 160 just west of the project. The reservoir will occupy approximately 319 acres and will be impounded by an earthen embankment (SJWCD 2011). The proposed reservoir will occupy about 70 acres of National Forest Service land.

The estimated embankment crest elevation (el.) will be approximately el. 7,345 feet, corresponding to a height of approximately 105 feet (SJWCD 2011). Preliminary drawings by MWH (2008) for a taller embankment impounding a 35,000 ac-ft reservoir show a 25-foot-wide crest and the upstream and downstream embankment slopes inclined at 3h:1v (horizontal:vertical) and 4h:1v. The preliminary drawings show a zoned, earth-rockfill dam composed of a relatively impermeable core and exterior rockfill shells. The core is shown founded in an approximately 15-foot-deep, 20-foot-wide cutoff trench. A grout curtain is shown extending from the bottom of the cutoff to a depth of 2/3 the hydraulic height of the dam. The MWH (2008) drawings show an internal drainage system consisting of an inclined layer of filter-processed sand and gravel on the upstream side of the impermeable core and a vertical chimney drain on the downstream side of the core. The chimney drain includes a layer of filter-processed sand and gravel and is hydraulically connected to the downstream toe of the embankment.

The embankment will be located in an east-west trending water gap in the San Juan Mountains. Dry Gulch drains the basin and meanders west through the water gap to the San Juan River. The project will include appurtenant structures such as a spillway, outlets works and intake system to draw reservoir water from the San Juan River or the Park Ditch, an irrigation ditch that encircles the basin and diverts water from the San Juan River, typically from early May to early October (Harris 1989).

Design criteria for the dam depend on the dam's hazard classification, defined by the Office of the State Engineer's Dam Safety *Rules and Regulations for Dam Safety and Dam Construction* (CDWR 2020). Failure of a dam with a high and significant hazard classification is expected to result in life loss or significant damage, and design criteria for those dams is typically more stringent than criteria for low hazard dams.

2.2 Existing Site Description

Figure 2 shows topographic data within the project limits collected by Davis Engineering (2013) overlying a Lidar hillshade map (USGS 2018). Dry Gulch is a seasonal stream fed by multiple southwest- to west-flowing tributary drainages that define topography within the basin. There are three ponds within the basin, located along the channel of Dry Gulch, that appear to hold water year-round. Elevations within the basin range from approximately el. 7,320 at the water gap to approximately el. 8,000 along the eastern margins of the basin. Natural grades within the relatively flat floor of the basin slope approximately 1 to 5 percent towards Dry Gulch. Natural grades of slopes along the limits of the basin range from approximately 15 to 25 percent down to Dry Gulch.

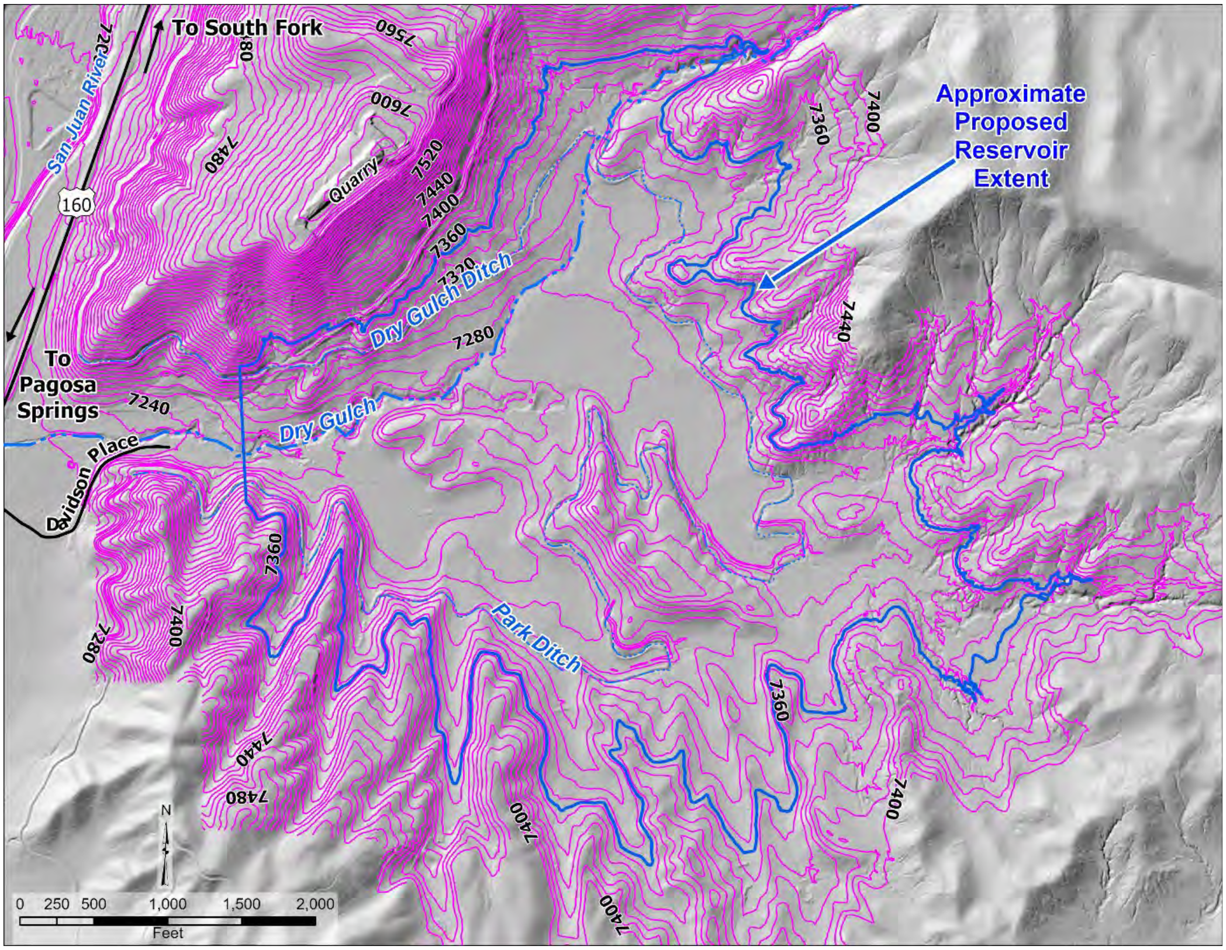

Figure 2: Proposed Reservoir Site

Land within the basin appears to be undeveloped or primarily used for grazing. Existing land uses adjacent to the project limits are predominantly industrial (e.g., quarry) and rural residential. There are two unpaved roads north and south of Dry Gulch to access the basin. The northern road provides access from Highway 160 to a quarry located along the northern limits of the basin. The southern road (Davidson Place) provides access to residential properties.

2.3 Previous Studies

Pertinent data from previous studies performed in the project vicinity were reviewed for this report and are summarized below. Relevant subsurface data from the previous studies are provided in Appendix A.

MWH Americas (MWH 2008) prepared a draft report that described preliminary assumed dimensions of the proposed dam, referred to as a component of the Dry Gulch Reservoir Project, for MWH's engineer's opinion of probable construction cost (EOPCC). MWH prepared preliminary cross sections and a topographic map with proposed footprints for embankments that were estimated to impound three different reservoir capacities: 12,500 ac-ft; 20,000 ac-ft; and 35,000 ac-ft.

Davis Engineering Service and Harris Water Engineering (D&H 2001) prepared a draft report for a *Preliminary Engineering Study of Water Supply Alternatives for Pagosa Area Water and Sanitation District*. The report described a 4,000-acre-foot reservoir and estimated dimensions for an earthen dam, referred to as Dry Gulch Dam, to provide that capacity. The proposed 11,000-acre-foot reservoir will occupy a similar but larger area than the area shown on Figure 5-4 of the D&H (2001) draft report. D&H also presented a preliminary cost estimate for the new dam and associated infrastructure.

SJWCD (1990) prepared a memorandum that described a drilling investigation at the Dry Gulch site. Two borings were drilled to depths of approximately 39 and 16.5 feet below the ground surface. The locations of the borings were vaguely described but not shown on a map, so the locations and elevations of the borings were not estimated for this report.

Ecosphere (undated) prepared a geology map and soils map for the proposed Dry Gulch Reservoir project. The maps provide similar information to the plates presented in this report.

3. ENGINEERING GEOLOGY AND SITE CONDITIONS

3.1 REGIONAL AND SITE GEOLOGY

The project site is located on the Archuleta anticlinorium, along the northern edge of the San Juan Basin that occupies northwest New Mexico and southwest Colorado. The Archuleta anticlinorium divides the San Juan basin to the southwest from the San Juan sag to the northeast (CGS 1980). The San Juan sag is a foreland basin concealed by the volcanic sediments of the San Juan Mountains in southern Colorado. The regional geology mapped by Steven et al (1974) is shown on Plate 1.

Steven et al (1974) mapped bedrock at the site as Cretaceous-age Mesaverde Formation (Kmv) and Lewis Shale (Kl). The Mesaverde Formation predominantly consists of interbedded sandstone and dark gray clayey shale with some carbonaceous shale and coal. The thickness of the unit was estimated to be approximately 250 feet. The Lewis Shale predominantly consists of dark- to light-gray clayey shale that overlies and is interbedded with the Mesaverde Formation (CGS 1980). The upper portion contains thin sandstone beds, and the lower portion contains rusty-weathering concretions. The thickness of the unit was estimated to be up to approximately 2,700 feet. Northeast-southwest trending Tertiary intrusive dikes were mapped southeast of the proposed reservoir limits.

3.2 AERIAL PHOTOGRAPH REVIEW AND GEOMORPHOLOGIC INTERPRETATIONS

Historic aerial photographs taken between 1960 and 2020 (about one per decade) were obtained from Environmental Data Research, Inc. (EDR 2024). Yeh also collected aerial photography between

1960 and 2023 obtained from the United States Geological Survey (USGS 2025a) Earth Explorer web application and Lidar elevation data from the United States Geological Survey (USGS 2018). The images were reviewed to evaluate changes in land use, topography, geomorphic features, and other characteristics pertinent to the site geology and geotechnical considerations discussed in this report. The aerial photos collected are provided in Appendix B with the approximate project limits shown as a red rectangle on each photo. The following observations were made during the review:

- The Park Ditch was constructed prior to the 1960 photo. The reservoir area generally consisted of open grassland with sparse trees along the approximate limits of the proposed reservoir. The 1960 photo shows relatively dark-toned areas within the limits that were likely associated with relatively moist soil due to agricultural irrigation. Eroded gullies are visible along the banks of the incised Dry Gulch channel that flows through the water gap at the proposed dam site.
- A pond occupied a section of the Dry Gulch channel near the proposed dam site in the 1976 photo. Further erosion appears to have occurred along the channel since the 1960 photo. Structures were constructed within the water gap, near the proposed dam site.
- The 1978 photo shows similar surface conditions as the 1976 photo.
- Two new ponds appear to have been excavated prior to the 1993 photo. The ponds are located near the center of the basin, upstream of the pond visible in the 1976 photo.
- A quarry along the northern margin of the basin was developed prior to the 2006 photo. A road that crosses Park Ditch to access the quarry appears to have been graded.
- The 2011 and 2015 photos show similar surface conditions as the 2006 photo.
- A second quarry site was developed along the northern margin of the basin prior to the 2019 photo.
- The 2021 and 2023 photos show similar surface conditions as the 2019 photo.

3.3 Anticipated Subsurface Conditions

Anticipated subsurface conditions within the project limits were interpreted based on published geologic and Natural Resources Conservation Service (NRCS 2025) soil maps, drill hole logs presented in SJWCD (1990), and well logs available on the Colorado Division of Water Resources (CDWR) website (https://maps.dnrgis.state.co.us/dwr/Index.html?viewer=mapviewer). The SJWCD (1990) logs and CDWR well logs are provided in Appendix A. Plate 2 shows soil types mapped by NRCS (2025) within the proposed reservoir limits, and the approximate locations of wells, as presented on the CDWR website. As noted above, the locations of the SJWCD (1990) drill holes cannot be estimated based on the information provided.

Subsurface conditions are anticipated to consist of predominantly fine-grained alluvial deposits and weathered shale overlying interbedded sandstone and shale bedrock of the Mesaverde and Lewis Shale formations. Alluvial soil types within the proposed reservoir limits are anticipated to predominantly consist of clay (CL, CH) or silt (ML, MH) based on mapping by NRCS (2025). The SJWCD

(1990) drill holes encountered topsoil and fine-grained soil to depths of approximately 5 to 12.5 feet below the ground surface. Weathered shale was encountered below soil to depths of approximately 13.5 to 36 feet. The driller apparently switched from drilling to coring methods below those depths, where hard shale was encountered to the termination depths of approximately 39 and 16.5 feet in Hole Nos. 1 and 2.

Drilling for well no. 50727, which appears to have been drilled near the anticipated elevation of the proposed embankment, encountered shale bedrock at a depth of approximately 5 feet. Drilling for well nos. 82038 and 84040, which were apparently drilled on the slopes north and south of the proposed embankment, encountered shale bedrock at depths of approximately 25 and 32 feet.

Groundwater. Groundwater depths were not noted on the SJWCD (1990) logs; however, Hole No. 1 encountered wet clay that may be indicative of groundwater from approximately 20 to 27 feet below ground surface. Drilling for well no. 50727 encountered groundwater at a depth of approximately 16 feet. Drilling for well nos. 82038 and 84040 encountered groundwater at depths of approximately 40 and 24 feet.

There is limited groundwater data available at the proposed embankment site, but groundwater elevations are likely seasonal and influenced by the elevation of water in Dry Gulch. Groundwater and soil moisture conditions within the project limits will vary seasonally and due to variations in storm runoff, irrigation schedules, and groundwater pumping in the site vicinity.

4. Geologic Hazards Evaluation

4.1 Historic Seismicity

The site is located within a seismically active region of southern Colorado where earthquakes resulting in strong ground motion have occurred within the historical record. A summary of magnitude 2.0 and greater seismic events recorded from 1869 through 2025 by the Advanced National Seismic System (ANSS 2025) and USGS (2025b) is shown on Plate 3 – Historic Seismicity and Regional Fault Map. Five earthquakes of magnitude 5.0 to 5.5 occurred within 20 and 125 miles of the project site between 1960 and 2011. Seismicity within Colorado is predominantly associated with tectonic extension of the Rio Grande Rift zone. The primary effects of strong ground motion will be those phenomena associated with seismic shaking and/or ground acceleration, which are discussed in subsequent sections of this report.

The 1966 magnitude 5.1 (M5.1) earthquake located approximately 23 miles south of the site occurred on January 23 near Dulce, New Mexico. Cash (1971) attributed the earthquake to an unnamed northwest-trending, strike-slip fault that was mapped by Bingler (1968) but is not included in the

USGS (2025b) Quaternary-age fault database. The effects of the earthquake were estimated as Modified Mercalli Intensity Scale (MMI) level V in Pagosa Springs (von Hake and Cloud 1966). MMI V events result in shaking felt by nearly everyone and some broken dishes and windows, and typically correspond to an approximate peak ground acceleration of 0.06g.

The 1960 M5.5 earthquake located approximately 80 miles northwest of the site occurred on October 11 near Montrose, Colorado. The earthquake occurred near the Holocene age Roubideau Creek and Busted Boiler faults (discussed below) but has not been attributed to a specific fault based on our review of published reports.

The 1976 and 1977 M5.0 and M4.6 earthquakes located approximately 127 miles southwest of the site occurred near Crownpoint, New Mexico. Wong et al (1984) attributed the earthquakes to a northwest-trending, normal fault and stated that the earthquakes are probably not associated with any geologic structure expressed at the surface, based on the estimated epicenter depths of 41 and 44 kilometers below the surface.

CGS (2011) noted that the cluster of earthquakes mapped approximately 105 miles east of the site, near Trinidad, may be attributable to natural gas production in the Raton Basin and associated waste injection wells, and not the Northern Sangre de Cristo fault, which is discussed in the following section.

4.2 Active Faulting and Coseismic Deformation

Fault rupture or coseismic deformation is the displacement of the ground surface caused by tectonic movement during a seismic event. The faults shown are classified as Historic, Holocene, Late Quaternary, or Quaternary. USGS defines these terms based on the age of a fault as follows:

> **Historic.** Faults that show evidence of displacement or activity within the historical record; approximately the last 150 years.
>
> **Holocene.** Faults that show evidence of displacement in Holocene time (the last 15,000 years).
>
> **Late Quaternary.** Faults that show evidence of displacement in the Late Quaternary period (the last 750,000 years), but no evidence of movement in Holocene time.
>
> **Quaternary.** Faults that show evidence of displacement in the Quaternary period (the last 1,600,000 years), but no evidence of movement in Holocene time.

4.2.1 Nearby Faulting

Holocene age faults within about 250 miles (or 400 kilometers) of the site include the Roubideau Creek fault, the Busted Boiler fault, the north to northeast-trending Northern and Southern Sangre de Cristo faults, the southern section of the Sawatch fault, and the Pajarito fault zone. The closest

Quaternary age fault is the Eight Mile Mesa fault, mapped approximately 4.5 miles southeast of the project site (Galloway 1980).

The Roubideau Creek fault is a northeast-dipping normal fault mapped approximately 93 miles northwest of the site. The fault dips to the northeast and is part of a fault zone that includes the Log Hill Mesa graben and the Busted Boiler fault. Quaternary landslide deposits of late Pleistocene to Holocene age are offset along the fault trace (Widmann et al 2010).

The Busted Boiler fault is a west-dipping, high-angle normal fault mapped approximately 77 miles northwest of the site. Sullivan et al (1980) and Lettis et al (1996) estimated late Pleistocene and possibly Holocene displacement on the fault, which defines the southeast margin of the Uncompahgre Uplift.

The Northern and Southern Sangre de Cristo faults are normal faults mapped approximately 80 miles east of the site. Faults that comprise the zones generally dip to the west and define the structural boundary between the Sangre de Cristo and Culebra ranges and the San Luis basin. The fault zones have been historically active, generating earthquakes near the mapped fault traces, as shown on Plate 3.

The southern section of the Sawatch fault is a high-angle normal fault mapped approximately 104 miles northeast of the site. The fault dips to the east and defines the eastern boundary of the Sawatch Range (USGS 2025b). Ostenaa et al (1981) estimated the most recent event on the fault was less than 4,000 years ago.

The Pajarito fault zone consists of predominantly normal faults mapped approximately 97 miles southeast of the site. The fault zone consists of four segments that define the east flank of the Jemez Mountains and exhibit east-dipping displacements (Golombek 1982).

4.2.2 Fault Rupture Hazard

Fault rupture is the displacement of the ground surface due to fault movement during an earthquake. Yeh reviewed the local fault setting, published maps and literature references, and historic aerial photographs. No special mitigation to address faulting or fault rupture is considered necessary based on our preliminary evaluation.

4.3 Liquefaction

Liquefaction typically occurs in young, loose to medium dense granular sand or sensitive clay and silt below the groundwater table that are subject to ground motions from an earthquake. The potential for liquefaction is dependent on site-specific properties such as: the relative density, plasticity, and particle size of soil; groundwater conditions; and geologic history. Potentially liquefiable soils may be vulnerable to loss of strength and foundation support, seismic settlement, slope instability or lateral spreading depending on the severity of the liquefaction hazard and site conditions.

It is anticipated that the proposed embankment will be founded on bedrock that is typically not considered vulnerable to liquefaction, lateral spreading, or seismic settlement during strong ground shaking. Alluvial deposits that may contain layers of loose, predominantly sandy soil should be removed from the embankment footprint during grading. The potential for liquefaction should be evaluated for structures founded on alluvial deposits, which are anticipated to consist of predominantly fine-grained alluvial soil.

4.4 Landslides and Slope Instability

The potential for landslides and slope instability was evaluated based on our review of aerial photographs, USGS (2018) Lidar hillshade data, and published geologic maps. The proposed reservoir site was not included in the Colorado Geological Survey's landslide inventory mapping (White et al 2022) based on published geologic maps. Moore and Lidke (2018) prepared a geologic map west of the proposed reservoir site that mapped landslide deposits within the Lewis Shale, which is mapped along the eastern margins of the proposed reservoir site. Geomorphic features are visible on the hillshade map (see Figure 2, Plates 1 and 2), such as hummocky terrain and arcuate-shaped landforms, that are typically associated with landsliding and should be evaluated further based on site-specific mapping.

4.5 Debris flows

Debris flows are slurries of sediment and water that commonly mobilize upslope and runout downslope during or after rainfall events. Debris flows develop where a source of material, such as unconsolidated soil veneers on steep slopes, can be mobilized by the addition of water. Debris flow source areas are often associated with steep gullies, and debris flows are typically deposited as debris fans at the mouths of gullies, although debris flows don't necessarily flow down a narrowly defined flood plain or an established drainage channel. Debris flows also mobilize from other types of landslides that occur on steep slopes, are nearly saturated, and consist of a large proportion of silt- and sand-sized material. Fires that denude slopes of vegetation will generally increase the susceptibility of slopes to debris flows (USGS 2004).

Geomorphic evidence of relatively large remnant debris flows, such as shallow arcuate scarps or runout channels smoothed by erosion, are not visible on the hillshade map (see Figure 2, Plates 1 and 2). The potential for debris flows was preliminarily evaluated using the method described in Wilford et al (2004). The evaluation considered the topographic relief and length of estimated debris flow source areas that might impact the proposed reservoir. The potential for debris flows is considered low based on the results of our preliminary evaluation but should be evaluated further based on site-specific mapping.

4.6 Erosion

It should be anticipated that soil disturbed by grading and earthwork associated with the project will be susceptible to erosion. Graded slopes associated with the proposed embankment and existing slopes along the rim of the proposed reservoir will also be susceptible to sheet and rill erosion.

Soil erosion and sediment runoff from the surrounding watershed can result in siltation, or the accumulation of sediment in the reservoir, that can reduce the reservoir storage capacity, reduce water quality, and damage appurtenant structures such as the intake system. Slopes within the proposed reservoir watershed appear to be generally denuded of vegetation based on our review of aerial photographs, which may increase the potential for erosion. Vegetation generally stabilizes soil within the root system and reduces the potential for erosion. Check dams can be placed on drainages at elevations above the reservoir to trap sediment upstream of the reservoir. The sediment that accumulates behind check dams could be periodically removed as part of the project operation and maintenance program.

Plate 2 shows erodibility factors (K) mapped by the NRCS within the proposed reservoir limits. There are areas within the proposed reservoir limits that have not been rated by NRCS. The erodibility factor indicates the susceptibility of a soil to sheet and rill by erosion by water. Values of K generally range from 0.02 to 0.69; the higher the K value, the more susceptible the soil is to surface runoff erosion. NRCS estimated K values of 0.24 and 0.28 for the silt (ML) and fat clay (CH) mapped as soil types derived from weathering of the Lewis Shale and Mesaverde Formation. The potential for siltation should be evaluated relative to the design life and capacity of the proposed reservoir. The evaluation should review documentation of siltation from existing reservoirs in the project vicinity, if available, particularly those that are sited within watersheds mapped as Lewis Shale and/or Mesaverde Formation.

4.7 Expansive Soil

Expansive soil conditions can cause differential movement and damage to foundations, slabs, slopes, and other improvements due to shrinking and swelling of the soil in response to moisture fluctuations. These movements are most common in near surface soils, near the edge of slabs where seasonal moisture contents in the soil fluctuate the most. Predominantly fine-grained soil types, such as the clay and silt anticipated within the reservoir limits, are typically considered susceptible to volume changes in response to moisture changes. Expansion and contraction of foundation soil can result in distress to new structures.

It is anticipated the new embankment will be founded on bedrock, and that site preparation will remove potentially expansive soil from within the embankment footprint. Predominantly fine-grained soil underlying proposed appurtenant structures, concrete flatwork, or pavements should be evaluated for expansion potential. The design of embankment core or low-permeability material should consider the potential for expansion of predominantly fine-grained soil.

4.8 Hydroconsolidation, Collapse, and Subsidence

Hydroconsolidation is the potential for a soil to consolidate or collapse due to wetting. The Colorado Geological Survey (White and Greenman 2008) stated that areas of Colorado with at least 18 inches of annual precipitation are generally considered exclusion zones for collapse-susceptible soils. Soil collapse events in areas with at least 18 inches of annual rainfall were reportedly rare and generally occurred on relatively dry south- to southwest-facing slopes with heavy sun exposure, on terrain mapped as alluvial fan deposits. The Dry Gulch Basin averages approximately 20 inches of annual precipitation based on data collected between 1906 and 1998 (WRCC 2025). The potential for hydroconsolidation is considered low. Predominantly clayey soil and weathered bedrock may contain voids and fissures that are susceptible to hydroconsolidation, and should be removed from the embankment footprint during grading.

Deep subsidence is typically associated with the extraction of groundwater from water or oil wells that results in lowering of the groundwater table. Dewatering of young sediments or porous soil types can result in subsidence if the soil is prone to consolidation or collapse due to an increase in effective overburden stress that occurs when the groundwater level is lowered. The reservoir project is not anticipated to result in lowering of the groundwater table.

Anticipated subsurface conditions within the project limits include predominantly fine-grained alluvial deposits that are generally considered susceptible to subsidence. The potential for subsidence of the embankment or other structures founded on bedrock is considered low. Construction of appurtenant structures founded on predominantly fine-grained soil may require dewatering based on the groundwater conditions. Dewatering systems should be designed to limit the potential for subsidence of underlying soil layers.

4.9 Naturally Occurring Asbestos

Naturally occurring asbestos in the Rocky Mountain region is typically found in altered magnesium-rich host rocks, such as serpentinized ultramafic rocks and serpentinite, mafic alkaline igneous intrusions and alkalic intrusive complexes, dolomitic marbles, skarns that replace dolostones, mafic igneous rocks, and mafic metamorphic rocks (Van Gosen 2007). The geologic units mapped within the project limits predominantly consist of alluvial deposits and predominantly shale and sandstone bedrock units that are not typically known to contain naturally occurring asbestos (NOA).

4.10 Radon and Hazardous Gases

Radon (222Rn) is formed from the decay of small amounts of uranium and thorium naturally present in certain types of soil and rock. Radon gases are typically associated with organic-rich marine shale, diatomaceous shale, phosphate-rich marine sedimentary units, and certain granitic units. Radon gas or other hazardous gases may be encountered during the excavations for the embankment. However, gas hazards are typically considered relative to an accumulation of gases within closed spaces and structures (such as homes) and are therefore not considered applicable to the proposed project.

4.11 Reservoir-Triggered Seismicity

Reservoir-triggered seismicity (RTS) is the triggering of earthquakes by the physical processes that accompany the impoundment of large reservoirs. Houquin et al (2010) noted that earthquakes associated with reservoirs can be distinguished as:

1) earthquakes of non-tectonic nature with shallow focus, which are mainly related to stress adjustments in the foundation rock, such as the consolidation of fractured rock, or collapse of karst caves and mining tunnels. These relatively small magnitude events (generally less than M5.0) often occur shortly after impoundment or sudden reservoir water level fluctuations; or
2) earthquakes of tectonic nature caused by seismogenic faults passing through or adjacent to the reservoir area. The initial stress state of the fault(s) are typically close to failure prior to impoundment so that a minor change in stress or strength along the fault plane could trigger seismic events.

Seismogenic faults are not mapped within the reservoir area (USGS 2025b); therefore, the potential for RTS would be associated with relatively small magnitude earthquakes of non-tectonic nature. Schwartz et al (1996) stated that RTS historically occurred in regions of low tectonic loading rates dominated by normal faulting, similar to the regional faulting described in Section 4.2.1. There is historic evidence of seismicity induced by waste injection wells approximately 105 miles east of the proposed reservoir site (CGS 2011). Reservoir-triggered earthquakes typically have a relatively high likelihood of occurring within the first decade of impoundment, and the epicenters are typically within 10 to 15 kilometers (or 6 to 9 miles) of a site.

The prediction of RTS is not possible; however, Weiland (2017) notes that typical design methods for dams consider seismic loads that are typically greater than seismic loads associated with RTS. The design seismic event for the proposed embankment will likely be greater than events associated with RTS. Weiland (2017) recommends monitoring the reservoir region before dam construction to assess the existing natural seismicity relative to additional seismicity measured during and after impoundment, if any, that may be attributable to RTS.

5. Preliminary Geotechnical Considerations

The following sections provide preliminary geotechnical considerations as input to the feasibility study. Our preliminary evaluation identified the following geologic hazards that should be further evaluated by the design-level geotechnical investigation. Recommendations for subsurface exploration are also provided below.

Landslides and Debris Flows. The potential for landslides and debris flows to impact the reservoir should be evaluated, particularly within the areas mapped as Lewis Shale, which is associated with landslides mapped west of the proposed reservoir site.

Erosion. The potential for erosion should be considered in the design of earthwork and the embankment slope. Preliminary recommendations to address erosion and site drainage are provided below. The potential for siltation should be evaluated relative to the design life and capacity of the proposed reservoir.

Expansive Soil. Fine-grained soil should be evaluated for expansion potential relative to the proposed improvements, and mitigation options to reduce the impact of expansive soil on improvements should be provided, if necessary. Expansive soil is not anticipated to impact the embankment design but may need to be considered for the design of appurtenant structures, concrete flatwork, pavements, or re-use of predominantly fine-grained soil as embankment core or low-permeability material.

Reservoir-Triggered Seismicity. Design of the dam should consider the potential for seismic loads associated with reservoir-triggered seismicity.

5.1 Seepage and Slope Stability Analyses

Seepage and slope stability analyses should be performed as a basis for the design of the reservoir. The design of dam embankments typically involves an evaluation of the potential for seepage beneath the embankment, referred to as underseepage, and seepage through the embankment, referred to as through-seepage. Sustained underseepage or through-seepage and erosion can lead to piping, which typically consists of a tunnel-like void that forms and increases in diameter and length with continued seepage, ultimately leading to catastrophic expansion of the erosion pathway and breach of the embankment.

Slope stability analyses should be performed for the embankment and reservoir rim slopes in accordance with CDWR (2020). The design typically involves slope stability analyses that consider static and seismic conditions. Loading conditions evaluated for static slope stability should include steady state seepage considering the maximum reservoir water level, and rapid drawdown. Rapid drawdown can destabilize the interior embankment slope if the reservoir water surface elevation is lowered without allowing sufficient time for pore pressure dissipation within the embankment, particularly after the development of steady-state seepage conditions.

5.2 Preliminary Design Earthquake

Yeh estimated the preliminary design earthquake magnitude and peak ground acceleration tabulated below using the USGS unified hazard tool (USGS 2025). The site is preliminarily considered a Site Class C based on the subsurface information presented in SJWCD (1990) and CDWR (2025). Seismic data and a site classification for the project design should be provided in the design-level geotechnical report in accordance with the CDWR (2020) Rules and Regulations for Dam Safety and Dam Construction. The preliminary design earthquake magnitude was estimated as the disaggregated mean magnitude corresponding to a peak ground acceleration having a 2 percent exceedance probability in 50 years (i.e., hazard level corresponding to a return period of approximately 2,475 years). Sources that contribute to the probabilistic seismic hazard are gridded seismic sources, which represent small earthquakes (M6.5 or less) on identified faults and earthquakes that are not associated with identified faults (Field et al 2013), such as the 1960 M5.5 earthquake located approximately 80 miles northwest of the site (discussed in Section 4.1). The seismic design could also consider ground motions from the historical earthquake record, if available, and compare those to ground motions estimated using the USGS unified hazard tool. The estimated design peak ground acceleration (PGA) for the site exceeds the PGA values expected at the site from the historic earthquakes discussed in Section 4.1 of this report.

Table 1: Preliminary Design Earthquake

Seismic Parameter	Value
Latitude, degrees	37.293800
Longitude, degrees	-106.961500
Site Class	C
Earthquake Magnitude	5.9
Peak ground acceleration (PGA) 2% in 50 years	0.15g

CDWR (2020) does not explicitly define a hazard level for new embankment dams, and states that seismic hazards “shall be justified with due consideration to the hazard classification of the structure, regional and site-specific seismic hazard considerations, and the designated operational function of the dam.” The design-level geotechnical report should provide design earthquake parameters (magnitude and peak ground acceleration) for use in geotechnical analyses, such as slope stability, liquefaction, and seismic settlement.

5.3 Embankment Design Considerations

The following presents considerations for preliminary design of the proposed dam embankment. Recommendations for foundation design and subgrade preparation should be provided in the design-level geotechnical report.

5.3.1 Adverse Geologic Structure

The embankment is anticipated to be founded on interbedded sandstone and shale bedrock. Measurements of geologic structure within the rock, such as bedding planes and discontinuities, were not shown on published geologic maps or included in existing subsurface data. Adversely oriented bedding and discontinuities can increase the potential for seepage along those bedrock planes and increase the potential for instability of rock supporting the embankment foundation or abutments, and should be considered in the design of temporary excavations in rock.

Design of the dam should include exploration and mapping to measure the orientation and characterize bedding and discontinuities in the bedrock. Test pits are typically used to expose relatively fresh (aka unweathered) bedrock. Oriented rock core samples can be collected from borings or a borehole televiewer system can be used to measure the orientation of bedding and discontinuity planes within the rock. The bedding and discontinuity data should be considered in seepage and slope stability analyses for the proposed embankment. The design may include shear keys to intercept potential failure planes in rock, rock dowels or bolting to improve the overall strength of a rock mass, or grouting methods to reduce seepage associated with adverse bedding and discontinuities in rock foundations.

5.3.2 Settlement

The embankment should be supported on a relatively firm foundation to reduce the potential for settlement and loss of freeboard. The magnitude of the settlement from static loads can range from fractions of an inch to feet, depending upon the compressibility characteristics and thicknesses of the foundation material, and the loads and distributions of loads. Settlement can occur rapidly or can occur over long periods of time (months or years) depending on the site subsurface conditions.

The design should remove existing alluvial deposits from the footprint of the dam embankment to expose the underlying bedrock prior to placing embankment fill. Post-construction settlement will likely be limited to compression of the embankment material.

Appurtenant structures founded on predominantly fine-grained alluvial soil may be susceptible to settlement. The structure foundations, and earthwork to prepare a building pad for those structures, can be designed with consideration for settlement and to limit the estimated settlement within tolerable limits.

5.4 Earthwork

Earthwork is anticipated to consist of excavations for the proposed embankment foundation, cutoff trench, abutments, and placement of embankment fill for the new dam. Terrain in the vicinity of the proposed embankment consists of the relatively flat Dry Gulch water gap bounded by bedrock slopes that will support the embankment abutments.

Grading will also likely be performed for appurtenant structures. A program of clearing and grubbing, overexcavation, and placing compacted fill should be anticipated as part of the earthwork for the proposed improvements.

5.4.1 Reuse of Excavated Onsite Material

Anticipated fill materials for the project consist of zoned embankment composed of a relatively impermeable core and exterior rockfill shells. Excavations for the project are anticipated to remove predominantly fine-grained alluvial deposits. Soil excavated from the alluvial deposits that is free of debris, organics, oversized rocks, and other deleterious materials may be suitable for use as relatively impermeable core material. The predominantly fine-grained soil is likely not suitable for embankment exterior shells or internal drainage features.

The design geotechnical investigation should evaluate the suitability of material within planned excavation depths for use as compacted fill. Predominantly fine-grained soil may be suitable for re-use as low permeability material depending on geotechnical properties such as expansion potential and compressibility. The soil could be blended with non-expansive materials, if necessary, to reduce permeability, reduce the expansion potential and compressibility of the material, reduce the potential for drying and cracking of the material during fill placement, and generally improve the workability of the material for placement and compaction. The engineering properties of embankment materials should be consistent with those assumed for design, including the permeability, strength, and compressibility needed to control seepage and provide slope stability for the new embankment.

Soil excavated from near or below groundwater table will likely be at a moisture content that is too high to be suitable for compaction. Wet soil removed from excavations will need to be dried to a moisture content suitable for compaction prior to being placed as compacted fill. Rainfall can prolong or impede drying efforts.

5.5 Erosion and Site Drainage

The downstream slope of the proposed embankment should be protected against erosion caused by wind and surface runoff using a layer of vegetative cover, rock mulch, or cobbles. Downstream slope protection at many dam sites, especially in arid regions, typically consists of cobbles or rock because of concerns with burrowing animals and the difficulty of obtaining adequate slope protection using vegetative cover.

Graded slopes and disturbed areas will be susceptible to erosion. Planted grasses or other vegetation used for slope protection should be suitable for the locality and embankment soil type. A layer of topsoil may be required to promote vegetation growth. Vegetation that will conceal seeps, animal burrows, etc., should not be used. Exit surfaces to internal drainage layers (i.e., toe drains) should not be covered by vegetation. Vegetative cover should be maintained in a condition that will not conceal potentially deleterious conditions. Landscaping and maintenance of graded slopes should be provided to assist the establishment of vegetation and reduce the potential for erosion.

Drainage should be provided such that concentrated flows and runoff are not permitted to discharge on slopes. Energy dissipation and erosion control devices should be provided at the outlet of drainpipes and in areas of concentrated runoff to reduce the potential for erosion.

5.6 Construction Considerations

5.6.1 Groundwater and Dewatering

Groundwater measured by previous studies ranged from approximately 13 to 30 feet below the ground surface. Groundwater elevations are anticipated to be generally consistent with water elevations in Dry Gulch. The new embankment will likely be founded on bedrock underlying predominantly fine-grained soil. Excavations extending below groundwater should include properly designed dewatering systems to lower groundwater levels, and to provide a stable subgrade for subsequent fill placement.

5.6.2 Excavation Characteristics

Soil within the proposed reservoir limits is expected to be excavatable with conventional earthmoving equipment including bulldozers, excavators, and backhoes. Soft, saturated ground conditions may be encountered, and the use of low ground pressure equipment and long-reach excavation equipment may be needed.

The hardness, quality, and weathering of the interbedded shale and sandstone bedrock anticipated within the proposed embankment limits should be evaluated during design relative to the excavation characteristics for construction. Heavy construction equipment equipped with tools for ripping, such as heavy teeth, or a hoe ram, or blasting methods may be required for excavations depending on the rock properties. As noted above, rock coring was apparently necessary where hard shale was encountered in the SJWCD (1990) drill holes.

5.7 Recommended Subsurface Exploration

Existing geotechnical data within the proposed reservoir site are limited and not considered suitable for the design of the proposed reservoir for the proposed project. Additional subsurface exploration is needed to characterize the geotechnical properties of the soil and bedrock for design. Subsurface exploration for the project should comply with the guidelines presented in CDWR (2020), including submittal of a subsurface investigation plan for approval by the State Engineer. The subsurface exploration program should consist of drilling borings, excavating test pits, and performing geophysical surveys within the proposed reservoir limits. The following table summarizes preliminary subsurface exploration recommendations.

Table 2: Preliminary Subsurface Exploration Recommendations

Recommended Exploration Method	Recommended In-situ Tests	Geotechnical Properties Measured	Notes
Drilling/Rock Coring	Packer Tests Oriented core or Borehole Televiewer	Rock quality/hardness/ weathering Permeability Orientation of bedding and discontinuities	Drilling program typically performed concurrent with geophysical exploration Monitoring wells can be installed to evaluate groundwater relative to design and construction Laboratory tests for slaking should be performed on recovered shale samples
Test Pits	Percolation Testing	Rock Rippability Orientation of bedding and discontinuities Percolation Rate	Relatively fresh (aka unweathered) rock exposures should be exposed
Seismic Refraction	Not applicable	Shear Wave Velocity Rock Rippability	Can be used to estimate depth to rock over length/width of embankment footprint
FDEM Ground Conductivity	Not applicable	General Soil Classifications	Identify potential borrow sources for the embankment material Could be performed prior to drilling and test pits to refine the subsurface investigation plan

The number and spacing of borings and test pits will depend on the proposed embankment footprint, the location of appurtenant structures, the location of potential embankment material borrow sources, and the hazard classification per CDWR (2020). In-situ tests, such as Packer tests and a borehole televiewer, can be performed in borings to estimate bedrock permeability for seepage analyses and measure the orientation of bedding and discontinuities within the bedrock. Geophysical surveys should include seismic refraction profiles and Frequency Domain Electromagnetic (FDEM) ground conductivity mapping. Seismic refraction is typically performed to estimate the depth to and rippability of the interbedded shale and sandstone within anticipated excavation limits. FDEM ground conductivity mapping is typically performed to estimate the location and areal extent of potential borrow sources for the proposed embankment material.

5.8 Design-Level Geotechnical Report

This report was prepared based on review of available existing data, published geologic maps, and historical aerial photographs. The design-level geotechnical report should include supporting project-specific subsurface exploration and mapping, as discussed above, and laboratory testing of soil and rock samples. Project-specific subsurface data will provide the basis for design and assist the project team in developing construction cost estimates relative to the geologic hazards and geotechnical considerations discussed in this report.

6. Limitations

This study has been conducted in general accordance with currently accepted geotechnical practices in this area for use by the client for preliminary design and conceptual planning purposes only. The conclusions and preliminary recommendations submitted in this report are based upon the data obtained from field reconnaissance, subsurface data from previous studies, and our understanding of the proposed project and type of construction described in this report. Site conditions will vary between points of observation or sampling, seasonally, and with time. The nature and extent of subsurface variations across the site may not become evident until excavation is performed.

If there are any changes in the project or site conditions, Yeh should review those changes and provide additional recommendations if needed. Any modifications to the recommendations of this report or approval of changes made to the project should not be considered valid unless they are made in writing. The report and drawings contained in this report are intended for preliminary design-input; and are not intended to act as a design-level geotechnical report, construction drawings, or specifications.

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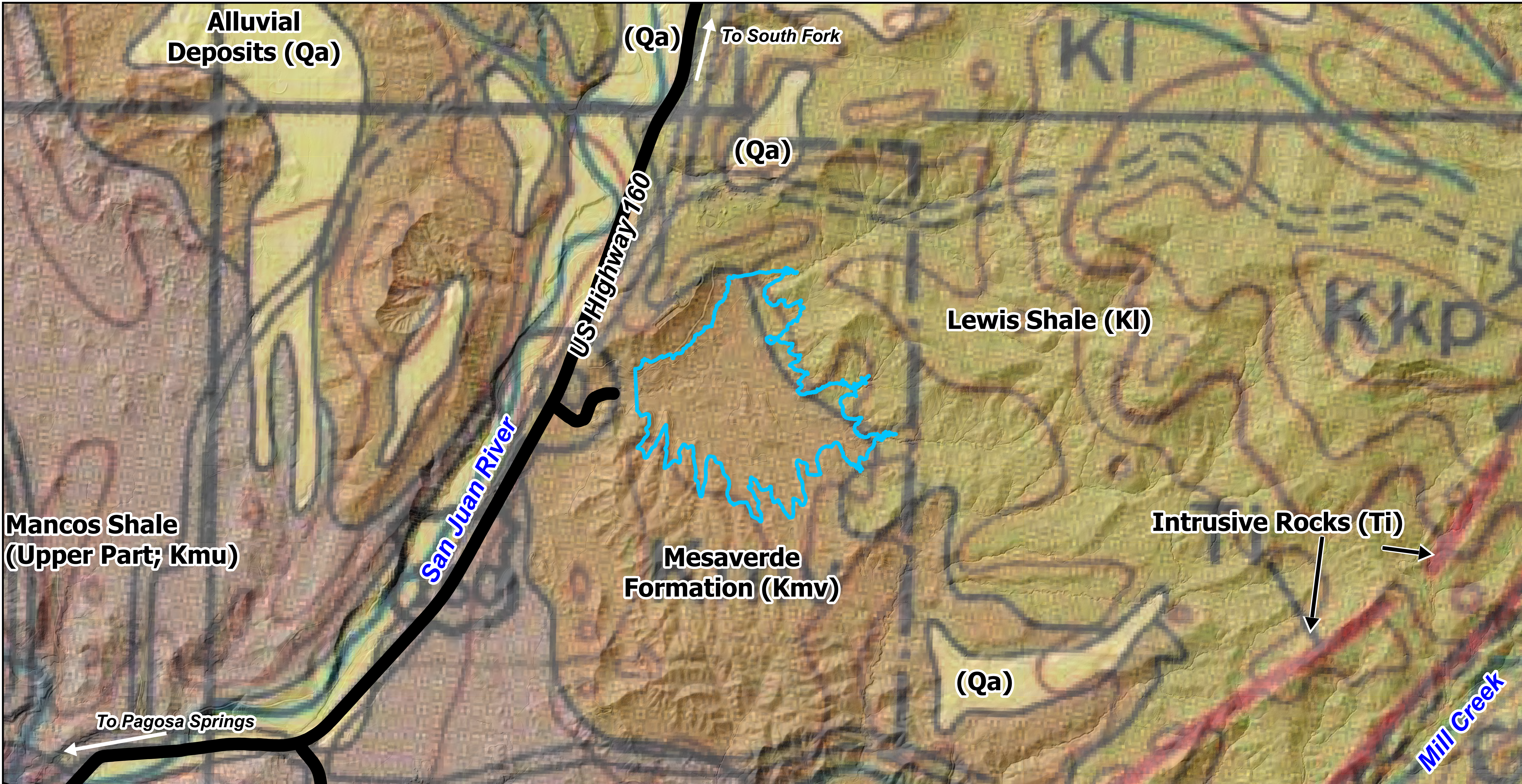


Qa	Alluvial Deposits (Quaternary): Alluvium, terrace gravels, and alluvial fan deposits.
Kl	Lewis Shale (Upper Cretaceous): Dark gray clay shale. Contains thin sandstone beds near top and rusty weathering concretions in lower part.
Kmv	Mesaverde Formation (Upper Cretaceous): Interbedded thin sandstone and dark gray clay shale. Minor carbonaceous shale and coal.
Kmu	Mancos Shale, Upper Part (Upper Cretaceous): Calcareous shale and argillaceous limestone in lower 600 feet. Sandy limestone and argillaceous sandstone at base.

Approximate Limits of Proposed Reservoir

Geology from Steven, T.A., Lipman, P.W., Hail, W.J., Barker, Fred, and Luedke, R.G., Geologic map of the Durango quadrangle, southwestern Colorado, United States Geological Survey, Miscellaneous Investigations Series Map I-764, 1974. Scale 1:250,000.

0 1,000 2,000 4,000 6,000 8,000 10,000 Feet

Scale: 1:24,000

N W E S

REGIONAL GEOLOGIC MAP

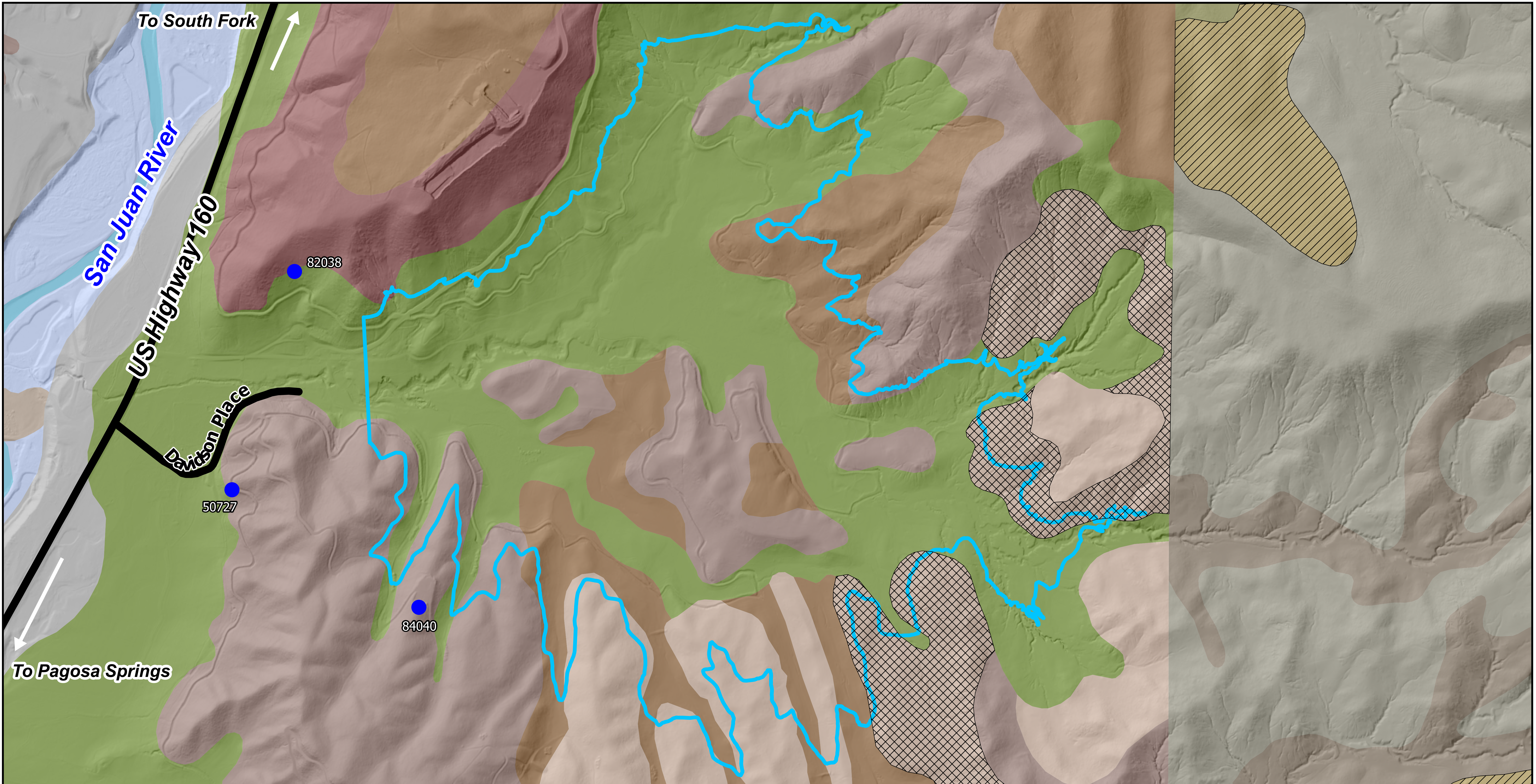
Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

Running Iron Ranch Reservoir
Pagosa Springs, CO

PLATE 1

Project Number: 224-459

Date: April 2025



Approximate Limits of Proposed Reservoir
Pagosa loam
Carracas clay loam
Abeyta-Carracas complex
Echolake clay loam
Herm family, clay loam
Herm family-Echolake complex

K Factor, USCS
0.24, ML
0.28, CH

Well

0 300 600 1,200 1,800 2,400 3,000 Feet

Scale: 1:8,000

Soil data from: Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at https://websoilsurvey.nrcs.usda.gov/ Accessed February 2025. K Factor and USCS data limited to the areas shown.

Well data from Colorado Division of Water Resources. Available online at https://dwr.colorado.gov/services/data-information/gis Accessed February 2025. Wells labeled with permit number.

N E S W

NRCS SOIL MAP

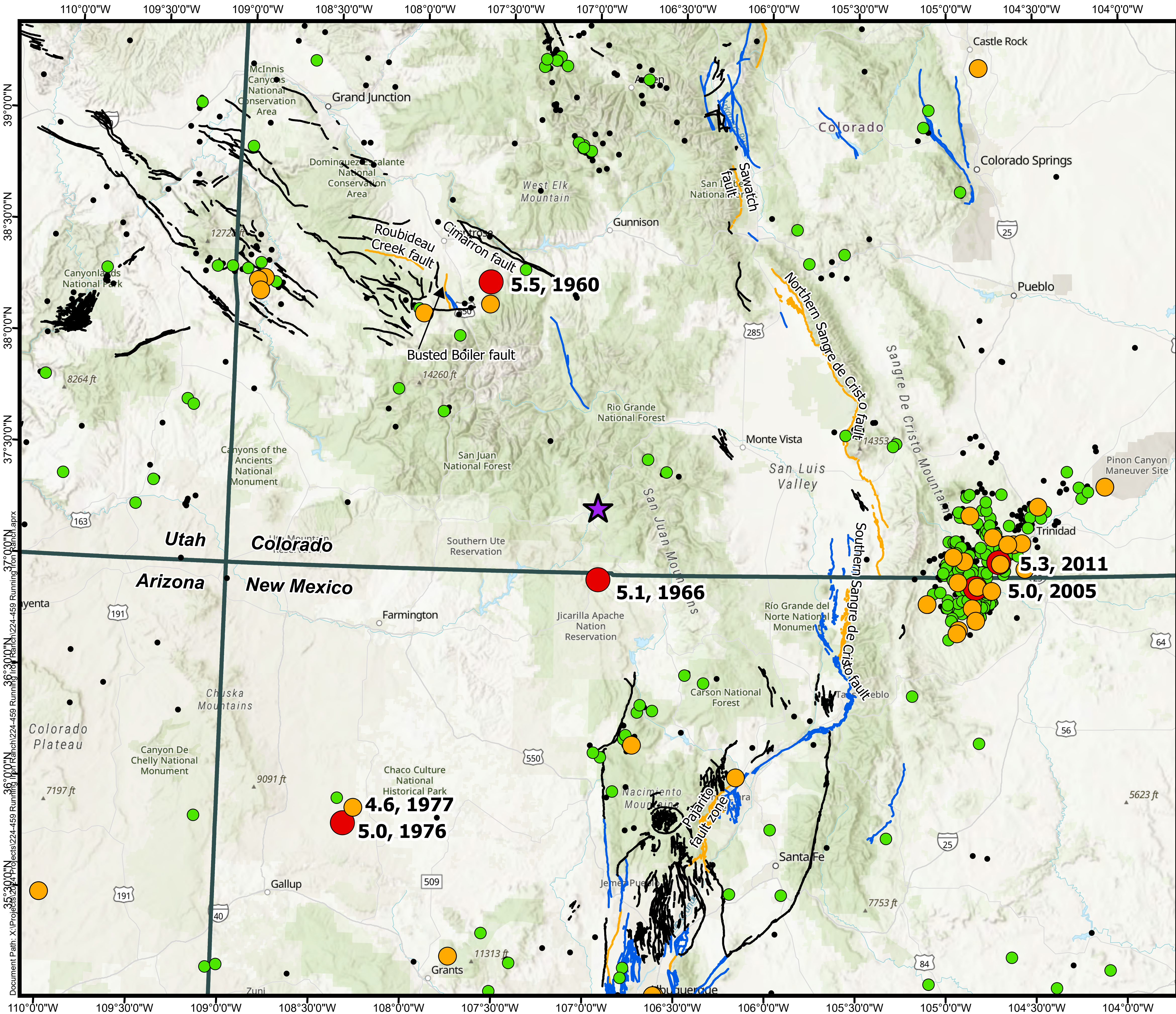
Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

Running Iron Ranch Reservoir
Pagosa Springs, CO

PLATE
2

Project Number: 224-459

Date: April 2025



LEGEND:

- Project Location
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9
- > 5.0

Faults

- Historic (last 150 years)
- Holocene (last 15,000 years)
- Late Quaternary (last 750,000 years)
- Quaternary (last 1,600,000 years)

Sources:

1) Earthquake Data:
Earthquake epicenters from ANSS Comprehensive Earthquake Catalog,
https://earthquake.usgs.gov/earthquakes/search/
(Downloaded February 2025)

2) Faults:
Quaternary Fault and Fold Database of the United States,
https://www.usgs.gov/programs/earthquake-hazards/faults

0 12.5 25 50 75 100 Miles

Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

HISTORIC SEISMICITY AND REGIONAL FAULT MAP

PROJECT NAME: Running Iron Ranch Reservoir, Pagosa Springs, CO	PLATE 3
PROJECT NUMBER: 224-459	DATE: April 2025

APPENDIX A - DATA FROM PREVIOUS STUDIES

San Juan
WATER
CONSERVANCY
DISTRICT

P.O. Box 4632 . Pagosa Springs, Colorado 81157

December 4, 1990

TO: Memorandum to Files

FROM: Cecil E. Tackett

SUBJECT: Core Drilling at the Dry Gulch and Hidden Valley Dam Sites.

On October 26 and 27, Beeman Drilling Company did core drilling at the two sites under preliminary investigation. No foundation information was available at either site prior to this drilling.

The objective of this drilling was two fold; determine the depth to bedrock and obtain a core sample to identify the condition of the bedrock. This information will permit the District to determine the feasibility of the sites and to prepare a construction cost estimate.

Two holes were drilled at the Dry Gulch site, one on each side of the valley. The holes were an estimated 600 feet apart. Results were about as expected.

Four holes were drilled at the Hidden Valley site. The bedrock (shale) was cored on two holes, No. 1 and No. 4. On holes No. 2 and No. 3 bedrock was identified from drill cuttings. Holes No. 2 and No. 3 were near, less than 50 feet, from hole No. 1. Due to closeness of the holes it was not necessary to core No. 2 and No. 3.

With no large scale topography available for either site the location of the drill holes cannot be plotted. It will be difficult to retain the locations in the future. Also no true elevation is available at either site, therefore no elevation is shown on the drill logs.

Copies of the drill logs are attached.

Cecil E. Tackett

San Juan
WATER
CONSERVANCY
DISTRICT

P.O. Box 4632 . Pagosa Springs, Colorado 81157

DRILL LOGS @ DRY GULCH SITE

HOLE No. 1

Located on north side of valley near a ranch access road.

Depth in Feet	
0-5	Topsoil and fine grained material
5-20	Badly weathered shale
20-27	Clay - wet
27-36	Weathered shale, harder with depth
36-39	Cored-hard shale - 30" recovery

HOLE No. 2

Located on south side of valley. Approximately 25 feet north of a ranch access road.

Depth in Feet	
0-10.0	Fine grained material
10.0-12.5	Fat clay
12.5-13.5	Drilled weathered shale
13.5-16.5	Cored - hard shale

WRJ-26-72

THIS FORM MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION OF THE WORK DESCRIBED HEREON. TYPE OR PRINT IN BLACK INK.

COLORADO DIVISION OF WATER RESOURCES

101 Columbine Bldg., 1845 Sherman St.
Denver, Colorado 80203

dw #3

WELL COMPLETION AND PUMP INSTALLATION REPORT

PERMIT NUMBER 50727

WELL OWNER Howard F. Carpenter NW ¼ of the NE ¼ of Sec. 8,

ADDRESS Box 7I4 Pagosa Springs Colo T. 35N, R. I W, NM P.M.

DATE COMPLETED 4 I6, 19 72

RECEIVED APR 27 '72 WATER RESOURCES STATE ENGINEER COLO.

WELL LOG

From	To	Type and Color of Material	Water Loc.
0	5	Black Top Soil	
5	20	Shale	
20	40	Shale & Rock	
40	220	Shale	

TOTAL DEPTH 220

Use additional pages necessary to complete log.

HOLE DIAMETER

6 in. from 0 to 220 ft.

in. from to ft.

in. from to ft.

CASING RECORD:

Plain Casing

Size 5 & kind Plastic from 0 to 60 ft.

Size & kind from to ft.

Size & kind from to ft.

Perforated Casing

Size 5 & kind pla. from 40 to 60 ft.

Size & kind from to ft.

Size & kind from to ft.

GROUTING RECORD

Material Cement

Intervals

Placement Method

GRAVEL PACK:

Size

Interval

TEST DATA

Date Tested 4 20, 1972

Static Water Level Prior to Test I6 ft.

Type of Test Pump Bailed

Length of Test 2 Hr.

Sustained Yield (Metered) 4 GPM

Final Pumping Water Level 96ft

WRJ-26-72

a.4

THIS FORM MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION OF THE WORK DESCRIBED HEREON. TYPE OR PRINT IN BLACK INK.

COLORADO DIVISION OF WATER RESOURCES

300 Columbine Bldg., 1845 Sherman St.
Denver, Colorado 80203

WELL COMPLETION AND PUMP INSTALLATION REPORT

PERMIT NUMBER 82038

RECEIVED
FEB 23 '76
WATER RESOURCES
STATE ENGINEER
COLO.

WELL OWNER JULIAN HATHAWAY

SW ¼ of the SE ¼ of Sec. 5

ADDRESS 11854 E Florence Santa Fe Springs, Calif. 90670

T. 35 N, R. 1 W, N.M. P.

DATE COMPLETED 12- 20, 19 75

WELL LOG

From	To	Type and Color of Material	Water Loc.
0	4'	TOP SOIL	
4	25'	RIVER ROCKS & SOFT SHALE	
25	140'	HARD GRAY SHALE	
140	150'	FRACTURED SHALE GRAY	W

TOTAL DEPTH 150'

Use additional pages necessary to complete log.

HOLE DIAMETER

7 in. from 0 to 150 ft.

in. from to ft.

in. from to ft.

DRILLING METHOD ROTARY

CASING RECORD:

Plain Casing

Size 5 & kind pvc from + 1 to 30

Size & kind from to

Size & kind from to

Perforated Casing

Size & kind from to

Size & kind from to

Size & kind from to

GROUTING RECORD

Material CEMENT

Intervals TOP 30'

Placement Method POURED IN

GRAVEL PACK:

Size

Interval

TEST DATA

Date Tested 12-20, 19 7

Static Water Level Prior to Test 40

Type of Test Pump BLOWED WITH AIR

Length of Test 45 MIN.

Sustained Yield (Metered) 5 GAL. per min.

Final Pumping Water Level 150'

WRJ-26-72

THIS FORM MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION OF THE WORK DESCRIBED HEREON. TYPE OR PRINT IN BLACK INK.

COLORADO DIVISION OF WATER RESOURCES

300 Columbine Bldg., 1845 Sherman St.
Denver, Colorado 80203

RECEIVED
SEP 10 '76
WATER RESOURCES
STATE ENGINEER
COLO.

WELL COMPLETION AND PUMP INSTALLATION REPORT

PERMIT NUMBER 84040

WELL OWNER Gordon N. Oneal

ADDRESS Box 674 Pagosa Springs Colo.

DATE COMPLETED 9 I, 19 76

SE ¼ of the NE ¼ of Sec. 8,

T. 35 N, R. I W, NM P.M.

WELL LOG

From	To	Type and Color of Material	Water Loc.
0	5	Black Top Soil	
5	32	Yellow Adobe	
32	43	Black Shale & Water	
43	90	Dark Shale	

TOTAL DEPTH 90

Use additional pages necessary to complete log.

HOLE DIAMETER

7 in. from 0 to 90 ft.

in. from to ft.

in. from to ft.

DRILLING METHOD Cable Tools

CASING RECORD: Plain Casing

Size 6 & kind Pla. from 0 to 40 ft.

Size & kind from to ft.

Size & kind from to ft.

Perforated Casing

Size & kind from to ft.

Size & kind from to ft.

Size & kind from to ft.

GROUTING RECORD

Material Cement

Intervals 0 to 20 Ft

Placement Method Shoveled Cement

GRAVEL PACK: Size

Interval

TEST DATA

Date Tested XX 9 2, 19 76

Static Water Level Prior to Test 24 ft.

Type of Test Pump Sub.

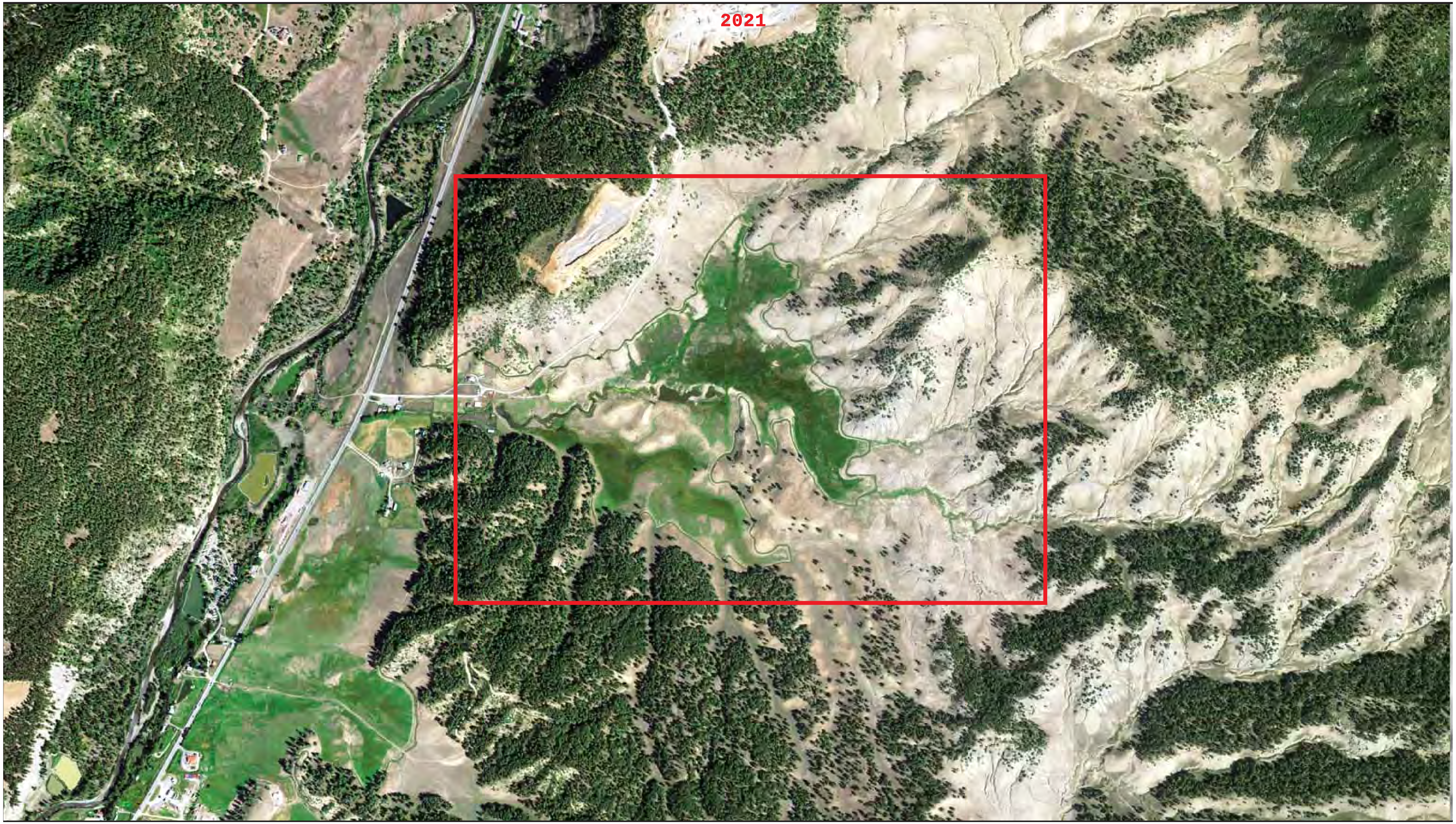
Length of Test 2 Hr

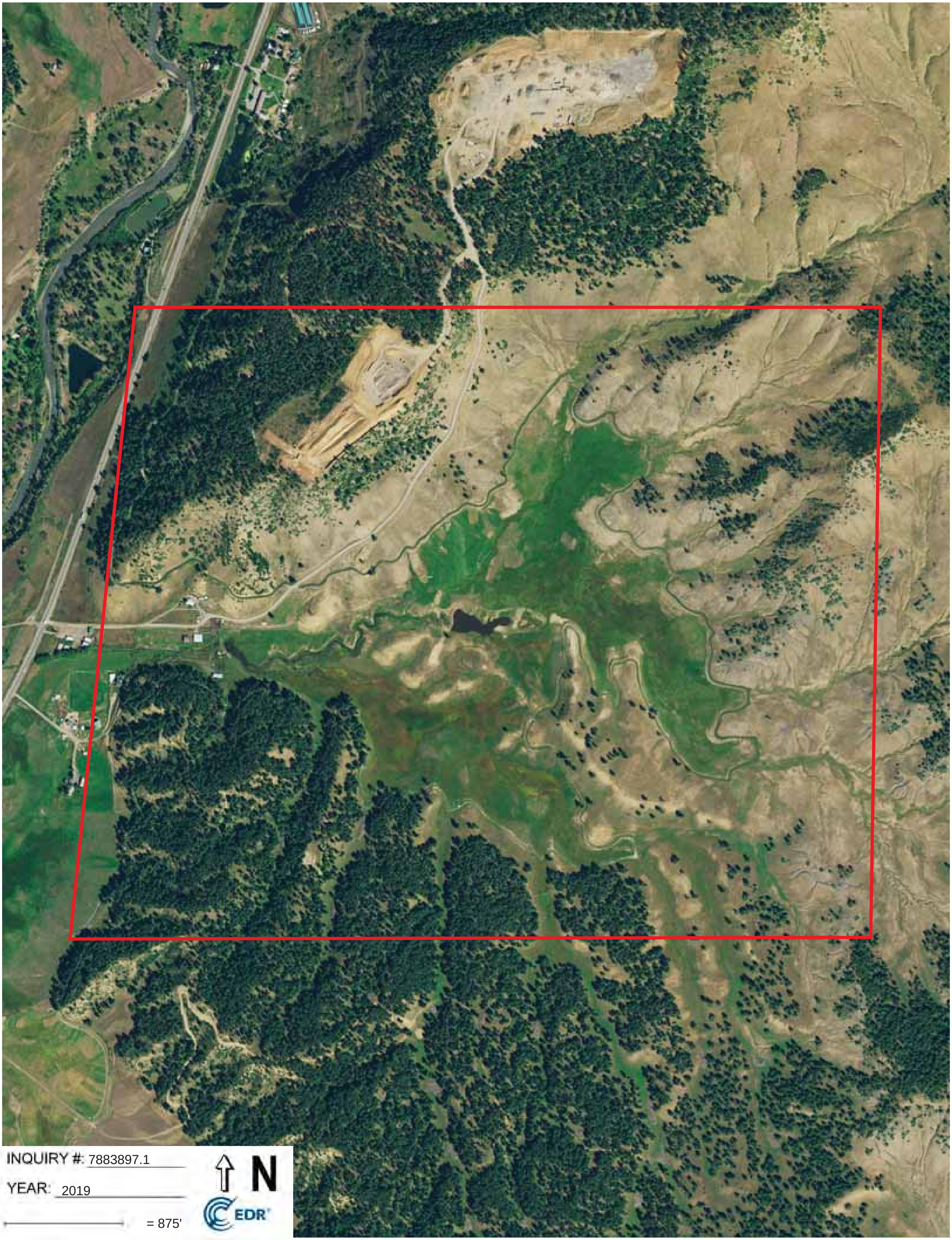
Sustained Yield (Metered) 3 gpm

Final Pumping Water Level

APPENDIX B - AERIAL PHOTOS


2023


2021

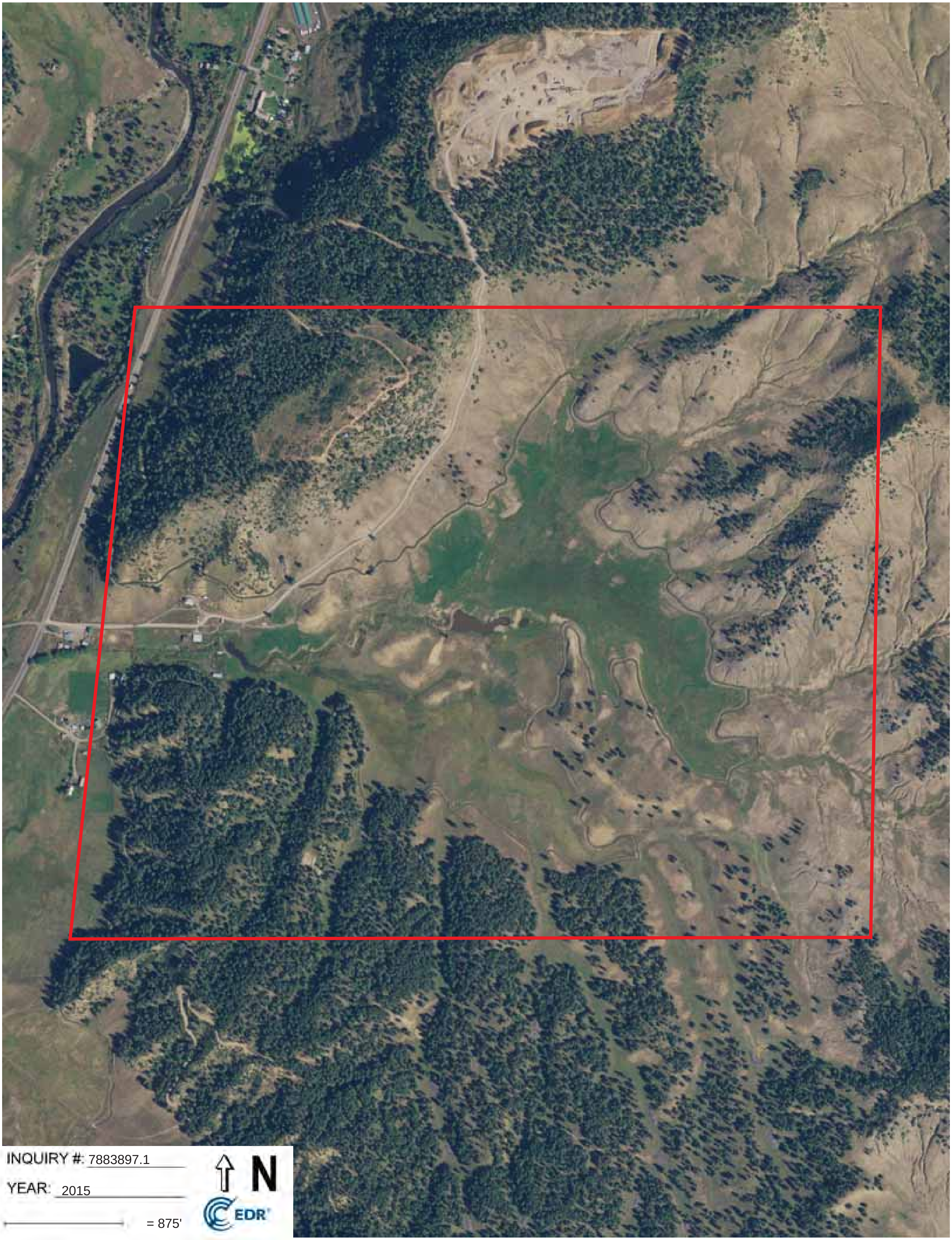


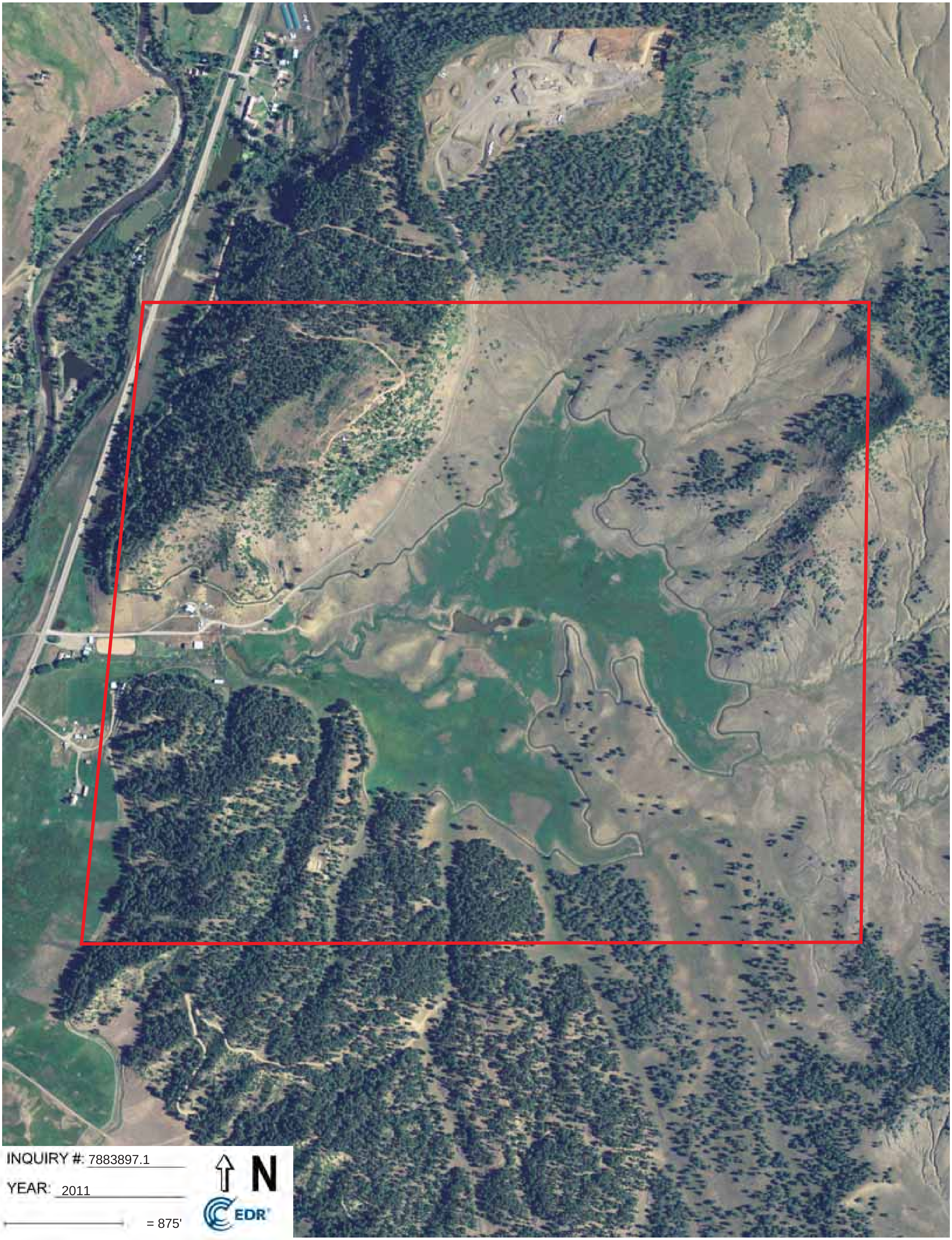
INQUIRY #: 7883897.1

YEAR: 2019

= 875'

N


INQUIRY #: 7883897.1
YEAR: 2015
= 875'
N
EDR



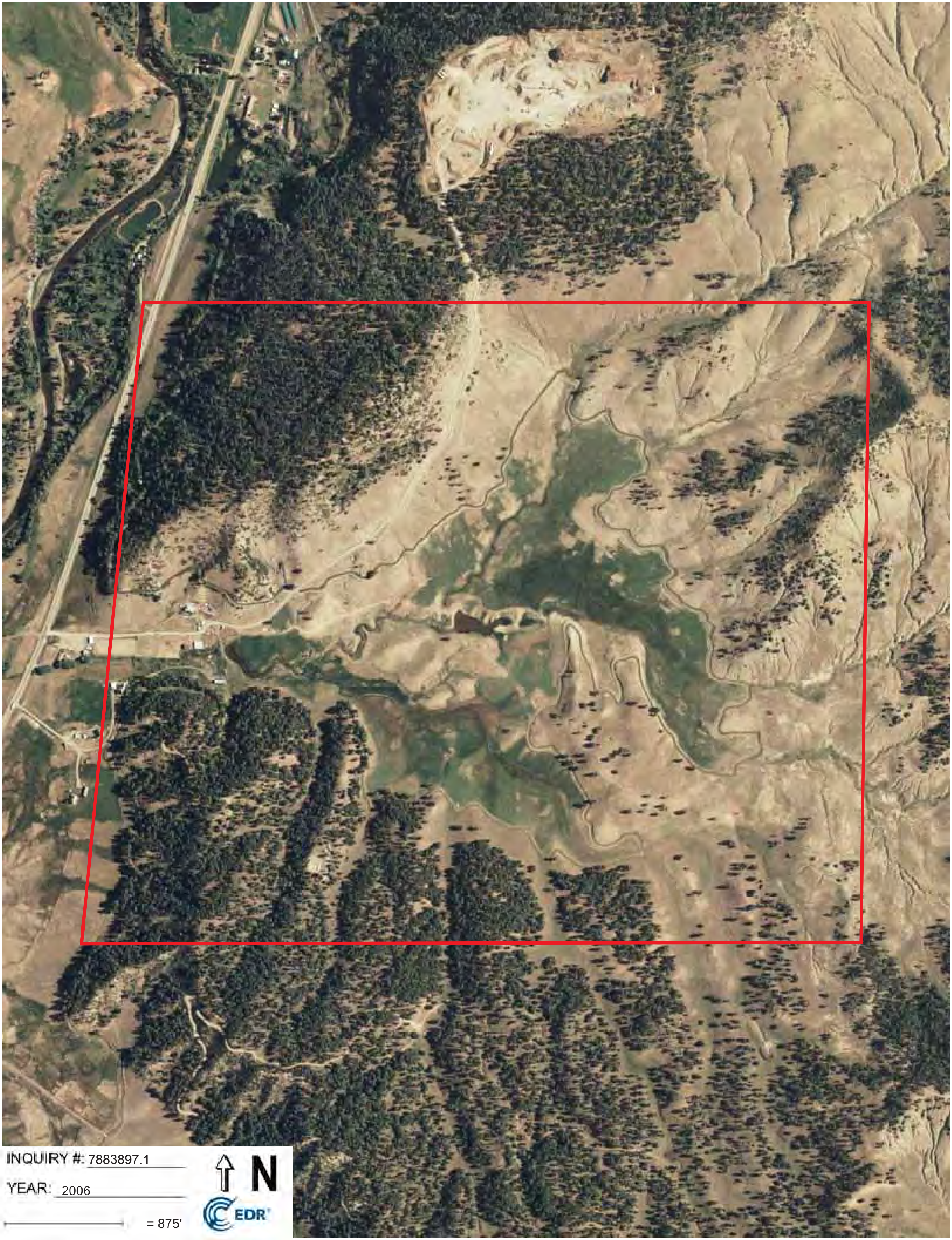
INQUIRY #: 7883897.1

YEAR: 2011

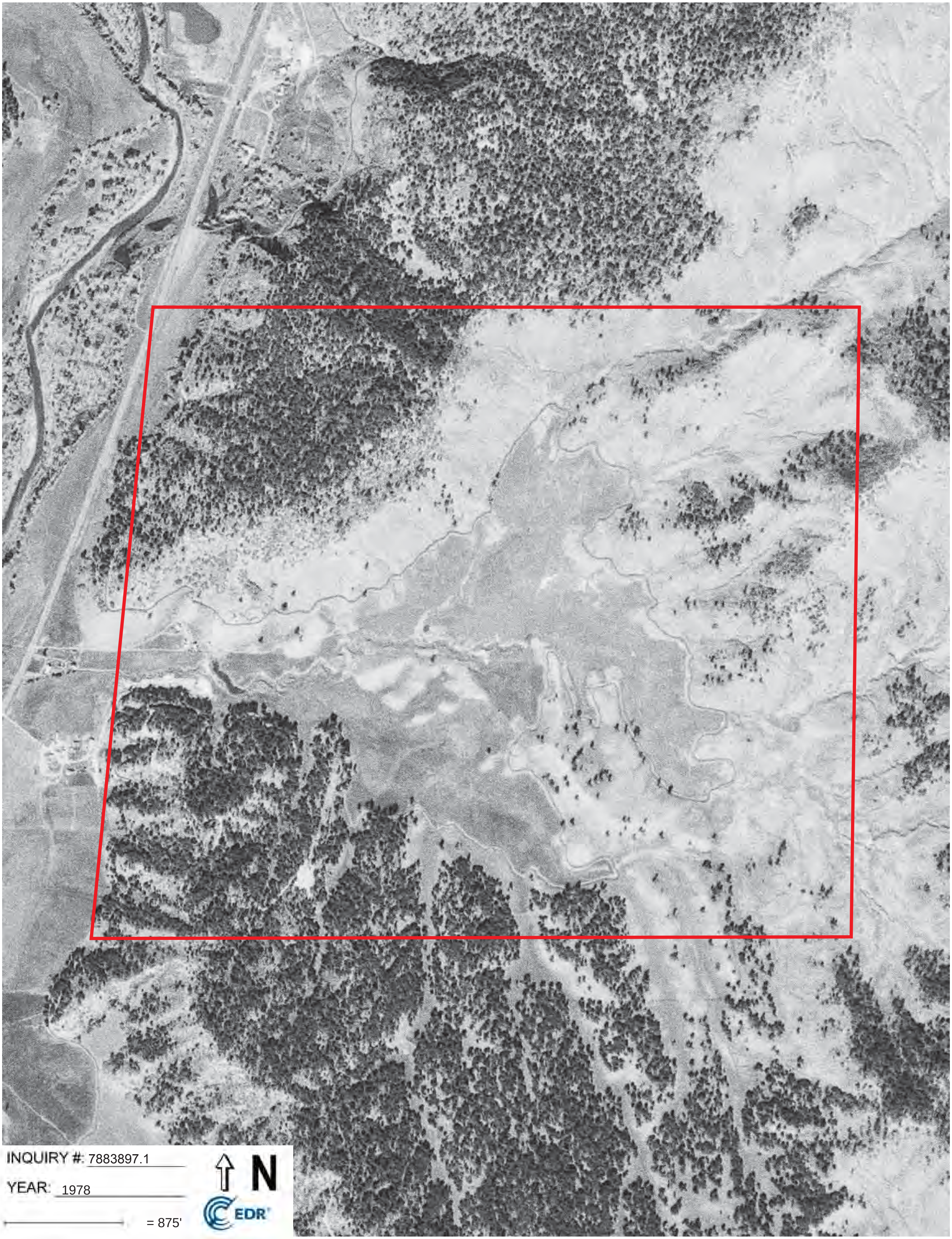
= 875'

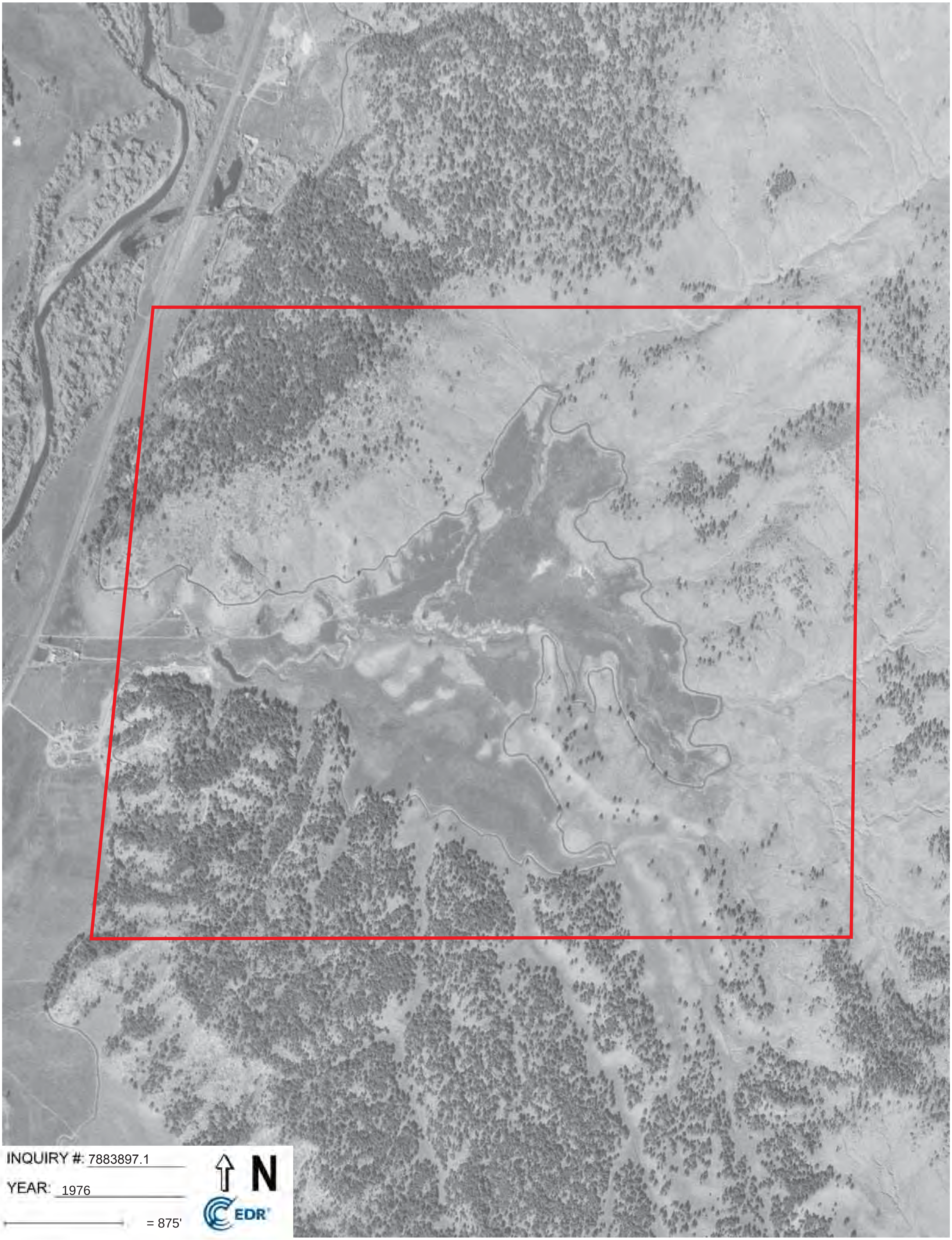
N

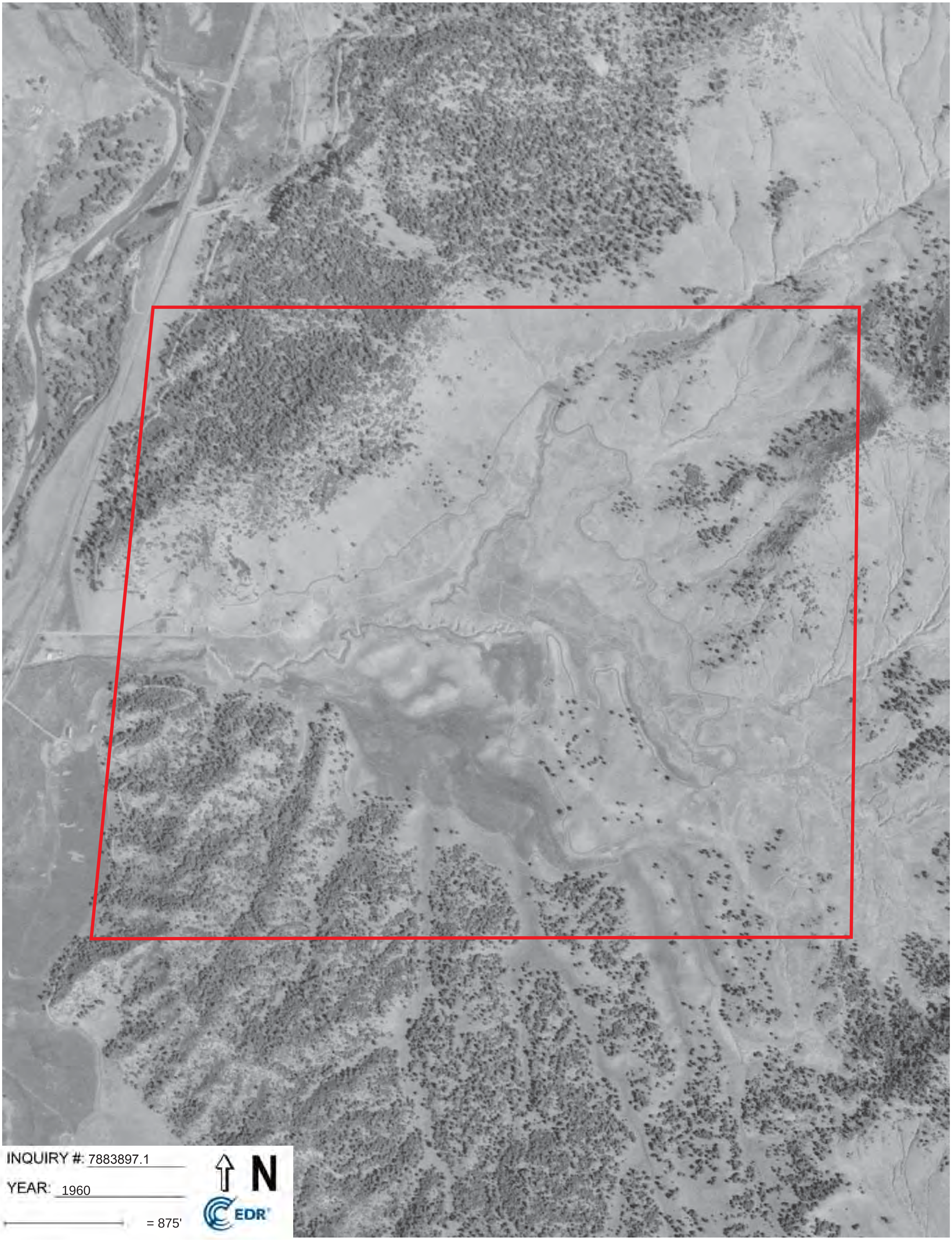
EDR


INQUIRY #: 7883897.1
YEAR: 2006
= 875'
N
EDR


INQUIRY #: 7883897.1
YEAR: 1993
= 875'
N
EDR


INQUIRY #: 7883897.1
YEAR: 1978
= 875'
N
EDR


INQUIRY #: 7883897.1
YEAR: 1976
= 875'
N
EDR


INQUIRY #: 7883897.1
YEAR: 1960
= 875'
N
EDR