RESOURCE REPORT NO. 6
GEOLOGICAL RESOURCES

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Northern Lights 2025 Expansion Project

FERC Docket No. CP24- -000

February 2024

RESOURCE REPORT 6 – GEOLOGICAL RESOURCES SUMMARY OF FILING INFORMATION

	Found in Section
1. Identify the location (by milepost) of mineral resources and any planned or active surface mines crossed by the proposed facilities – Title 18 Code of Federal Regulations (CFR) § 380.12(h)(1)&(2)	Section 6.3 and Table 6.3-1
2. Identify any geologic hazards to the proposed facilities – 18 CFR § 380.12(h)(2)	Section 6.4
3. Discuss the need for and locations where blasting may be necessary in order to construct the proposed facilities – 18 CFR § 380.12(h)(3)	Section 6.2
4. For liquefied natural gas (LNG) projects in seismic areas, the materials required by "Data Requirements for the Seismic Review of LNG Facilities," National Bureau of Standards Information Report 84-2833 – 18 CFR § 380.12(h)(5)	Not applicable
5. For underground storage facilities, how drilling activity by others within or adjacent to the facilities would be monitored, and how old wells would be located and monitored within the facility boundaries – 18 CFR § 380.12(h)(6)	Not applicable
Additional Information Often Missing and Resulting in Data Requests	
• Identify any sensitive paleontological resource areas crossed by the proposed facilities. (Usually, only if raised in scoping or required by land-managing agency.)	Section 6.7
• Briefly summarize the physiography and bedrock geology of the project.	Section 6.1
• If proposed pipeline crosses active drilling areas, describe plan for coordinating with drillers to ensure early identification of other companies' planned new wells, gathering lines, and aboveground facilities.	Not applicable
• If the application is for underground storage facilities: – Describe monitoring of potential effects of the operation of adjacent storage or production facilities on the proposed facility, and vice versa; – Describe measures taken to locate and determine the condition of old wells within the field and buffer zone and how the applicant would reduce risk from failure of known and undiscovered wells; and – Identify and discuss safety and environmental safeguards required by state and federal drilling regulations.	Not applicable

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Abbreviations and Acronyms

amsl	above mean sea level
CFR	Code of Federal Regulations
EI	Environmental Inspector
ERT	Electrical Resistivity Tomography
fbg	feet below grade
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
g	standard gravity
HDD	Horizontal directional drill
LNG	Liquefied natural gas
MDNR	Minnesota Department of Natural Resources
MGS	Minnesota Geological Survey
MP	milepost
N/A	Not applicable
Northern	Northern Natural Gas
NRCS	Natural Resources Conservation Service
PGA	peak ground acceleration
Plan	FERC Upland Erosion Control, Revegetation, and Maintenance Plan
Project	Northern Lights 2025 Expansion Project
ROW	right of way
SFHA	Special Flood Hazard Area
SSURGO	Soil Survey Geographic Database
USGS	U.S. Geological Survey
WGNHS	Wisconsin Geological and Natural History Survey

6.0 GEOLOGICAL RESOURCES

Resource Report 6 describes the geologic setting for Northern's proposed Project and details geological resources and hazards that may directly or indirectly affect the construction, operation and maintenance of the Project.

Northern owns and operates an approximately 14,300-mile-long natural gas transmission pipeline system and associated aboveground facilities, including pipeline and facilities in Minnesota and Wisconsin. Northern is proposing to construct the Project, which will consist of (1) a 3.00-mile extension of its 36-inch-diameter Lake Mills to Albert Lea E-line; (2) a 2.43-mile extension of its 30-inch-diameter Elk River 3rd branch line; (3) a non-contiguous 1.91-mile extension of its 30-inch-diameter Farmington to Hugo C-line; (4) a 1.28-mile extension of its 8-inch-diameter Tomah branch line loop; (5) minor modifications to its existing La Crescent compressor station; and (6) aboveground facilities including a launcher, receiver and tie-in valve settings. All Project components are located in various counties in Minnesota and Wisconsin.

Since a majority of the geologic resources described in Resource Report 6 occurs on a statewide or regional level, the Project components are analyzed collectively, except where otherwise noted.

6.1 GEOLOGIC SETTING

The Project is located within the Central Lowlands physiographic province (Fenneman 1928). The Central Lowlands is the largest physiographic province in the continuous U.S. and is subdivided into sections based on glacial features as most of the Central Lowlands were subjected to repeated glaciations during the Pleistocene epoch. The Lake Mills to Albert Lea E-line, Elk River 3rd branch line and Farmington to Hugo C-line are located within the glaciated portions of the province; the Tomah branch line loop and La Crescent compressor station are located within the driftless area. The driftless area is located in the southeast corner of Minnesota and the southwestern portion of Wisconsin, and is an area that was not covered by large ice flows during the last glacial period.

The rock of the Precambrian era is the oldest rock on earth. Precambrian rock ranges in age from 600 million years to as much as four billion years and constitutes the basement rock present beneath the Project area (MGS 1994). During the early Paleozoic Era, beginning about 545 million years ago, shallow marine seas filled a depression in the Precambrian basement rock in the southeast corner of Minnesota and southwestern Wisconsin, known as the Hollandale Embayment. As the seas advanced and retreated several times, thin layers of sandstone, shale and carbonates were deposited over the Precambrian basement rock, resulting in the Paleozoic bedrock formations present in the southeast part of Minnesota and southwest part of Wisconsin (MGS 2002). During the late Mesozoic Era, beginning about 100 million years ago, the interior of the North American continent was flooded by marine waters, known as the Western Interior Seaway. A northeastern extension of the seaway intermittently covered much of Minnesota and deposited conglomerate, sandstone, mudstone, shale, siltstone and marl. The remainder of Minnesota and Wisconsin were above sea level throughout the Mesozoic Era. As shown on Figure 6-1, the Lake Mills to Albert Lea line, Elk River 3rd branch line, Farmington to Hugo C-line, Tomah branch line loop, and the La Crescent compressor station are underlain by Paleozoic sedimentary rocks (Bauer 2016; Mudrey et al. 1982; Quade H.W. and Rongstad, J. 1991).

Bedrock was not encountered in geotechnical borings completed for the Lake Mills to Albert Lea E-line. Fourteen geotechnical borings completed for the Elk River 3rd branch line encountered bedrock at depths between 36 and 103 fbg. With the exception of BH-5, the bedrock at each boring

consisted of sandstone, interpreted as the Jordan Sandstone and St. Peter Sandstone. Borehole BH-5 contained shale underlain by sandstone, interpreted as being a fine-grained basal component of the Prairie du Chien Group overlying the Jordan Sandstone. Six geotechnical borings completed for the Farmington to Hugo C-line encountered bedrock at depths between approximately 60.5 to 95.0 fbg, consisting of sandstone interpreted to be St. Peter Sandstone or dolostone interpreted to be the Shakopee Formation of the Prairie du Chien Group. Four geotechnical borings completed for the Tomah branch line loop encountered bedrock at depths between 4.5 and 14.5 fbg, consisting of sandstone, interpreted to undivided Cambrian Trempealeau, Tunnel City and Elk Mound Formations.

During the Pleistocene Epoch of the Quaternary Period (which ranges from approximately 2.5 million to 11,700 years ago), a majority of the region that comprises the States of Minnesota and Wisconsin experienced a series of glacial and interglacial periods. During this time, large lobes of ice periodically covered all but the driftless area. When the glaciers advanced, eroded material was picked up by the ice sheets and then deposited as thick layers of drift when the glaciers receded (Lusardi et al. 2019). Aboveground pipeline facilities and pipelines for the Project are underlain by 50 feet or more of glacial drift, with the exception of the Tomah branch line loop, which is underlain by less than 50 feet of colluvium, and the La Crescent compressor station, which is constructed on carbonate bedrock at or near the land surface (Bauer 2016; Lusardi 2013; Quade, H.W. and Rongstad, J. 1991; Setterholm 2006; Trotta and Cotter 1973). Figure 6-2 depicts the surficial geology at the Project locations.

Topography of the Project in Minnesota generally consists of level to gently rolling terrain, with occasional hills formed by glacial moraines or valleys formed by flowing water. The greatest topographic relief is found within the Lake Mills to Albert Lea E-line with elevations ranging from approximately 1,264 feet amsl to 1,306 feet amsl. Topography within the other Project components exhibit between 25 and 38 feet of relief between maximum and minimum elevations. Topography of the Project in Wisconsin consists of a rolling terrain with dissected bedrock valleys. The topographic relief for the Tomah branch line loop ranges between 804 feet amsl and 930 feet amsl.

Three geotechnical boring logs completed along the Lake Mills to Albert Lea E-line indicate glacial till, predominantly lean clay with varying amounts of sand, and clayey sand, to depths of at least 31.5 fbg, the terminal depth of the borings. Fourteen geotechnical boring logs completed along the Elk River 3rd branch line indicate glacial till, predominantly sand, sand with gravel, silty sand, clayey sand, silty/sandy lean clay, and minor instances of gravel with sand/silt, to depths of 36 and 103, with bedrock encountered at depths between 36 and 103 feet in ten borings. Six geotechnical boring logs completed along the Farmington to Hugo C-line indicate glacial till, predominately silty sand, clayey sand, sandy lean clay, and minor gravel with sand layers, to depths of 60.5 to 95.0 fbg, where bedrock was encountered. Four geotechnical boring logs completed along the Tomah branch line loop indicate alluvium consisting of sand with silt and poorly graded sand, to depths of 4.5 to 14.5 fbg, where bedrock was encountered. No geotechnical borings were completed for the La Crescent compressor station.

6.2 BLASTING

Based on the soil survey data, the Project components except the Tomah branch line loop are located in areas with a depth to bedrock of 78 inches or greater. Approximately 4.90 acres (19%) of soil within the Tomah branch line construction footprint is identified as having the potential for shallow bedrock (USDA 2024). Shallow bedrock was also encountered in the geotechnical borings completed on the Tomah branch line loop.

Should shallow bedrock be encountered, Northern will implement the following measures to prevent incorporation of rock into the topsoil:

- Segregation and protection of topsoil at excavations
- Disposal of excess rock fragments in an approved manner so as not to incorporate rock fragments into topsoil layers

Rock encountered during excavation will be removed using one of the following techniques: conventional excavation with a backhoe; ripping with a bulldozer followed by backhoe excavation; or hammering with a pointed backhoe attachment or a pneumatic rock hammer, followed by backhoe excavation. The technique selected will be dependent on relative hardness, fracture susceptibility, expected volume, and location.

Based on the relative softness of the bedrock encountered on the Tomah branch line loop, no blasting is currently anticipated. If blasting is required, Northern will submit a project-specific blasting plan to FERC.

6.3 MINERAL RESOURCES

The mineral industry in Minnesota consists of iron ore mining operations, which are limited to Itasca, Lake and St. Louis counties, Minnesota; peat production in northern Minnesota; and dimension stone, crushed stone, sand and gravel throughout the state (USGS 2019A). Iron ore mining and peat production do not occur in the vicinity of the Project. The mineral industry in Wisconsin consists of dimension stone, crushed stone, sand and gravel and lime, and historically, ferrous and non-ferrous metals. Monroe County, Wisconsin, produces crushed stone, sand, gravel, and industrial sands (USGS 2019B). A desktop analysis of topographic maps and aerial images of the Project area was completed to determine the presence of other nearby mining or quarrying activities.

No evidence of surface mining within 0.25 mile of the Lake Mills to Albert Lea E-line, Elk River 3rd branch line, Farmington to Hugo C-line, Tomah branch line loop, and La Crescent compressor station during desktop review (MDNR 2024b and WDNR 2024). While oil and gas exploration has occurred in Minnesota, no commercially viable oil and gas extraction has occurred (MGS 1984); therefore, no oil or gas extraction wells will exist within 0.25 mile of the Project. Wisconsin does not have any fossil fuel resources (EIA 2024).

No mineral resources were identified within 0.25 mile of the Lake Mills to Albert Lea E-line, Elk River 3rd branch line, Farmington to Hugo C-line, Tomah branch line loop, and La Crescent compressor station. No evidence of surface mining was observed via desktop review within 0.25 mile of these Project components.

6.4 GEOLOGIC HAZARDS AND OTHER NATURAL HAZARDS

6.4.1 Seismicity

An assessment of the potential for seismic ground motions within the Project area was conducted using data available from the USGS's 2018 Update to the U.S. National Seismic Hazard Model (Petersen et al. 2019; Rukstales and Petersen 2019). USGS National Seismic Hazard Probability Mapping shows that for the Project area, within a 50-year period, there is a 2% probability of an earthquake with an effective PGA of 2 to 4% g, and a 10% probability of an earthquake with an effective PGA of less than 2% being exceeded (Petersen et al. 2019). For reference, PGA of 10% (0.1 g) is generally considered the minimum threshold for damage to older structures or structures not constructed to resist earthquakes.

While Minnesota and Wisconsin are two of the least seismically active states in the U.S., there have been at least 14 earthquakes in Minnesota since 1860 (MGS 1979; USGS 2024a) and at least 30 earthquakes in Wisconsin since 1899 (Mudrey 1984; USGS 2024b). The closest recorded earthquake to the Project is the Mankato earthquake that occurred April 25, 2017 (USGS 2024b). This earthquake had a magnitude of 2.8 on the Richter scale and was located approximately 48 miles northwest of the Lake Mills to Albert Lea E-line. Based on the frequency of historic earthquakes and minor strength of the earthquakes, the Project is located in an area of low seismic risk.

Northern compared the Project footprint to the USGS Fault Map (USGS 2024c). There are no active mapped faults in Minnesota or Wisconsin. Northern does not anticipate any impacts associated with active fault lines.

6.4.2 Landslides

Assessment of the landslide incidence and susceptibility for the Project area was conducted using data available from the USGS National Landslides Hazards Program. According to the USGS, the Project is located in an area of low landslide incidence and low landslide susceptibility (Radbruch-Hall et al. 1982). Susceptibility to a landslide is defined as the probable degree of response of the area (rocks and soils) to natural or artificial cutting or loading of slopes. Low landslide incidence is defined by the USGS as an area having a less than 1.5% chance of a landslide incidence. The USGS Landslide Inventory did not indicate the presence of landslides within the Project area (USGS 2024d).

Soil liquefaction occurs when a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress. Deposits most susceptible to liquefaction are sands and non-plastic silty soils deposited within the last 10,000 years and saturated with water. Since the glacial deposits in the Project area occurred over 11,000 years ago and due to the lack of seismic activity in the Project area, the potential for soil liquefaction within the Project area is minimal.

Northern has reviewed site-specific civil survey elevation data to identify steep slopes present in the Project area. Slopes between 5% and 15% and between 15% and 30% are identified by beginning and ending MP in Appendix 6A. In accordance with the Plan, Northern will install temporary trench plugs and temporary slope breakers during construction on slopes greater than 5%. The temporary slope breakers will channel water off the ROW through a J-hook or other baffling device to limit water flow down long steep slopes. Temporary trench plugs will reduce the velocity of water flowing along the trench and volume of water that collects at the bottoms of slopes. In accordance with the Plan, Northern will install permanent trench breakers and permanent slope breakers in areas of steep slopes. Trench breakers are designed to prevent preferential water flow along the pipeline trench by diverting subsurface water flow to the land surface. Groundwater discharging to the land surface is then redirected off the ROW by slope breakers. Used in combination, these structures prevent subsurface piping of soils that can lead to slope instability and failure.

6.4.3 Karst Topography and Ground Subsidence

Land subsidence can occur as a result of oil and gas extraction. While some oil and gas exploration has occurred in Minnesota and Wisconsin, no commercially viable oil and gas extraction has occurred, and the geologic characteristics of the states make any future petroleum discoveries highly unlikely (MGS 1984; EIA 2024). The Project components will be part of a natural gas transportation system but will not extract oil or natural gas; therefore, the potential for land subsidence due to oil and gas extraction is minimal.

Assessment of the potential for land subsidence due to groundwater pumping was conducted using data available from the USGS. The USGS map depicts no extensive historical subsidence has occurred within the Project area (USGS 2000). The Project facilities will be part of a natural gas transportation system and will not conduct high-capacity groundwater extraction or use water for any industrial purposes.

Assessment of the potential for karst terrain was conducted using data available from the MDNR and WGNHS. The majority of the Project components are underlain by a thick layer of glacial drift, which significantly reduces the likelihood of the surface expression of karst bedrock features. The Tomah branch line loop is located in area of silicious sedimentary rocks, which are not subject to karst development. The remaining components are located in areas with moderate to low probability for karst features (Adams et al. 2016; WGNHS 2019).

The type and thickness of the unconsolidated material over carbonate bedrock is related to the frequency and type of sinkhole that can form. The USGS states that surface expression of sinkholes and other karst features is unlikely in areas where karst bedrock is covered by more than 50 feet of unconsolidated glacial material (Weary and Doctor 2014). Figure 6-1 depicts areas of the Project where carbonate bedrock is covered by glacial drift. The USGS identifies portions of the Lake Mills to Albert Lea E-line, Elk River 3rd branch line and Farmington to Hugo C-line as being located in areas with carbonate bedrock overlain by more than 50 feet of unconsolidated glacial material.

Geotechnical boring logs completed for the Lake Mills to Albert Lea E-line indicate glacial till, predominantly sandy lean clay and silty/clayey sand are present to depths of 31.5 fbg, the terminal depth of the borings. Geotechnical boring logs completed along the Elk River 3rd branch line indicate a combination of shale and sandstone bedrock encountered at depths between 31.5 and 103.0 feet in ten borings. Geotechnical boring logs completed along the Farmington to Hugo C-line indicate a combination of sandstone and dolostone to a depth of 60.5 to 95.0 fbg was encountered. Geotechnical boring logs completed along the Tomah branch line loop indicate sandstone bedrock was encountered at 4.5 to 14.5 fbg. Due to the thickness of the unconsolidated overburden and the results of the geotechnical borings, the potential for encountering karst features along the Lake Mills to Albert Lea E-line, Elk River 3rd branch line, and Farmington to Hugo C-line is negligible. According to the USGS, La Crescent compressor station is located in an area of Lower Ordovician bedrock with carbonate rocks at or near the surface. However, Northern is not completing any subsurface work at the facility; karst resources will be not be impacted.

6.4.4 Flooding and Scour

FEMA Risk Maps have been prepared for Freeborn, Washington and Houston counties, Minnesota, and Monroe County, Wisconsin. A review of these maps indicates that the Lake Mills to Albert Lea E-line, Farmington to Hugo C-line, the Tomah branch line loop and the La Crescent compressor station are located outside of any identified SFHAs. Three SFHAs were identified between MP 2.01 and MP 2.04, MP 2.54 and MP 2.55 and MP 2.90 and MP 2.92 on the Elk River 3rd branch line. These SFHAs will be crossed via HDD and the HDD entry and exit points and associated workspaces are located outside the SFHAs. Additionally, aboveground pipeline appurtenances will not be constructed in the SFHA (FEMA 2022).

Northern will complete three waterbody crossings during construction. The three crossings will be completed via HDD. The waterbody crossings on the Elk River 3rd branch line, ERT-S02 at MP 1.70 and ERT-S01 at MP 2.74, will be 19 and 47 feet below the bed of the waterbody, respectively, and the waterbody crossing on the Tomah branch line loop (TBL-S01) will be 26 feet below the bed of the waterbody.

6.5 AVOIDANCE AND MINIMIZATION OF ADVERSE EFFECTS

The overall effects of construction and operation of Project facilities on topography and geology will be minor. Primary impacts will be limited to construction activities and include temporary disturbance to slopes within the ROW resulting from grading and trenching operations. Northern will minimize impacts by returning contours to preconstruction conditions to the extent practicable with the exception of the aboveground pipeline appurtenances, where grading and filling will be required to create a safe and stable land surface, and to support facility drainage.

The Project will be designed and installed in accordance with the U.S. Department of Transportation's standards found in Title 49 CFR Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, to provide adequate protection from hazards that could cause the pipeline and facilities to move or to sustain abnormal loads such as washouts, floods, subsidence, landslides and earthquakes. Minimal geologic hazards exist in the Project area and no impacts are anticipated.

The majority of the proposed Project will be constructed with the conventional open-cut technique, where a length of trench is excavated, the pipe is installed and the trench is backfilled. The Project is located in areas with low potential for karst features and Northern does not anticipate encountering unknown karst features during construction of the Project due to lack of suitable geological formations necessary for karst formation.

Northern minimized the potential for the pipeline components to be exposed by flooding or scour events as the minimum depth of cover at the waterbody crossings will be 25 feet between the bed of the perennial waterbody (ERT-S01) and the top of the proposed pipeline. The two intermittent waterbodies will be less than 25 feet between the bed of the waterbody and top of the proposed pipeline; however, Northern did not observe significant signs of flooding or downcutting in these two areas during its field visits. The beds and banks of the intermittent waterbodies appeared stable and well-vegetated; Northern anticipates minimal risk for exposure due to flooding or scour events.

6.6 LNG FACILITIES IN SEISMIC RISK AREAS

The Project does not involve an LNG facility.

6.7 PALEONTOLOGY

A review of existing paleontological information for the states of Minnesota and Wisconsin was conducted. While fossils may be found throughout the states, unique paleontological resources are not known to exist within the proposed locations of the Project (MDNR 2024a; Paleobiology Database 2024; WGNHS 2024).

In the event that paleontological resources (e.g., fossilized vertebrate remains such as bones, teeth etc.) are encountered during construction, the construction contractor would report the finding to Northern's on-site EI. The EI would temporarily suspend construction activities in the immediate area of the paleontological finding while a qualified paleontologist is consulted. The on-site EI would coordinate with Northern's environmental manager of construction compliance to determine the appropriate actions if the find is determined to be a significant paleontological resource. Northern's initial action would be to contact the MDNR or WGNHS, and FERC. Northern will comply with applicable laws, regulations, procedures and recommendations from the MDNR and WGNHS.

6.8 GEOTECHNICAL INVESTIGATIONS

Northern has completed a geotechnical investigation for the Project. Specifically, Northern completed geotechnical borings in the vicinity of proposed HDDs.

Northern has completed three geotechnical borings to depths of 31.5 fbg for the Lake Mills to Albert Lea E-line. The borings were completed along the pipeline centerline in the vicinity of the proposed road crossings. The most prevalent soil type encountered was sandy lean clay. Several borings also contained clayey sand interspersed with the sandy lean clay. Bedrock was not encountered in any of the borings. HDDs are not currently planned for the Lake Mills to Albert Lea E-line.

Northern has completed 14 geotechnical borings to depths between 31.5 and 131.5 fbg for the Elk River 3rd branch line. Borings were completed along the pipeline centerline in the vicinity the proposed HDDs. The most common soil types encountered were poorly graded sand, clayey sand, sandy lean clay, and silty sand. Sandstone was encountered at nine boreholes at depths ranging between 36 fbg to 100 fbg. Shale was encountered at the top of the bedrock surface in one borehole at a depth of 103 fbg.

Northern has completed six geotechnical borings to depths between 81.5 and 120.1 fbg for the Farmington to Hugo C-line. The borings were generally completed along the pipeline centerline in the vicinity of proposed HDDs. The most prevalent soil type encountered was silty sand, clayey sand, and sandy lean clay. Several borings also contained silty sand at depths below 20 feet. Bedrock was encountered in five of the borings ranging from 60.5 to 95.0 feet. The bedrock layers consisted of sandstone, dolostone, or a combination thereof.

Northern has completed four geotechnical borings to depths between 30 to 50 fbg for the Tomah branch line loop. Three of the borings were completed to evaluate the potential for shallow bedrock while the fourth borehole was completed along the pipeline centerline in the vicinity of proposed HDD of Gardener Avenue. The most prevalent soil types encountered were poorly graded sand and silty sand, underlain by bedrock. Bedrock was encountered in both borings, at depths between 4.5 and 14 fbg, consisting of sandstone, interpreted to undivided Cambrian Trempealeau, Tunnel City and Elk Mound Formations. Northern is waiting for landowner approval prior to completing a geotechnical borehole for the HDD under County Road Q.

The geotechnical reports are included with Northern's HDD Plan in Resource Report 1, Appendix 1A (Attachment 2).

Northern evaluated HDDs along the Project. The MPs, depth to bedrock, where encountered, and the maximum depth of each HDD location are listed in Table 6.8-1.

Table 6.8-1 – Geotechnical Testing Results

Pipeline Facility	Crossing Number/ Ref. Drawing	Begin MP	End MP	Arc Drill Length (feet)	Maximum Depth HDD (feet)	Related Geotechnical Borings	Approximate Depth to Bedrock (feet)
Elk River 3rd branch line	ERT P4-1	1.02	1.30	1,492	62	BH-15, BH-16	44, 88
	ERT P4-2	1.45	1.70	1,214	49	BH-13, BH-14	50, 36
	ERT P4-3	1.90	2.13	1,202	42	BH-10, BH-11, BH-12	100, >121.5, 50
	ERT P4-4	2.14	2.21	293	12	BH-9, BH-10	90, 100
	ERT P4-5	2.43	2.94	2,736	75	BH-4, BH-5, BH-7	78, 103, 83

Pipeline Facility	Crossing Number/ Ref. Drawing	Begin MP	End MP	Arc Drill Length (feet)	Maximum Depth HDD (feet)	Related Geotechnical Borings	Approximate Depth to Bedrock (feet)
	ERT P4-6	3.28	3.32	136	10	BH-2	>71.5
	ERT P4-7	3.41	3.45	159	11	BH-1	>31.5
Farmington to Hugo C-line	FAR P4-1	0.18	0.54	1,907	63	BH-1, BH-2, BH-3	86.5, 95, 60.5
	FAR P4-2	0.64	1.01	1,982	71	BH-3, BH-4, BH-5	60.5, 75, 80
Tomah branch line loop	TBL P4-1	2.53	2.57	140	12	BH-2	4.5
	TBL P4-2	3.42	3.53	553	28	---	BH not yet completed

Northern utilized the results of the geotechnical borings to finalize the HDD designs, specifically optimizing the angle of entry and adjusting the entry and exit pit locations. The current HDD design indicates the drills will be completed at depths above the uneven bedrock surface. Based on the results above, the HDDs for the Project will not encounter bedrock; therefore, Northern designed them to meet the parameters of the unconsolidated materials along the profiles.

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Figures

Figure 6-1

Bedrock Geology

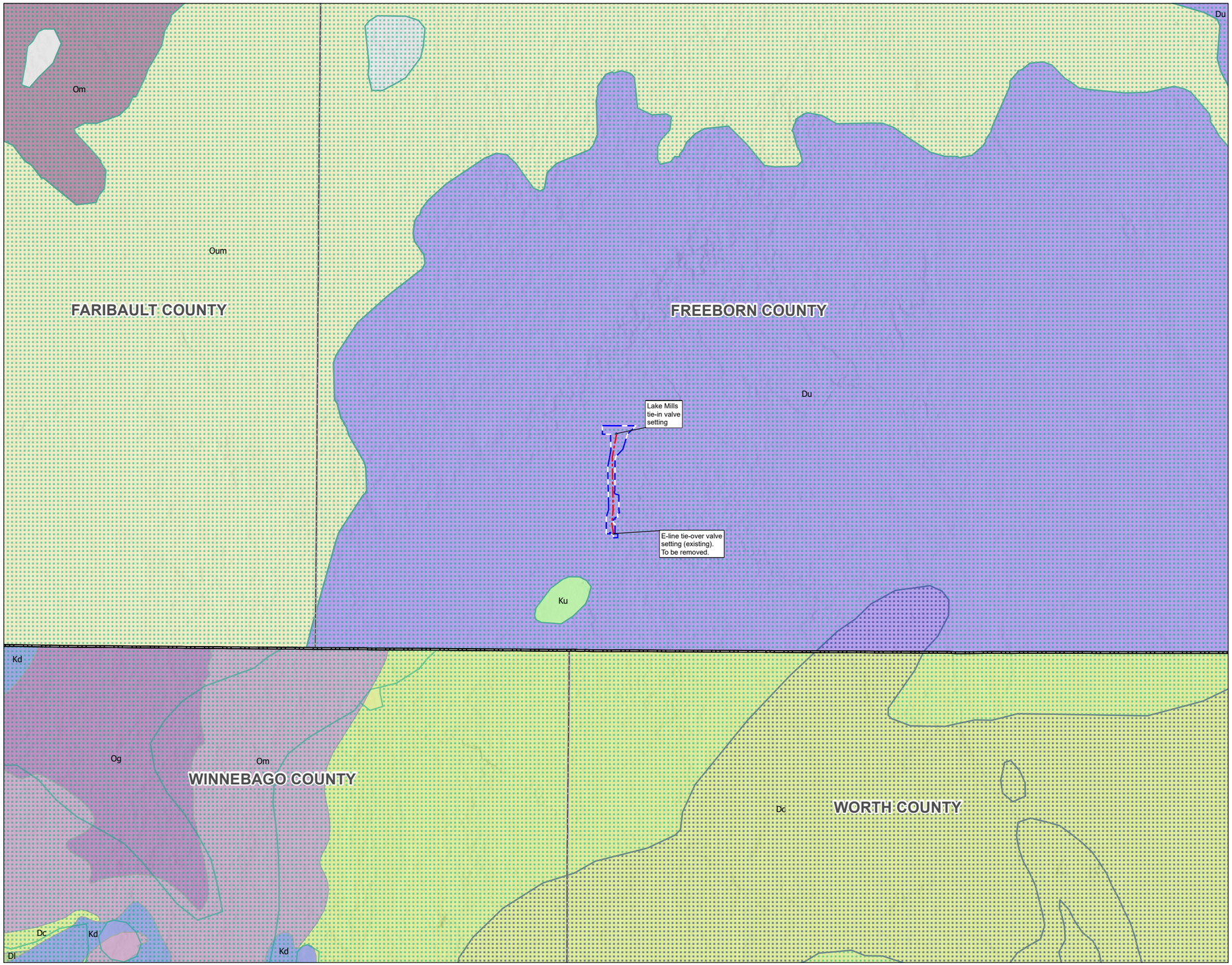


Figure No.
6-1

Title
Karst & Bedrock Geology

Client/Project 172608212
Northern Natural Gas
Northern Lights 2025 Expansion Project
Lake Mills to Albert Lea E-Line Extension

Project Location
Freeborn Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

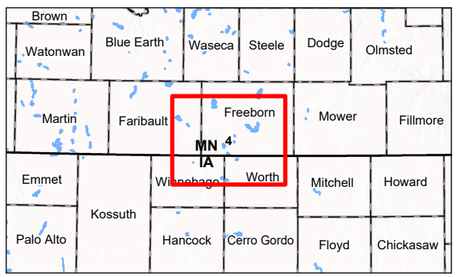
N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Karst Type
- Carbonate rocks buried under >50 ft of glacially derived insoluble sediments in a humid climate
- Carbonate rocks buried under ≤50 ft of glacially derived insoluble sediments in a humid climate

SymbolType
- Cretaceous - shale, sandstone [Ku]
- Devonian - limestone, dolostone (dolomite) [Du]
- Late and Middle Ordovician - limestone, dolostone (dolomite) [Oum]
- Middle Ordovician - sandstone, limestone [Om]
- Sedimentary, carbonate [Dc]
- Sedimentary, carbonate [Og]
- Sedimentary, clastic [Kd]
- Sedimentary, undifferentiated [Dl]
- Sedimentary, undifferentiated [Om]



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

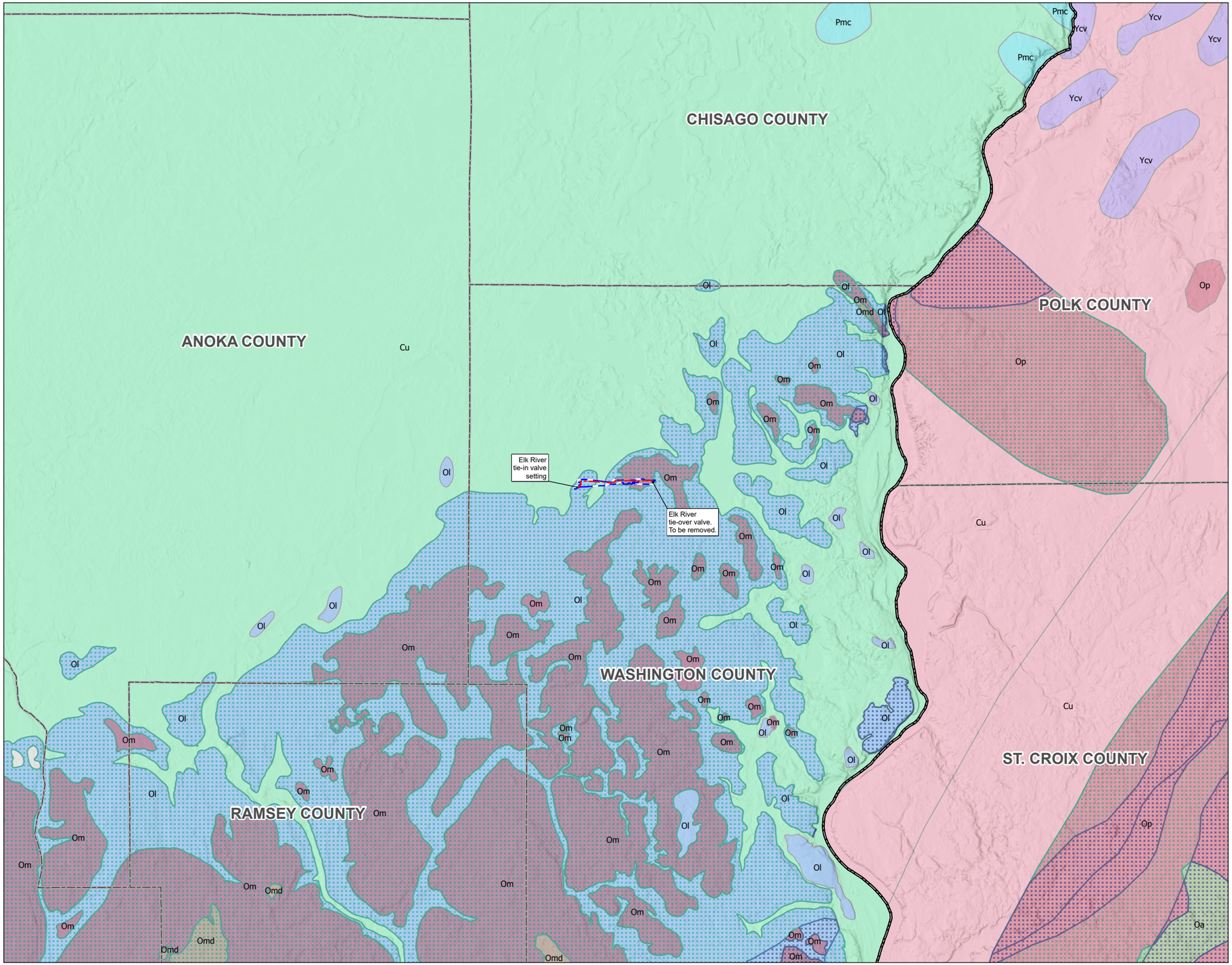


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Figure No.
6-1

Title
Karst & Bedrock Geology

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Elk River 3rd Branch Line Extension

172608212

Project Location
Washington Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

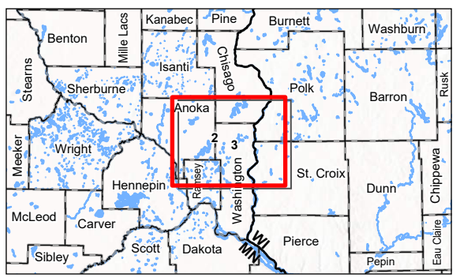
N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Karst Type
- Carbonate rocks buried under >50 ft of glacially derived insoluble sediments in a humid climate
- Carbonate rocks buried under ≤50 ft of glacially derived insoluble sediments in a humid climate

SymbolType
- Cambrian - sandstone, dolostone (dolomite) [Cu]
- Late Cambrian - dolostone (dolomite), sandstone [Cu]
- Lower Ordovician - dolostone (dolomite), limestone [Ol]
- Middle Ordovician - sandstone, limestone [Om]
- Middle Ordovician - shale, limestone [Omd]
- Middle Proterozoic - basalt [Ycv]
- Middle Proterozoic - basalt, rhyolite [Pmc]
- Ordovician - dolostone (dolomite), sandstone [Op]
- Ordovician - sandstone, limestone [Oa]



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

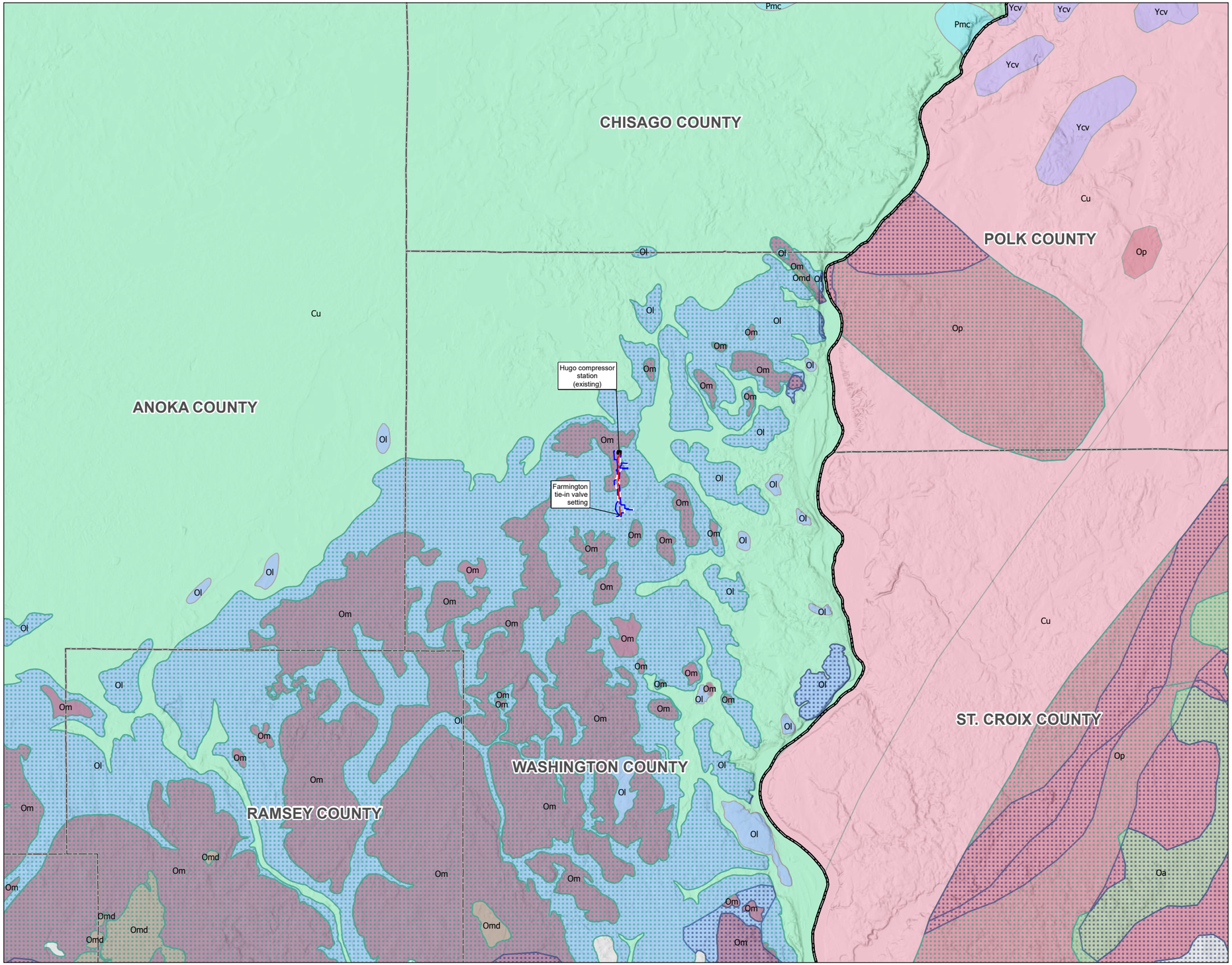


Figure No.
6-1

Title
Karst & Bedrock Geology

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Farmington to Hugo C-Line Extension

172608212

Project Location
Washington Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

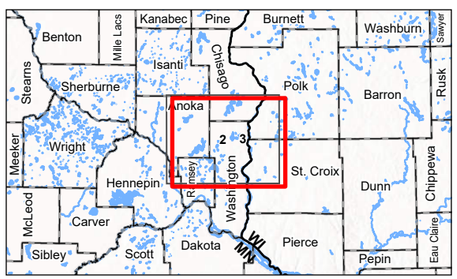
N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Karst Type
- Carbonate rocks buried under >50 ft of glacially derived insoluble sediments in a humid climate
- Carbonate rocks buried under ≤50 ft of glacially derived insoluble sediments in a humid climate

SymbolType
- Cambrian - sandstone, dolostone (dolomite) [Cu]
- Late Cambrian - dolostone (dolomite), sandstone [Cu]
- Lower Ordovician - dolostone (dolomite), limestone [Ol]
- Middle Ordovician - sandstone, limestone [Om]
- Middle Ordovician - shale, limestone [Omd]
- Middle Proterozoic - basalt [Ycv]
- Middle Proterozoic - basalt, rhyolite [Pmc]
- Ordovician - dolostone (dolomite), sandstone [Op]
- Ordovician - sandstone, limestone [Oa]



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

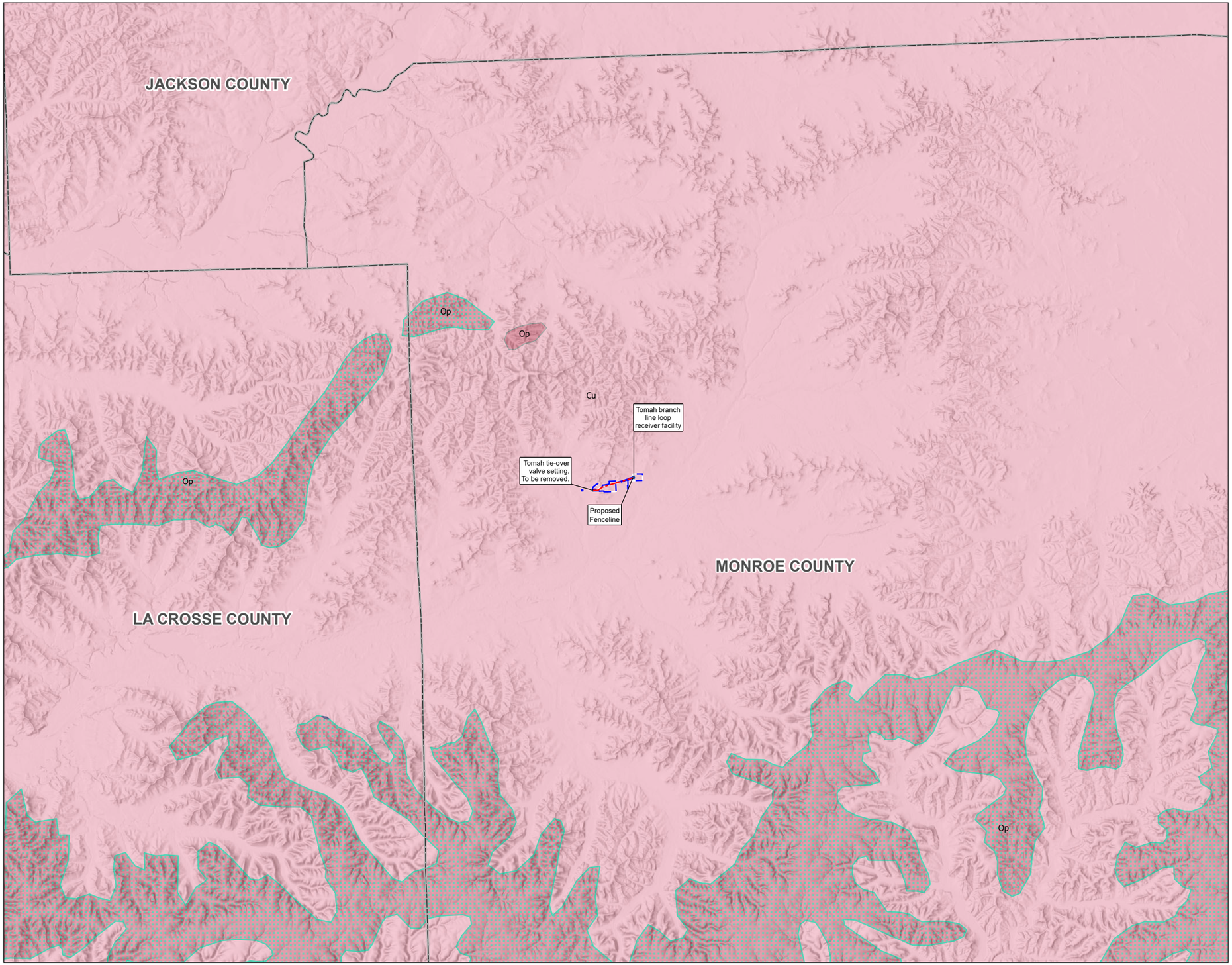


Figure No.
6-1

Title
Karst & Bedrock Geology

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Tomah Branch Line Loop Extension

172608212

Project Location
Monroe Co., WI

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

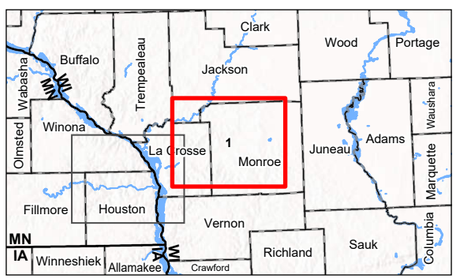
N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Karst Type
- Carbonate rocks at or near the land surface in a humid climate
- Carbonate rocks buried under ≤50 ft of glacially derived insoluble sediments in a humid climate

SymbolType
- Cambrian - sandstone, dolostone (dolomite) [Cu]
- Ordovician - dolostone (dolomite), sandstone [Op]



Notes
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2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

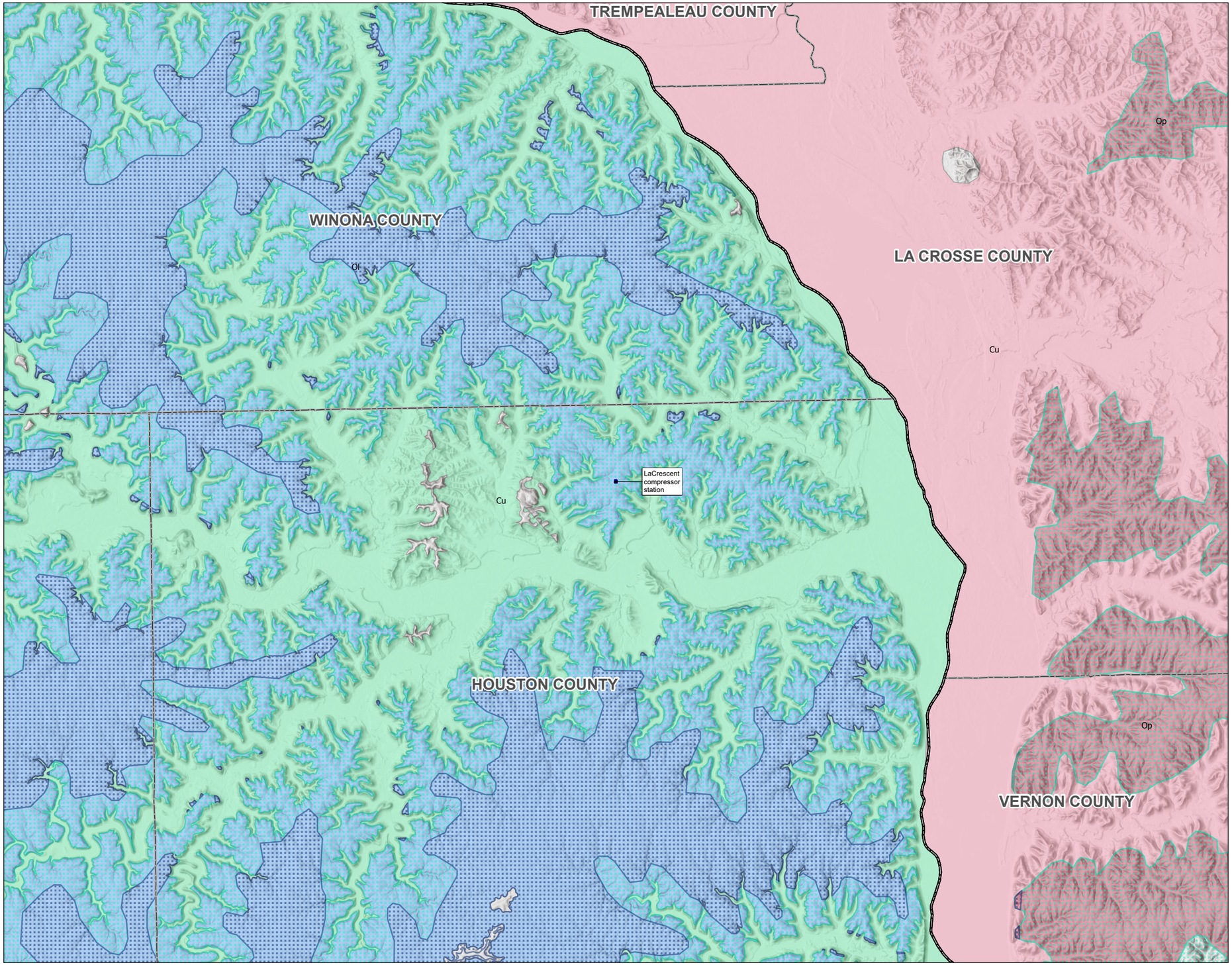

Figure No.
6-1

Title
Karst & Bedrock Geology

Client/Project 172608212
Northern Natural Gas
Northern Lights 2025 Expansion Project
La Crescent Compressor Station

Project Location
Houston Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility

Karst Type
- Carbonate rocks at or near the land surface in a humid climate
- Carbonate rocks buried under >50 ft of glacially derived insoluble sediments in a humid climate
- Carbonate rocks buried under ≤50 ft of glacially derived insoluble sediments in a humid climate

SymbolType
- Cambrian - sandstone, dolostone (dolomite) [Cu]
- Late Cambrian - dolostone (dolomite), sandstone [Cu]
- Lower Ordovician - dolostone (dolomite), limestone [Ol]
- Ordovician - dolostone (dolomite), sandstone [Op]

Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

Figure 6-2

Surficial Geology

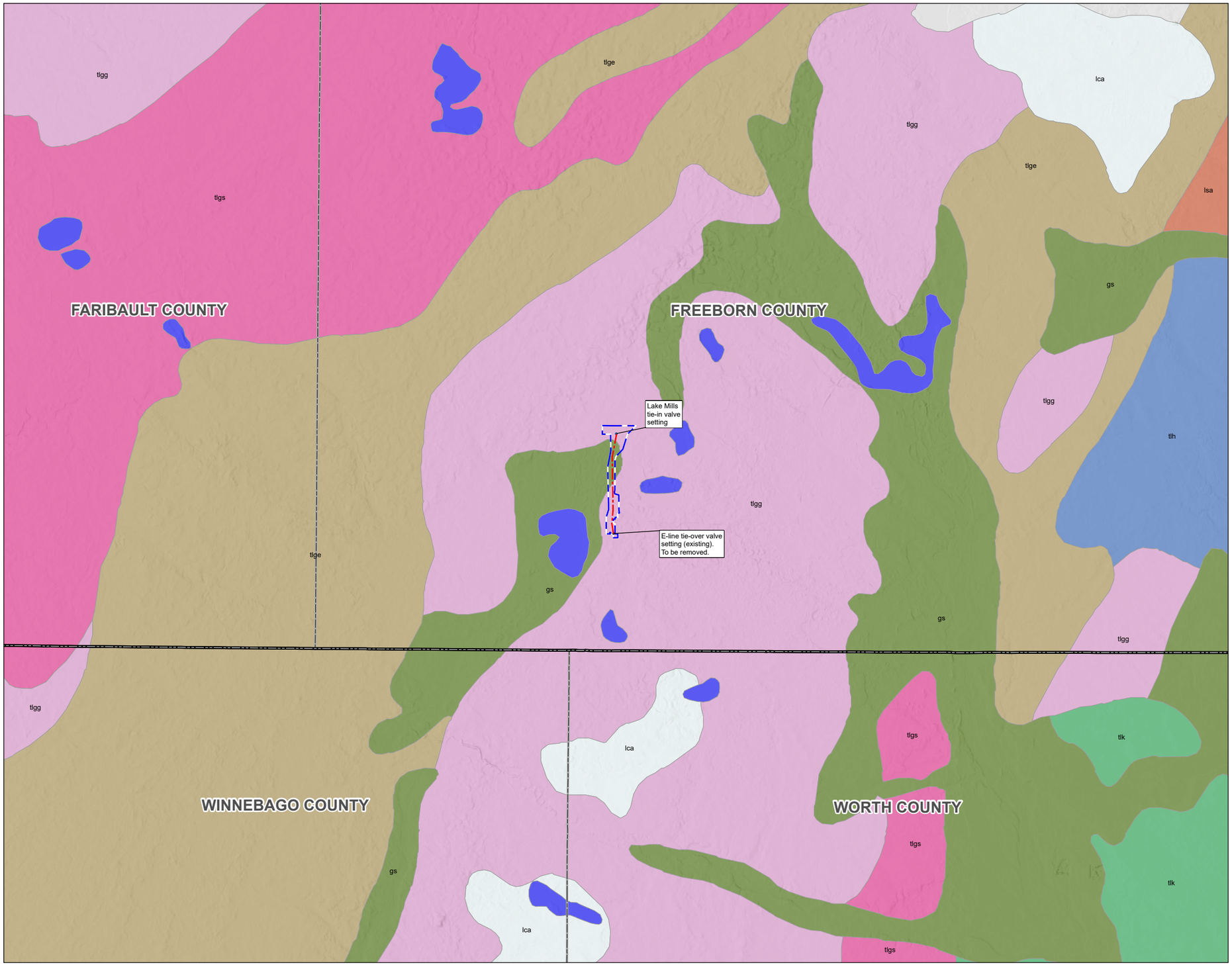

Figure No.
6-2

Title
Surficial Geology

Client/Project 172608212
Northern Natural Gas
Northern Lights 2025 Expansion Project
Lake Mills to Albert Lea E-Line Extension

Project Location
Freeborn Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1.5 3 Miles
(At original document size of 11x17)
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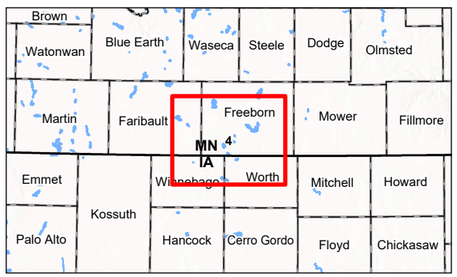
Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Surficial Geology Type
- LAKE SAND [lsa]
- LAKE SILT AND CLAY [lca]
- LOAMY TILL [tlh]
- LOAMY TILL [tlk]
- LOAMY TILL--End moraine [tlge]
- LOAMY TILL--Ground moraine [tlgg]
- LOAMY TILL--Stagnation moraine [tlgs]
- OUTWASH SAND [gs]
- LAKE



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

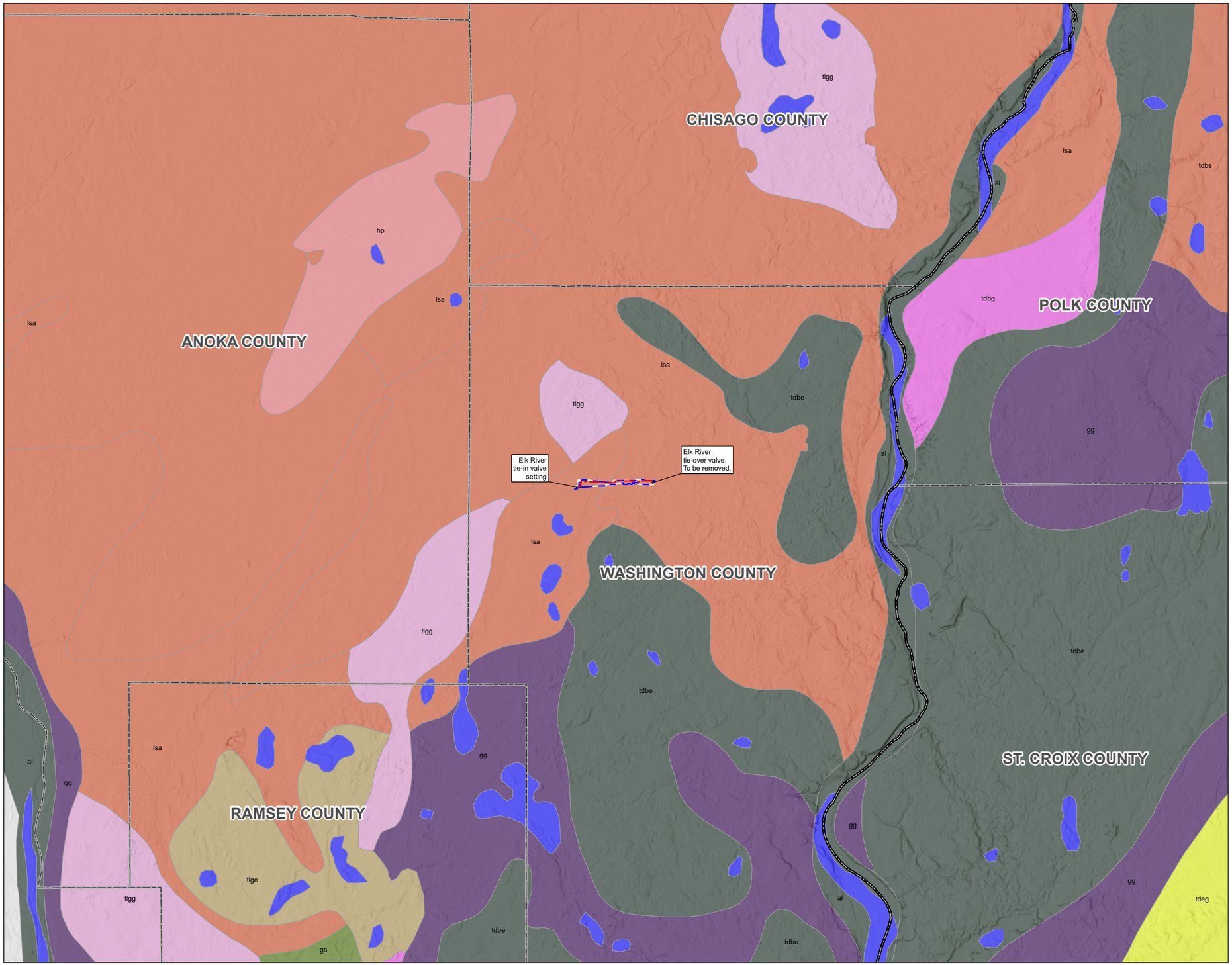


Figure No.
6-2

Title
Surficial Geology

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Elk River 3rd Branch Line Extension

172608212

Project Location
Washington Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1.5 3 Miles
(At original document size of 11x17)
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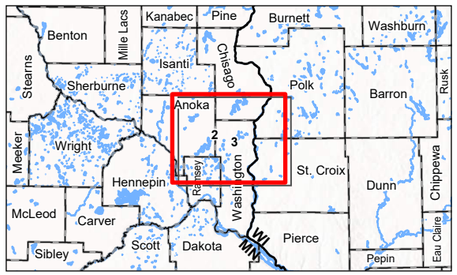
Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Surficial Geology Type
- ALLUVIUM [al]
- LAKE SAND [lsa]
- LOAMY TILL--End moraine [tlge]
- LOAMY TILL--Ground moraine [tlgg]
- OUTWASH SAND AND GRAVEL [gg]
- OUTWASH SAND [gs]
- PEAT [hp]
- SANDY LOAMY TILL--End moraine [tdbe]
- SANDY LOAMY TILL--Ground moraine [tdbg]
- SANDY LOAMY TILL--Ground moraine [tdeg]
- SANDY LOAMY TILL--Stagnation moraine [tdbs]
- LAKE



Notes
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3. Background: ESRI Hillshade

Stantec

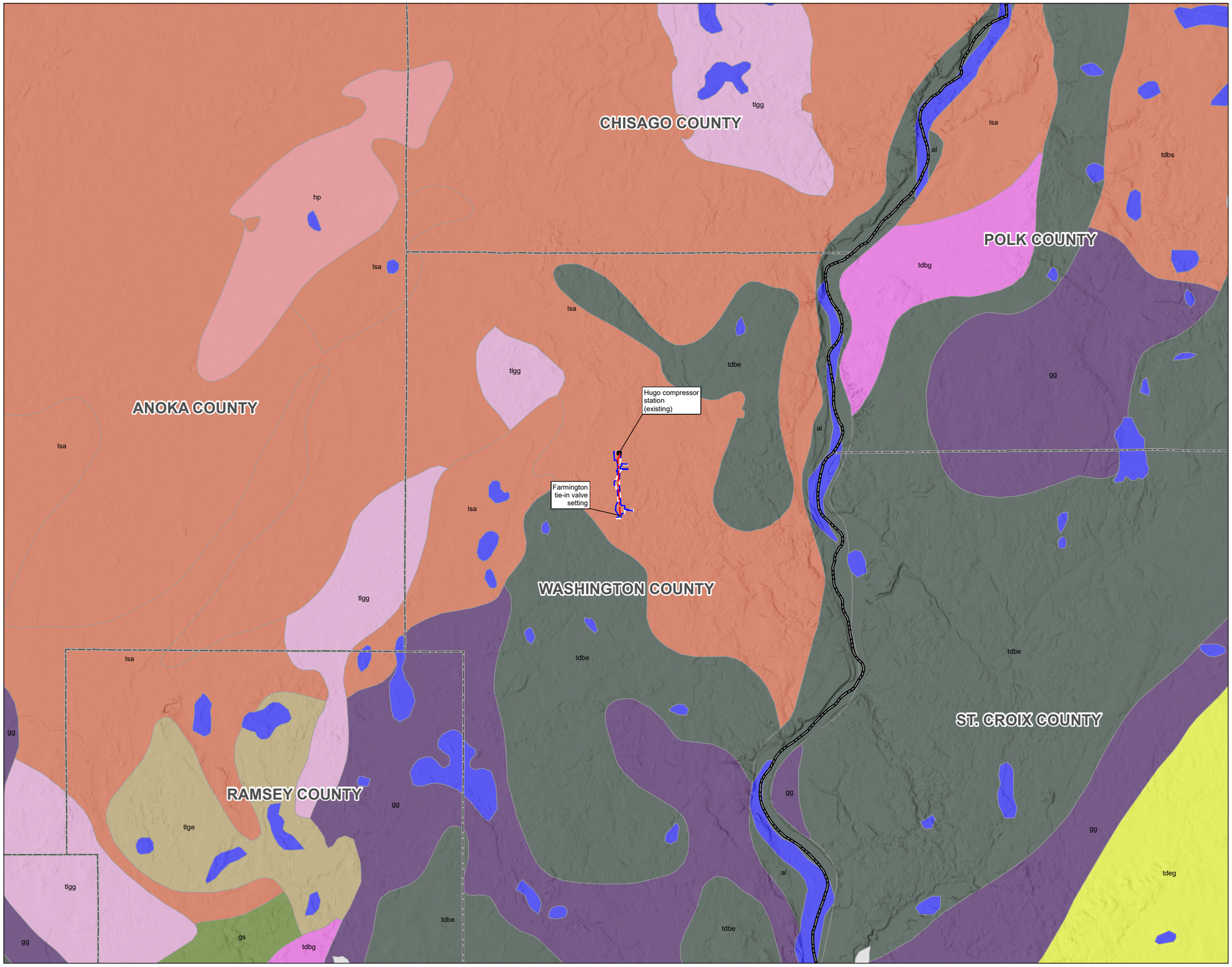

Figure No.
6-2

Title
Surficial Geology

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Farmington to Hugo C-Line Extension

172608212

Project Location
Washington Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1.5 3 Miles
(At original document size of 11x17)
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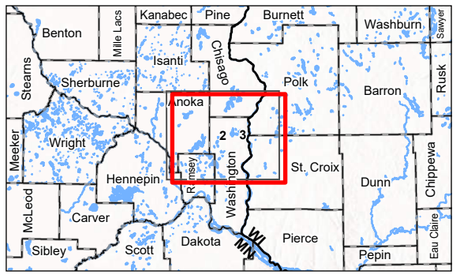
Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Surficial Geology Type
- ALLUVIUM [al]
- LAKE SAND [lsa]
- LOAMY TILL--End moraine [tlge]
- LOAMY TILL--Ground moraine [tlgg]
- OUTWASH SAND AND GRAVEL [gg]
- OUTWASH SAND [gs]
- PEAT [hp]
- SANDY LOAMY TILL--End moraine [tdbe]
- SANDY LOAMY TILL--Ground moraine [tdbg]
- SANDY LOAMY TILL--Ground moraine [tdeg]
- SANDY LOAMY TILL--Stagnation moraine [tdbs]
- LAKE



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2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

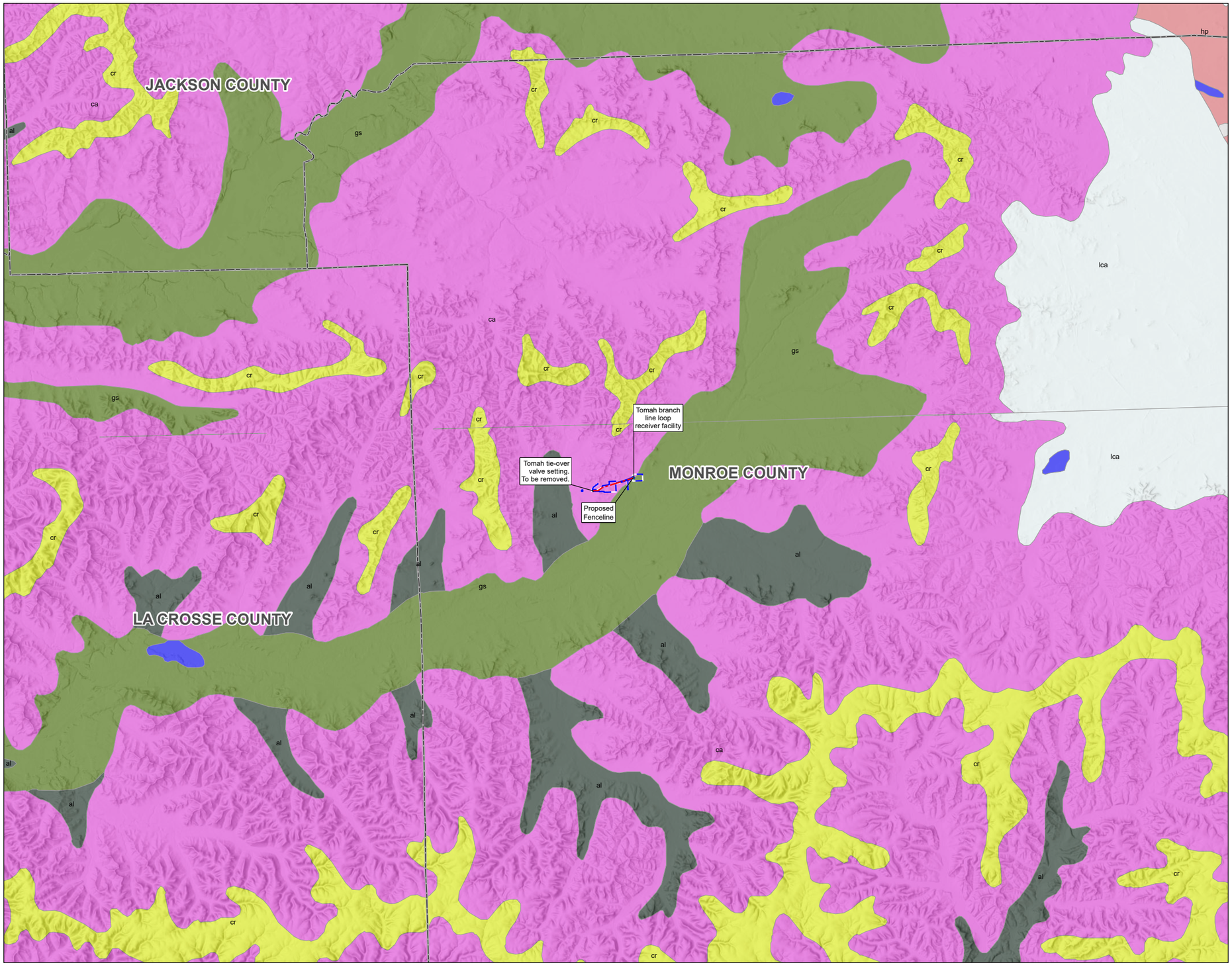


Figure No.
6-2

Title
Surficial Geology

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Tomah Branch Line Loop Extension

172608212

Project Location
Monroe Co., WI

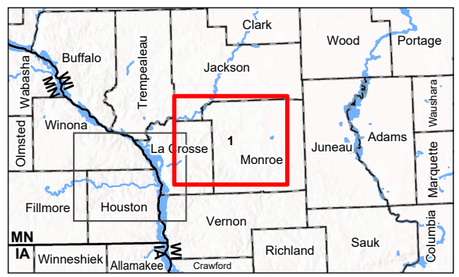
Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

Surficial Geology Type
- ALLUVIUM [al]
- COLLUVIUM AND SHEETWASH ALLUVIUM [ca]
- COLLUVIUM [cr]
- LAKE SILT AND CLAY [lca]
- OUTWASH SAND [gs]
- PEAT [hp]
- LAKE



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

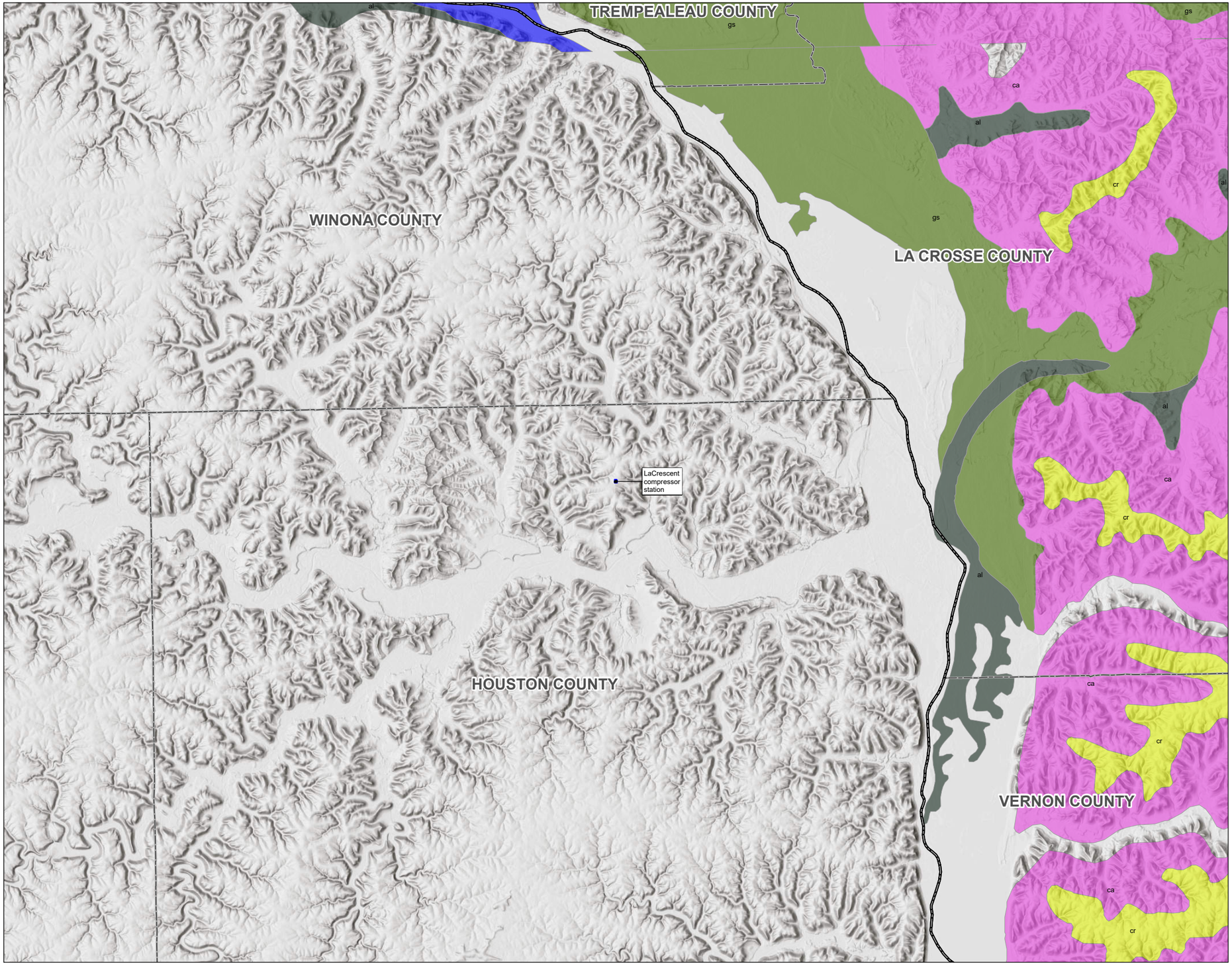


Figure No.
6-2

Title
Surficial Geology

Client/Project 172608212
Northern Natural Gas
Northern Lights 2025 Expansion Project
La Crescent Compressor Station

Project Location
Houston Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1.5 3 Miles
(At original document size of 11x17)
1:190,080

Legend
- Proposed Centerline
- Environmental Survey Boundary
- Existing Facility

Surficial Geology Type
- ALLUVIUM [al]
- COLLUVIUM AND SHEETWASH ALLUVIUM [ca]
- COLLUVIUM [cr]
- OUTWASH SAND [gs]
- LAKE

Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, USGS, MGS
3. Background: ESRI Hillshade

Stantec

Figure 6-3

FEMA Floodplain Data for the Project

Figure No.
6-3

Title
FEMA Floodplain Data

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Lake Mills to Albert Lea E-Line Extension

172608212

Project Location
Freeborn Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

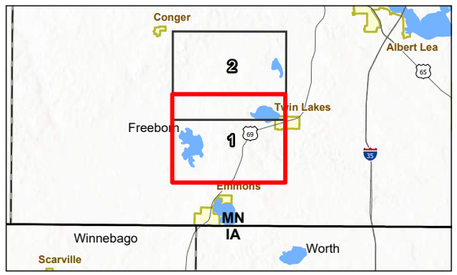
N

0 1,000 2,000 Feet
(At original document size of 11x17)
1:24,000

Legend
- Milepost
- Proposed Centerline
- Existing Centerline
- Environmental Survey Boundary
- Existing Facility

FEMA Flood Hazard Area
- Floodway
- 100-year Floodplain

National Hydrography Dataset
- Perennial Stream
- Intermittent Stream
- Waterbody



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, WDNR, FEMA
3. Background: 2020 NAIP

Stantec

Figure No.
6-3

Title
FEMA Floodplain Data

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Lake Mills to Albert Lea E-Line Extension

172608212

Project Location
Freeborn Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

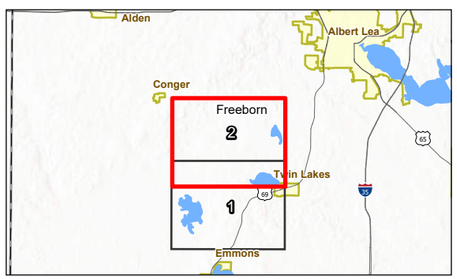
N

0 1,000 2,000 Feet
(At original document size of 11x17)
1:24,000

Legend
- Milepost
- Proposed Centerline
- Existing Centerline
- Environmental Survey Boundary
- Proposed Facility

FEMA Flood Hazard Area
- Floodway
- 100-year Floodplain

National Hydrography Dataset
- Perennial Stream
- Intermittent Stream
- Waterbody



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, WDNR, FEMA
3. Background: 2020 NAIP

Stantec

Figure No.

6-3

Title

FEMA Floodplain Data

Client/Project 172608212

Northern Natural Gas
Northern Lights 2025 Expansion Project
Elk River 3rd Branch Line Extension

Project Location
Washington Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1,000 2,000 Feet

(At original document size of 11x17)
1:24,000

Legend

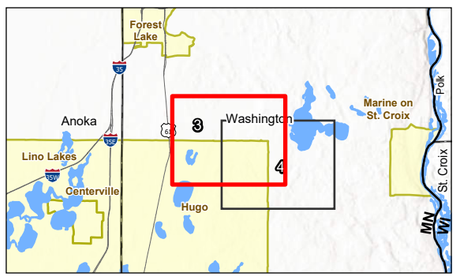
- Milepost
- Proposed Centerline
- Existing Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

FEMA Flood Hazard Area

- Floodway
- 100-year Floodplain

National Hydrography Dataset

- Perennial Stream
- Intermittent Stream
- Waterbody



Notes

1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, WDNR, FEMA
3. Background: 2020 NAIP

Stantec

Figure No.
6-3

Title
FEMA Floodplain Data

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
Farmington to Hugo C-Line Extension
172608212

Project Location
Washington Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

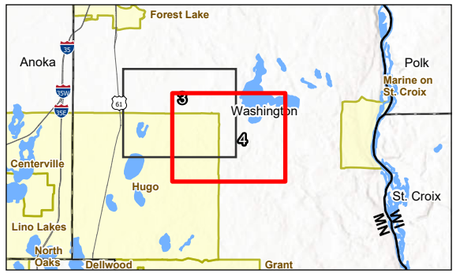
N

0 1,000 2,000 Feet
(At original document size of 11x17)
1:24,000

Legend
- Milepost
- Proposed Centerline
- Existing Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

FEMA Flood Hazard Area
- Floodway
- 100-year Floodplain

National Hydrography Dataset
- Perennial Stream
- Intermittent Stream
- Waterbody



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, WDNR, FEMA
3. Background: 2020 NAIP

Stantec

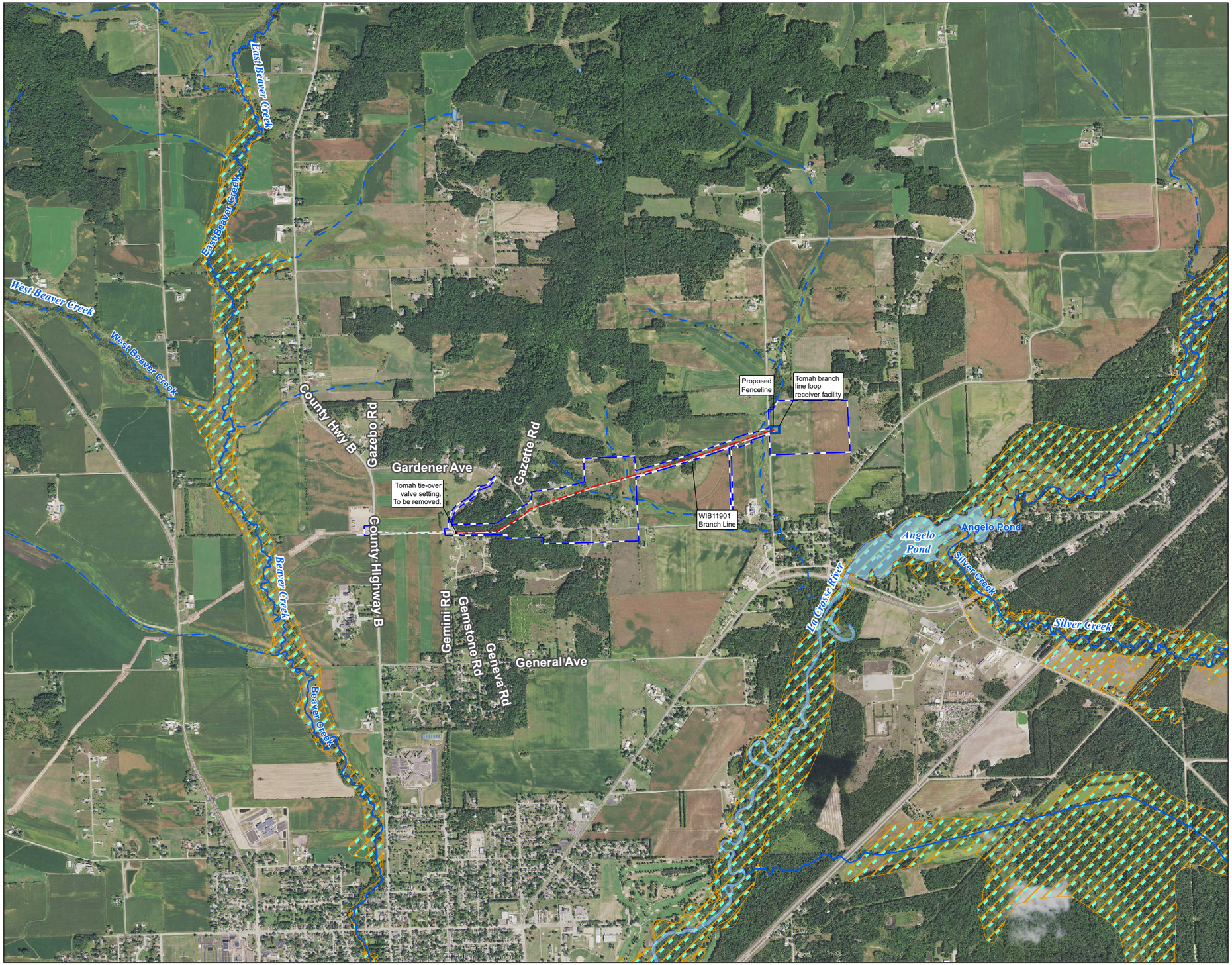


Figure No.

6-3

Title

FEMA Floodplain Data

Client/Project

Northern Natural Gas
Northern Lights 2025 Expansion Project
Tomah Branch Line Loop Extension

172608212

Project Location
Monroe Co., WI

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

N

0 1,000 2,000 Feet

(At original document size of 11x17)
1:24,000

Legend

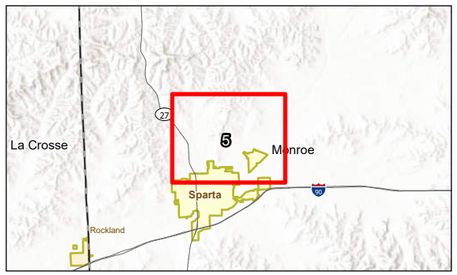
- Milepost
- Proposed Centerline
- Existing Centerline
- Environmental Survey Boundary
- Existing Facility
- Proposed Facility

FEMA Flood Hazard Area

- Floodway
- 100-year Floodplain

National Hydrography Dataset

- Perennial Stream
- Intermittent Stream
- Waterbody



Notes

1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, WDNR, FEMA
3. Background: 2020 NAIP

Stantec

Figure No.
6-3

Title
FEMA Floodplain Data

Client/Project
Northern Natural Gas
Northern Lights 2025 Expansion Project
La Crescent Compressor Station

172608212

Project Location
Houston Co., MN

Prepared by DJG on 2023-12-11
TR by SF on 2023-12-20
IR by SK on 2024-01-31

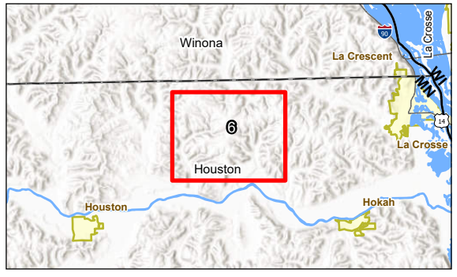
N

0 1,000 2,000 Feet
(At original document size of 11x17)
1:24,000

Legend
- Milepost
- Proposed Centerline
- Existing Centerline
- Environmental Survey Boundary
- Existing Facility

FEMA Flood Hazard Area
- Floodway
- 100-year Floodplain

National Hydrography Dataset
- Perennial Stream
- Intermittent Stream
- Waterbody



Notes
1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Stantec, NNG, NADS, WDNR, FEMA
3. Background: 2020 NAIP

Stantec

Appendix 6A
Steep Slopes Within the Project Area

Appendix 6A Steep Slopes Within the Project Area

MP Begin	MP End	Slope Category[1]	Length (feet)
Lake Mills to Albert Lea E-Line			
31.43	31.45	5-15	99
31.49	31.52	5-15	135
31.55	31.56	5-15	94
31.60	31.63	5-15	198
32.08	32.09	5-15	84
32.13	32.17	5-15	206
33.07	33.08	5-15	24
33.50	33.53	5-15	174
33.95	33.95	5-15	19
Elk River 3rd branch line			
1.43	1.44	5-15	15
1.46	1.46	5-15	19[2]
1.61	1.61	5-15	23[2]
1.66	1.66	15-30	26[2]
1.66	1.66	5-15	13[2]
2.04	2.06	5-15	81[2]
2.07	2.07	5-15	19[2]
2.12	2.12	5-15	26[2]
2.19	2.20	5-15	44[2]
2.22	2.23	5-15	39
2.24	2.25	5-15	59
2.25	2.26	5-15	33
2.27	2.28	5-15	61
2.30	2.30	5-15	29
2.32	2.32	5-15	40
2.33	2.33	5-15	13
2.37	2.38	5-15	12
2.39	2.39	5-15	33
2.44	2.45	5-15	45[2]
2.77	2.79	5-15	130[2]
Farmington to Hugo C-Line			
0.34	0.35	15-30	31[2]
0.38	0.38	15-30	17[2]
0.49	0.52	15-30	110[2]
0.69	0.71	15-30	129[2]
0.75	0.78	15-30	173[2]
0.79	0.81	15-30	108[2]
0.94	0.96	15-30	69[2]
1.01	1.02	15-30	69
1.21	1.22	15-30	19

MP Begin	MP End	Slope Category[1]	Length (feet)
1.28	1.31	15-30	140
1.37	1.37	15-30	48
1.38	1.39	15-30	77
1.43	1.46	15-30	161
Tomah branch line loop			
2.26	2.27	5-15	29
2.27	2.35	5-15	422
2.39	2.42	5-15	181
2.42	2.46	15-30	195
2.46	2.46	15-30	73
2.46[3]	2.47	>30	72
2.47[3]	2.49	15-30	64
2.49[3]	2.52	5-15	107
2.54	2.54	5-15	16[2]
2.54	2.62	5-15	420
2.67	2.68	5-15	48
2.69	2.69	5-15	16
2.71	2.73	5-15	135
2.76	2.78	5-15	107
2.80	2.81	5-15	57
2.90	2.93	5-15	157
2.95	2.98	5-15	119
3.09	3.10	5-15	61
3.17	3.25	5-15	406
3.31	3.34	5-15	187
3.44	3.47	5-15	198[2]
3.47	3.50	5-15	150[2]

[1]Slopes were obtained from civil survey data.

[2]Area is within a drill or bore.

[3]Area is continuous with row above but has different slope category.