

## 5.0 GEOLOGY

### 5.1 TERRAIN AND GEOLOGY

The Project primarily traverses the Interior Plain Physiographic Province, crossing into the Laurentian Upland Province—Superior Upland in the eastern portion of its preferred route in Minnesota (USGS, 2004). The geologic terrain of both of these provinces is characterized by ancient pre-Cambrian igneous and metamorphic rocks that have been uplifted and eroded to a relatively low-relief plain, forming the stable geologic core of the North American continent, known as the craton. The North American craton has been tectonically stable for over 500 million years. The Superior Upland is a southern extension of the Laurentian Upland Province. The basement rocks of this province are associated with the 2.5-billion-year-old Kenoran Orogeny, a mountain-building event, and are part of the Canadian Shield. Basement rocks of the Interior Plains Physiographic Province were generally formed from the tectonic collision of smaller continental plates over one billion years ago that resulted in continental accretion and expansion of the North American craton.

The bedrock geology underlying the preferred route is illustrated in Figure 5.1-1 (after Jirsa and others, 2011). Very limited occurrences of Paleozoic and Mesozoic sedimentary bedrock units lie randomly over the pre-Cambrian basement rocks across northern Minnesota. Ordovician sedimentary bedrock occurs in the northwestern portion of Polk County, but lies to the north of the preferred route. However, two relatively short segments (total length approximately 18.5 miles) of the preferred route cross Cretaceous sedimentary bedrock in both Aitkin and Cass counties. These sediments were deposited 65 to 136 million years ago and consist of sandstone lenses near the base of predominantly gray, soft, argillaceous shale (solidified mud and clay) sections.

Surficial geology along the preferred route is characterized by unconsolidated deposits from Pleistocene continental glaciation. In the Project area, these sediments were deposited primarily during four major episodes of glaciation of variable provenance. The sediments are comprised of both ground and end moraine, outwash deposits, ice-contact stratified drift (e.g., kames and eskers), and lacustrine sediments, including lake bottom and beach ridge deposits. Additionally, there are more recent deposits of alluvium in river channels and peat in the pothole depressions that are characteristic of the interrupted drainage of glaciated terrain. Figure 5.1-2 is a simplified map (after Hobbs and Goebel, 1982) of the surficial geology in relation to the preferred route.

Topography across the preferred route varies widely given the variable nature of glacial deposition. The interrupted drainage of glacial terrain can be of low relief and include wetlands, lakes, and gently rolling to undulating hills and ridges, as well as hummocky areas of high relief with steep hills and ridges associated with glacial end moraine deposits. Additionally, glacial erosion can remove unconsolidated deposits and scour bedrock, and glacial meltwater can incise significant valleys into bedrock (MNDNR, 1997). Elevations in

the Project area range from approximately 797-feet to 1,678-feet above mean sea level (see Table 5.1-1).

Regional maps of depth-to-bedrock coverage generally lack sufficient resolution to identify areas where bedrock occurs at specific depths (see Section 5.4). Accordingly, the depth to bedrock in a specific location is difficult to determine without sampling. Generally, depth to bedrock along the preferred route segments can exceed 450-feet; however, using digital coverage of depth-to-bedrock (Olsen and Mossler, 1982), the preferred route was found to cross an area of more or less continuous bedrock exposure from approximate MP 580.9 to MP 583.4. This area of shallow bedrock is located in Carlton County, and the bedrock geology is dominated by graywackes, slates, and metasediments. In areas where the pipeline is installed using HDD techniques, bedrock could be at a depth where it may be encountered during construction. These areas will be identified from geotechnical borings at the HDD crossings and will be factored into the design of the crossings.

As stated previously, the area crossed by the Project has been tectonically stable for over 500 million years. Therefore, there is a low probability of an earthquake of significant intensity or other seismic event in the Project area (National Atlas of the United States, 2013).

<b>Table 5.1-1 Elevation Along the Sandpiper Pipeline Project</b>			
County	Elevation Above Mean Sea Level (feet)		
	Lowest	Average	Highest
Polk	797	1,043	1,332
Red Lake	1,030	1,090	1,126
Clearwater	1,270	1,463	1,617
Hubbard	1,361	1,460	1,678
Cass	1,276	1,385	1,517
Crow Wing	1,333	1,374	1,417
Aitkin	1,203	1,263	1,369
Carlton	908	1,196	1,317
<b>Average</b>	<b>1,147</b>	<b>1,284</b>	<b>1,422</b>

**Figure 5.1-1  
 Bedrock Geology**

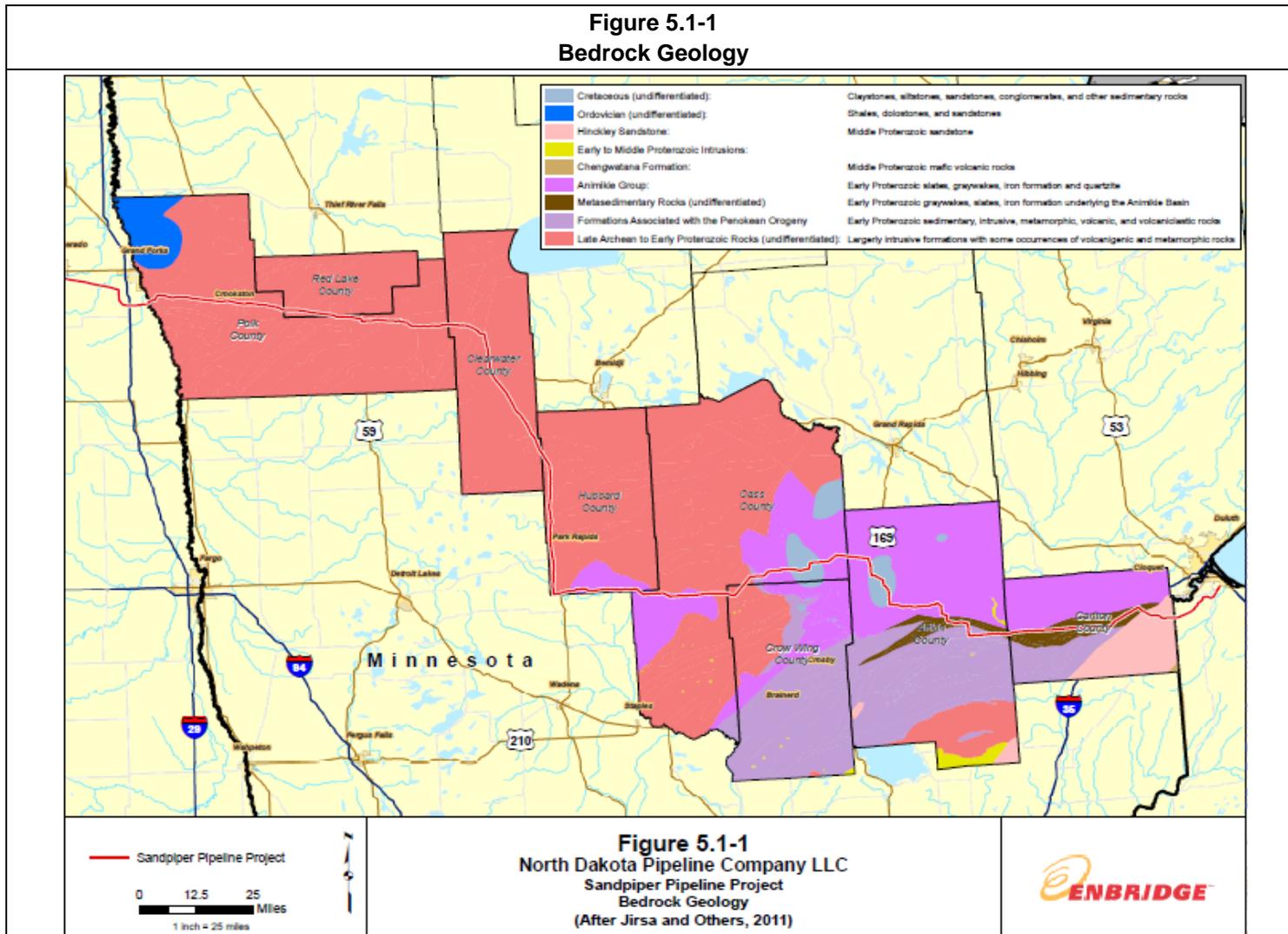
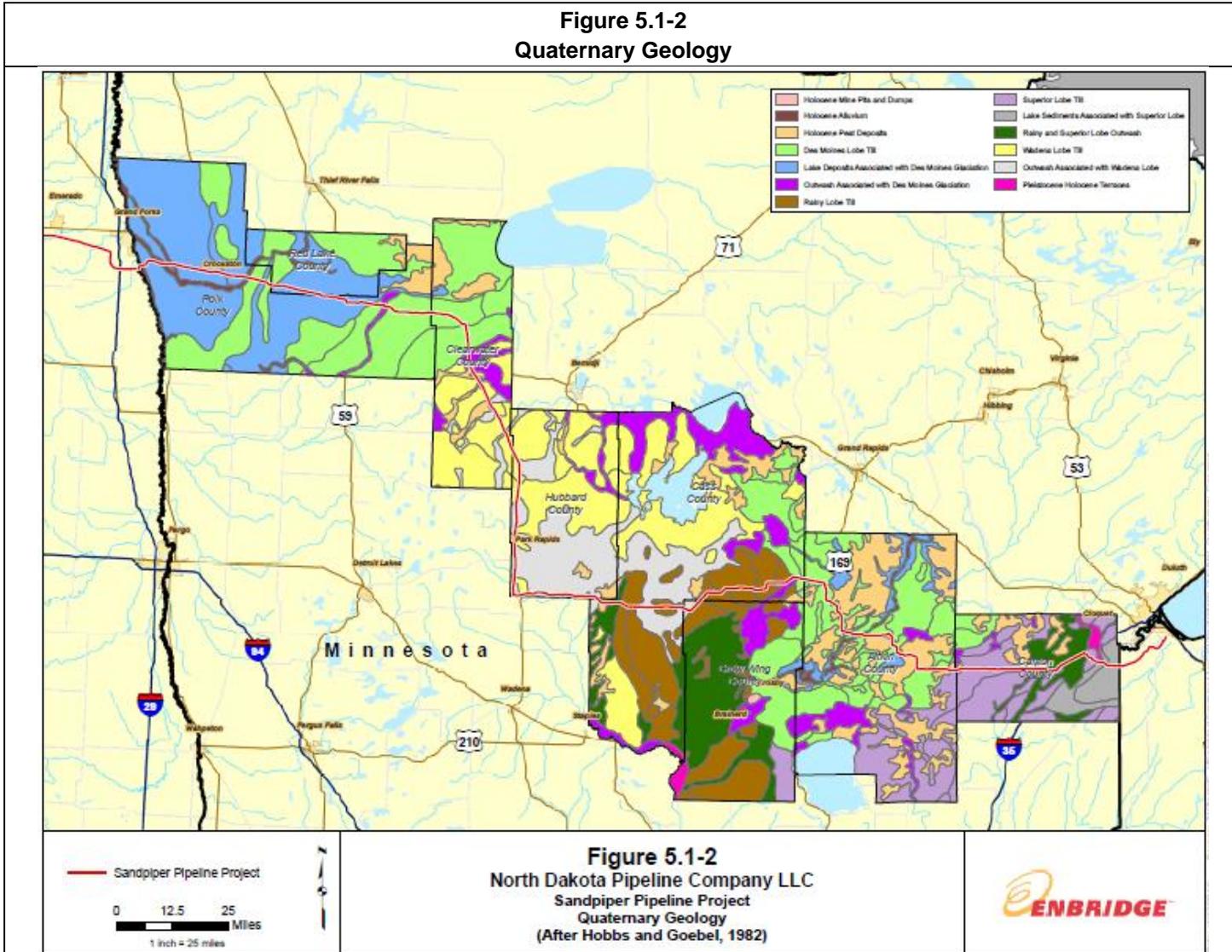


Figure 5.1-2  
 Quaternary Geology



### 5.1.1 Mineral Resources

Mineral resources in Minnesota include industrial (e.g., sand, gravel, and crushed stone) and metallic (e.g., iron ore, nickel, and titanium) minerals. USGS topographic maps, 2013 aerial photography, and MNDNR spatial data for mineral leases on state lands (as of January 2014) were used to identify surface features associated with mining or mineral resources.

Table 5.1.1-1 identifies possible mining and mineral resource areas within 1,500-feet of the construction workspace. Of the localities listed, 24 sites are possibly associated with non-metallic resources (20 gravel pits, 3 sand/gravel pits, and 1 sand pit) and 23 are tracts associated with active metallic mineral leases, all of which are located in Carlton County.

County	Milepost	Operation	Distance and Direction from the Right-of-Way
Polk	318.1	Sand/Gravel Pit <sup>a</sup>	1498 feet south
Red Lake	331.6	Sand/Gravel Pit <sup>a, b</sup>	813 feet south
Polk	329.1	Gravel Pit <sup>b, c</sup>	1400 feet south
	352.6	Sand/Gravel Pit <sup>c</sup>	660 feet north (does not appear active)
	367.1	Gravel Pit <sup>c</sup>	1400 feet northwest (does not appear active)
Clearwater	375.4	Gravel Pit <sup>c</sup>	1150 feet northeast (does not appear active)
	383.8	Gravel Pit <sup>c</sup>	910 feet west (does not appear active)
	386.3	Gravel Pit <sup>c</sup>	1320 feet west
Cass	479.8	Gravel Pit <sup>b, c</sup>	80 feet north (from aerial coverage)
	497.6	Gravel Pit <sup>b, c</sup>	50 feet north (from aerial coverage)
	500.7	Gravel Pit <sup>c</sup>	1260 feet north (does not appear active)
Aitkin	516.2	Gravel Pit <sup>b</sup>	80 feet north
	524.0	Gravel Pit <sup>c</sup>	1200 feet southwest (does not appear active)
	528.3	Sand Pit <sup>c</sup>	250 feet west (does not appear active)
	529.3	Gravel Pit <sup>c</sup>	770 feet south (does not appear active)
	532.1	Gravel Pit <sup>b, c</sup>	780 feet south (from aerial coverage)

Table 5.1.1-1 Mineral Resources within 1,500-Feet of the Sandpiper Pipeline Project			
County	Milepost	Operation	Distance and Direction from the Right-of-Way
	532.2	Gravel Pit <sup>b, c</sup>	1420 feet south (does not appear active)
Carlton	561.8	Metallic Mineral Exploration <sup>d</sup>	858 feet south
	562.0	Metallic Mineral Exploration <sup>d</sup>	1450 feet south-southeast
	562.1	Metallic Mineral Exploration <sup>d</sup>	1039 feet north-northwest
	562.1	Metallic Mineral Exploration <sup>d</sup>	159 feet south-southeast
	562.3	Metallic Mineral Exploration <sup>d</sup>	575 feet north-northeast
	562.4	Metallic Mineral Exploration <sup>d</sup>	620 feet south-southeast
	562.5	Metallic Mineral Exploration <sup>d</sup>	1373 feet north-northwest
	562.5	Metallic Mineral Exploration <sup>d</sup>	128 feet north
	562.6	Metallic Mineral Exploration <sup>d</sup>	1249 feet north
	562.7	Metallic Mineral Exploration <sup>d</sup>	120 feet north
	562.7	Metallic Mineral Exploration <sup>d</sup>	1042 feet south
	563.0	Metallic Mineral Exploration <sup>d</sup>	109 feet north
	563.0	Metallic Mineral Exploration <sup>d</sup>	1051 feet south
	563.2	Metallic Mineral Exploration <sup>d</sup>	99 feet north
	563.2	Metallic Mineral Exploration <sup>d</sup>	1057 feet south
	563.4	Metallic Mineral Exploration <sup>d</sup>	1210 feet north
	563.5	Metallic Mineral Exploration <sup>d</sup>	88 feet north
	563.5	Metallic Mineral Exploration <sup>d</sup>	1121 feet south-southwest
	563.7	Metallic Mineral Exploration <sup>d</sup>	1071 feet south
	563.8	Metallic Mineral Exploration <sup>d</sup>	899 feet north
	563.9	Metallic Mineral Exploration <sup>d</sup>	890 feet north
	564.0	Metallic Mineral Exploration <sup>d</sup>	23 feet south
	564.7	Metallic Mineral Exploration <sup>d</sup>	124 feet south
	565.5	Gravel Pit <sup>b</sup>	1350 feet south
	581.3	Gravel Pit <sup>c</sup>	970 feet north (does not appear active)
	587.9	Gravel Pit <sup>b</sup>	570 feet northwest
588.2	Gravel Pit <sup>b</sup>	700 feet southeast	
593.1	Gravel Pit <sup>b, c</sup>	620 feet northeast (from aerial coverage)	
594.1	Gravel Pit <sup>b, c</sup>	750 feet southwest	
594.2	Gravel Pit <sup>b, c</sup>	790 feet northeast	

Table 5.1.1-1 Mineral Resources within 1,500-Feet of the Sandpiper Pipeline Project			
County	Milepost	Operation	Distance and Direction from the Right-of-Way
<sup>a</sup> USGS (2013a) <sup>b</sup> Based on a review of 2013 aerial photography <sup>c</sup> Based on a review of USGS topographic maps <sup>d</sup> Source: Minnesota Minerals Coordinating Committee (2013), MNDNR (2009). Does not include terminated or expired mineral contracts or leases.			

Of the 23 metallic mineral exploration tracts presented in Table 5.1.1-1, the project would cross 10 tracts that the MNDNR actively leases for mineral exploration (see Table 5.1.1-2). All 10 tracts are located in Carlton County and are leased by Kennecott Exploration Company. A total of 2.4 miles of actively leased lands would be crossed by the Project.

Table 5.1.1-2 Lands Leased for Mineral Exploration Crossed by the Sandpiper Pipeline Project				
Township / Range / Section	Beginning Milepost	End Milepost	Length (Miles) <sup>a</sup>	MNDNR Land Class
T47N / R21W / S6	561.8	562.0	0.2	Tax Lands
T47N / R21W / S6	562.0	562.1	0.1	Tax Lands
T47N / R21W / S6	562.1	562.3	0.3	Tax Lands
T47N / R21W / S6	562.3	562.6	0.3	School Trust
T47N / R21W / S6	562.6	562.9	0.3	Tax Lands
T47N / R21W / S5	562.9	563.1	0.3	Tax Lands
T47N / R21W / S5	563.1	563.4	0.3	Tax Lands
T47N / R21W / S5	563.4	563.6	0.3	Tax Lands
T47N / R21W / S4	563.9	564.1	0.2	Tax Lands
T47N / R21W / S4	564.6	564.9	0.2	Tax Lands
<b>TOTAL</b>			2.4	
<sup>a</sup> Discrepancies between miles presented and the total are due to rounding.				

In addition, the preferred route will cross two areas of bedrock greenstone belt terrain in the western portion of Minnesota (MNDNR, 2013g). Greenstone belt terrains is characterized by variably metamorphic rock that has undergone a change in existing rock structure or composition induced by location, chemicals, or temperature. Greenstone belt terrains have the potential to contain gold mineralizations.

### **5.1.2 Paleontology**

Based on the thickness of the unconsolidated glacial material in the Project area, significant paleontological resources are not likely to be encountered during construction. Despite the fact that glacial deposits in Minnesota are of Pleistocene age, megafauna fossils tend to be scarce where glacial ice was present (Mather, 2009; Sloan, 2005). NDPC consulted with the Minnesota Geological Survey (“MGS”) and confirmed that paleontological finds are not common in the northern half of Minnesota. However, NDPC has developed a Draft Unanticipated Discoveries Plan (included as Appendix D) that will be implemented in the event of an unanticipated paleontological find.

## **5.2 GENERAL CONSTRUCTION AND OPERATION IMPACTS AND MITIGATION**

No unique geological features that have received state or federal protection will be disturbed by the Project. Construction and operation of the Project will result in minor impacts on topography and geology. Primary impacts will be limited to construction activities and consist of temporary alteration of slopes on the construction right-of-way due to grading and trenching operations. These disturbances will be necessary to create a level and safe construction area.

NDPC will minimize impacts by returning contours to pre-construction conditions to the extent practicable. In addition, NDPC will implement the erosion control measures described in the EPP (see Appendix A). These measures include the installation of slope breakers, temporary sediment barriers, and permanent trench breakers, as well as the revegetation and mulching of the construction right-of-way.

Blasting is not anticipated but may be required if bedrock is encountered within the depth of the trench. Only 2.5 miles of the preferred route will cross bedrock outcrops. If blasting is required, NDPC will conduct these activities in accordance with applicable U.S. Occupational Safety & Health Administration regulations.

Based on USGS topographic maps, 2013 aerial photography and data, and MNDNR mineral lease spatial data, the preferred route is located within 1,500-feet of 47 possible mining operations and mineral leases. Ten individual parcels where active MNDNR metallic mineral leases have been granted will be crossed by the Project’s construction right-of-way. The greenstone belt terrains crossed by the Project do not contain any known gold mineralizations or high gold potential zones and are currently unexplored due to immensely thick overlying glacial materials. However, these areas may attract mineral exploration activities in the future. There is a potential that future use of sand and gravel or mineral resources will be precluded where the pipeline is installed across these resource deposits. In areas where the Project is located adjacent to any existing utilities, any sand and gravel deposits in the Project area will be unavailable for mining.

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For mineral leases on state lands, Minnesota Rule 6125.0700 requires that the mineral lessee be consulted prior to issuance of any other surface leases, permits or licenses, and such leases, permits or licenses shall not unduly interfere with the exploration or mining operations conducted on the leased mining units. NDPC will continue to consult with the MNDNR, Carlton County, and Kennecott concerning metallic mineral resources and active mineral leases that will be crossed by the Project.

Construction of the pipeline will not likely affect any significant paleontological resources; however, any unique resources exposed or excavated during pipeline construction will be recovered and studied for the scientific record and managed in accordance with NDPC's Unanticipated Discoveries Plan.

NDPC does not anticipate impacts associated with seismic activity within the Project area. Due to the limited potential for large, seismically induced ground movements, there is minimal risk of earthquake-related impacts on the pipeline. No additional mitigation beyond designing the pipeline to currently accepted industry specifications will be required.

No additional disturbance or loss of unique geological features, mineral resources, or scientifically important fossils will occur during operations because there will be no additional surface disturbance required beyond that used for construction.