# GS2024-26

# Geophysical imaging of a buried gravel deposit in the Rural Municipality of Taché, southeastern Manitoba (part of NTS 62H15)

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**In Brief:**

- Investigation of a buried gravel deposit in the RM of Taché was done using geophysics to assist in the understanding of the deposit
- Interpretation of geophysical results provide details on stratigraphy, depth, and deposit extent

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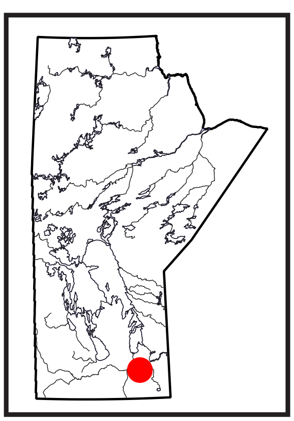

## Summary

The Manitoba Geological Survey, in collaboration with the University of Manitoba, carried out a geophysical investigation of a buried gravel deposit at an active gravel pit, within the Rural Municipality of Taché, with the goal of better understanding the characteristics of the deposit. These included the thickness of the deposit, the lateral extent, thickness of overburden cover and, if possible, variations in the deposit structure. The survey used a combination of techniques including direct-current resistivity, ground-penetrating radar, electromagnetic induction and total magnetic intensity. Of these, only direct-current resistivity and ground-penetrating radar yielded useable results. The surveys were able to delineate a subsurface resistive structure that is approximately 10 m thick, buried beneath a less resistive layer 2–5 m thick. Results from the surveys were not extensive enough to fully delineate the deposit. Future work will include additional geophysical surveys and ground-truthing prior to expanding the study to investigate other buried deposits.

## Introduction

Manitoba sand and gravel resources are commonly identified using fieldwork, in combination with remotely sensed imagery and elevation models. These methods work well when aggregate is visible at the surface, or forms easily identifiable landforms known to contain sand and gravel (e.g., eskers, beach ridges, fans). Interestingly, parts of southeastern Manitoba are host to gravel deposits that do not have a surface expression and are often covered by >0.5 m of overburden (Matile and Conley, 1979a–d; Gauthier and Hodder, 2023). As such, it can be difficult to map the lateral extent of existing known buried deposits, and to predict the location of additional buried aggregate resources. Several of the pits in southeastern Manitoba contain buried aggregate deposits that are at least 20 m thick, hence buried gravel has the potential to be a significant future source of aggregate. Given that the Winnipeg Metropolitan Region may be largely depleted of useable aggregate resources by as early as 2026 (The UMA Group, 1976), identifying new resources is of utmost importance. To gain a better understanding, a buried aggregate deposit in the Monominto gravel pit in the Rural Municipality of Taché (Figure GS2024-26-1) was analyzed using various geophysical techniques. The objectives of this study are to see which geophysical techniques work best to image the site's subsurface geology, attempting to answer questions about overburden thickness and both the lateral and vertical extent of the buried aggregate deposit.

## Study area

The Monominto gravel pit (deposit 2318, Matile and Conley, 1979d) is located 2.5 km east of the Red River lowland in southeastern Manitoba, in an area with till and shallow glaciolacustrine sediments at the surface (Matile and Conley, 1979d; Matile, 2004). The area is relatively low lying (Figure GS2024-26-1) and well drained. The current gravel pit is approximately 1300 m long, averaging 250 m in width, and has been dug as a rough rectangle striking to the southeast. The pit is currently owned by the Rural Municipality (R.M.) of Taché and has been in operation since the 1970s. Aggregate from this site was most recently used for the rehabilitation of Provincial Trunk Highway 12, attesting to the high quality and importance of the buried deposit.

One area of the pit (site 118-23-010, Figure GS2024-26-1), visited in 2023, consists of 1.4 m of massive matrix-supported diamict with a clayey sandy silt matrix and 15% clasts overlying 1.2 m of crossbedded fine- to medium-grained sand, which is underlain by >1 m of sandy gravel with 40–60% clasts (Figure GS2024-26-2a–d; Gauthier and Rentz, 2024). The sandy gravel is currently being extracted from up to ~10 m below the water table (A. Brandt, pers. comm., 2023). At approximately

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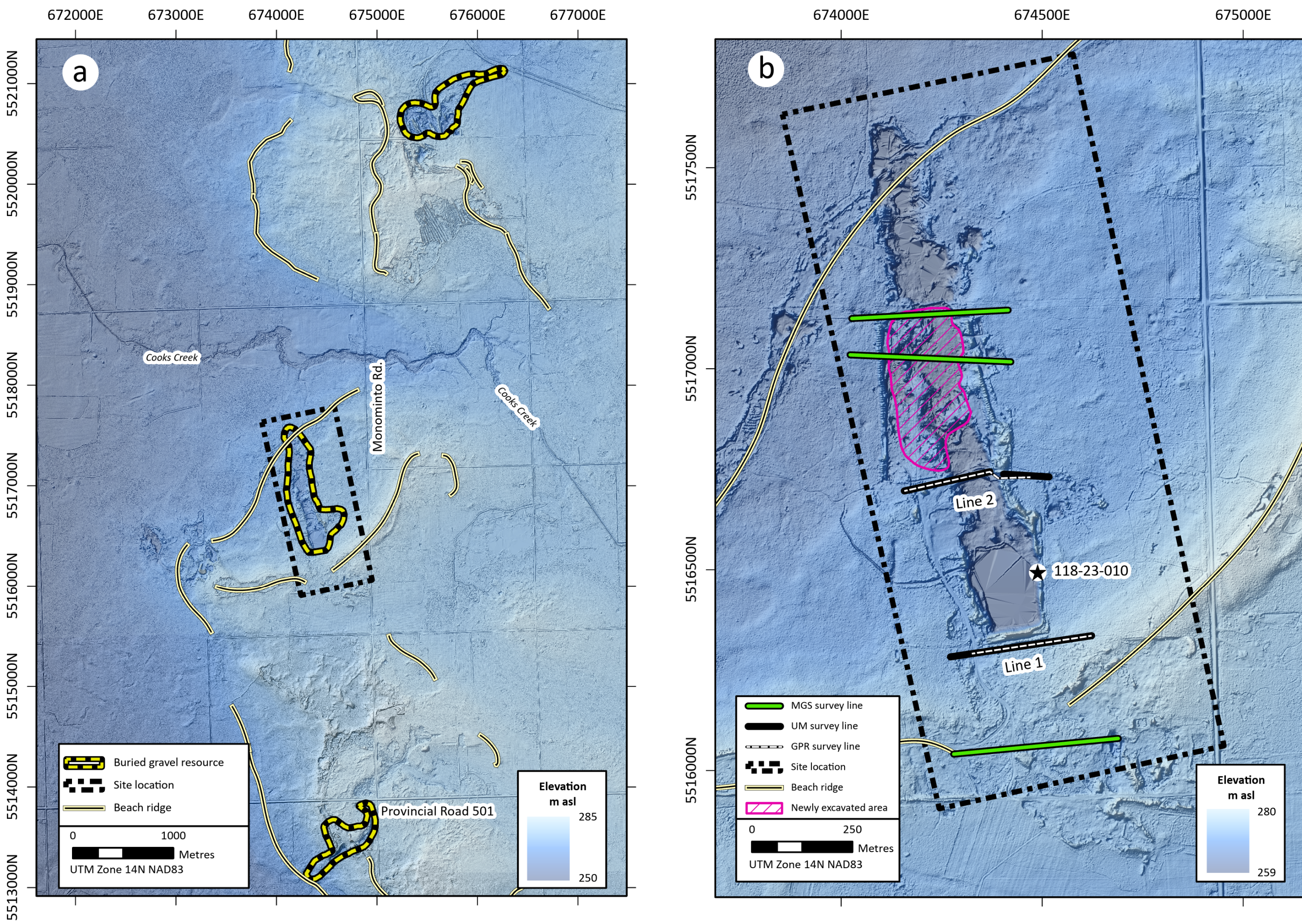


***Figure GS2024-26-1:*** *Light detection and ranging (LiDAR) image with a background hillshade image (ATLIS Geomatics Inc., 2016, 2018) of the study area:* ***a)*** *site location (Sec. 28, Twp. 9, Rge. 7, E 1st Mer.) as well as the locations of nearby aggregate pits excavated into buried gravel deposits;* ***b)*** *locations of both the University of Manitoba (UM) and Manitoba Geological Survey (MGS) geophysical survey lines. Star indicates the site of stratigraphic section 118-23-010. Abbreviations: GPR, ground-penetrating radar; m asl, metres above sea level.*

3 m below the water table there is a cemented gravel layer that is approximately 0.6 m thick (Diamond Construction & Gravel Ltd., pers. comm., 2024).

## Methods

Geophysical surveys took place in two phases. In May 2024, the first phase was undertaken by the University of Manitoba (UM) in collaboration with the Manitoba Geological Survey (MGS). In August 2024, the second phase was undertaken by MGS staff using resistivity equipment; see Marks and Rentz (2024) for details on geophysical methods. In the first phase, two transects were conducted transverse to the existing pit (Figure GS2024-26-1b). The first line was located approximately 25–30 m south of the southern extent of the pit, and the second located across the middle of the pit (Figure GS2024-26-1b). Line 2 follows a road and dips down approximately 3.5 m where gravel was extracted, before moving back up to the same elevation. These two locations were chosen to examine the stratigraphy beyond the pit's current extent (line 1), examine the depth and stratigraphy of the known gravel pit (line 2), and act as a geophysical control line for resistivity values. Geophysical techniques used included direct-current resistivity (DC-resistivity), ground-penetrating radar (GPR), electromagnetic induction and total magnetic intensity. A summary of the common uses and limitations of the techniques are given in Table GS2024-26-1.

### *Direct-current resistivity*

Two resistivity lines were surveyed using an Iris Instruments Syscal Junior Resistivity Metre in a dipole-dipole configuration. Each of the lines consisted of three 115 m spreads of 24 electrodes with an electrode spacing of 5 m. Additionally, a 15 m horizontal overlap was applied to the lines after each set of readings. The raw data was processed by removing erroneous values and by adding elevation data to each of the 5 m stations using a digital elevation model (ATLIS Geomatics Inc., 2016). The processed data was then inverted using the Geotomo Software Res2DInv software package using a least squares method with a maximum of seven iterations and a root-mean-square convergence of <5%.

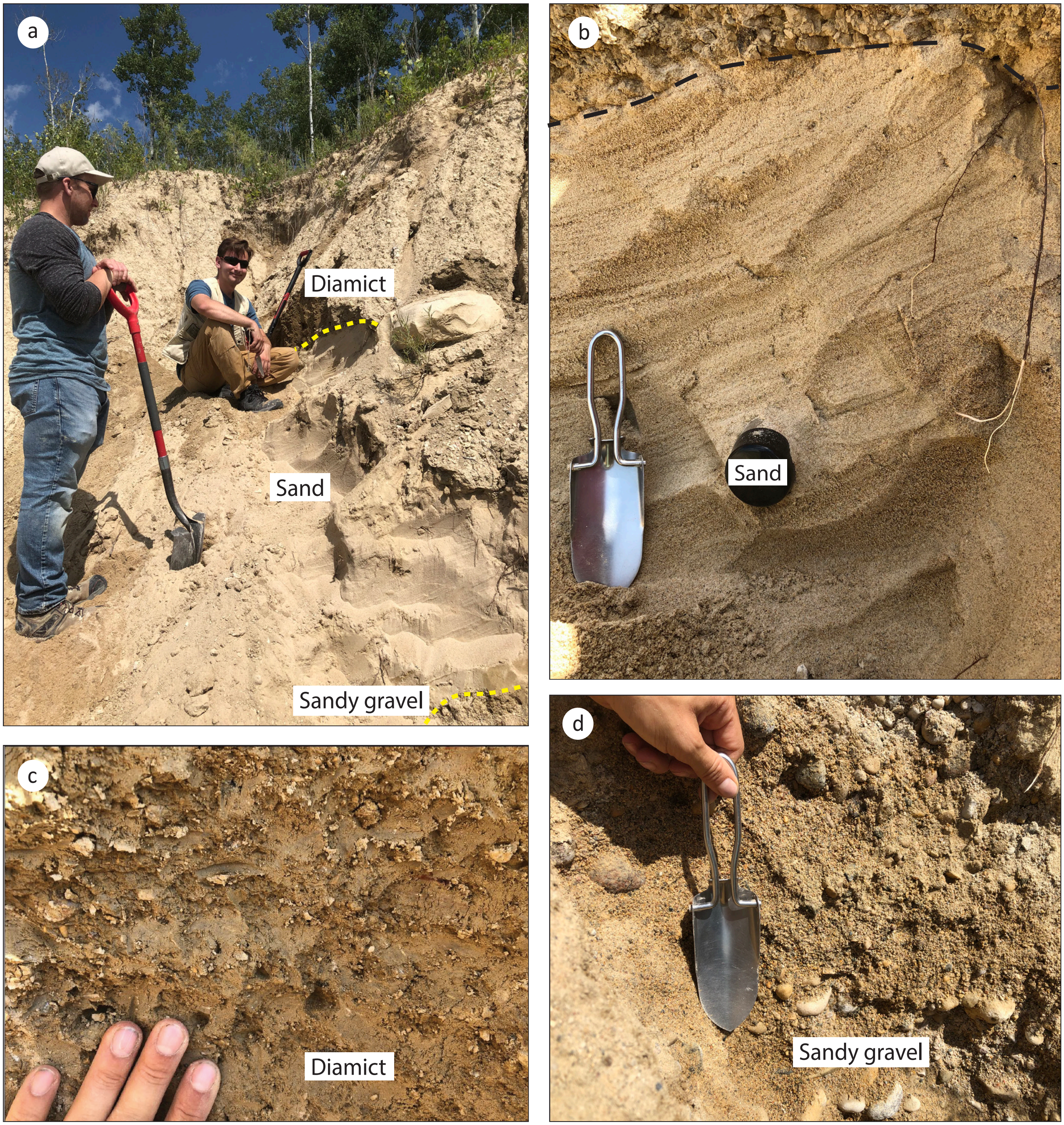


***Figure GS2024-26-2:** Quaternary stratigraphy at site 118-23-010, southeastern Manitoba: **a)** overview of the stratigraphic section; **b)** close-up of crossbedded fine- to medium-grained sand; **c)** close-up of diamict with clayey sandy silt matrix; **d)** close-up of sandy gravel shown in a). See Figure GS2024-26-1 for location of site.*

A model cell width of 2.5 m (half the electrode spacing) was also used along with a horizontal weighting filter to optimize data fitting.

### *Ground-penetrating radar*

A GPR survey was conducted using a Geophysical Survey Systems, Inc. (GSSI) SIR 3000 system along both lines 1 and 2. Line 1 was surveyed using a frequency of 400 megahertz (MHz) and line 2 was surveyed using a frequency of 200 MHz. The difference in frequencies relates to the ability of the GPR's electromagnetic waves to reach different depths—generally, the lower the frequency, the deeper the instrument can read. However, a lower frequency will also result in a lower resolution. The 400 MHz frequency was used to characterize the overburden at surface,

**Table GS2024-26-1:** Common uses and limitations of the geophysical instruments used in this study. Abbreviations: DC, direct-current; GPR, ground-penetrating radar.

| Instrument | Uses | Common limitations |
|---|---|---|
| DC-resistivity | Mapping aggregate resources | Different materials may have the same resistivity |
| | Mapping stratigraphy | Influenced by near-surface groundwater |
| | Determining depth to bedrock | Influenced by conductive groundwater |
| | Determining depth to water table | Poor contact between electrodes and ground may result in inaccurate readings |
| | | Interference by subsurface metal objects |
| Ground penetrating radar | Mapping stratigraphy | Poor contact between GPR system and ground surface can interfere with the radar waves |
| | Mapping of subsurface features such as faults and bedding | High conductivity soils may limit the survey depth |
| | Archaeological mapping | Large subsurface cobbles and boulders may interfere with the radar waves |
| Electromagnetic induction | Mapping ground conductivity, which can be used to evaluate soil types | Complex stratigraphy is not easily mapped due to the weighting of layers versus depth |
| | Mapping aggregate resources | Data can be unreliable in highly conductive and highly resistive soils |
| | | Interference by subsurface metal objects |
| Total magnetic intensity | Identifying geological structures | Interference by metal objects |
| | Mapping subsurface lithology | Penetration depth may be variable |
| | Identifying mineral resources | Not commonly used in aggregate exploration |

whereas the 200 MHz frequency was used to characterize the gravel deposit's depth and structure in an area where the overburden had been stripped away. Additionally, a dielectric constant of 6 was used for depth determination. Typical dielectric constants for sand and gravel range from 3 (dryer conditions) to 6 (more saturated conditions), as the survey was conducted in the spring a dielectric constant of 6 was used for both survey lines.

### *Electromagnetic induction and total magnetic intensity*

Electromagnetic induction and total magnetic intensity surveys were completed along line 1. Using a 10 m coil spacing, a Geonics Limited EM-34-3 instrument was used to map the ground conductivity in both the horizontal and vertical dipoles. A Gem Systems GSM-19 Overhauser magnetometer/gradiometer was used to measure the magnetic intensity of the subsurface to capture any magnetic anomalies that may exist within a resistive layer.

## Preliminary results

Four geophysical techniques were tested along the UM lines 1 and 2. Of the techniques used, the most useful data was provided by the DC-resistivity survey followed by the GPR survey, whereas neither the electromagnetic induction nor the total magnetic intensity surveys provided very useable data. The lack of useable data is likely because a) the apparent conductivity of the electromagnetic induction readings consists of a weighted-average response over the exploration depth and in this case the readings may have been masked by the overburden (McNeill, 1980; Fitterman and Labson, 2005; Rentz et al., 2021) and b) magnetic material was not sufficiently abundant within the stratigraphic column for total magnetic intensity to be effective.

### *Direct-current resistivity*

There is an extensive subsurface resistive deposit of linear continuity, ~400–4039 ohm-metre (Ω•m), across most of line 1 (Figure GS2024-26-3). The resistive layer of interest appears to reside between 5 and 15 m below ground surface with at least 10 m of depth extent, if not more. There is a similar extensive subsurface resistive deposit of linear continuity, ~400–4039 Ω•m across most of line 2 (Figure GS2024-26-3). Again, the resistive layer of interest is approximately 10 m thick and is located approximately 2–4 m below a less resistive layer.

### *Ground-penetrating radar*

The low frequency ground-penetrating radar survey on line 2 provided useful data, whereas the high frequency survey on line 1 did not. The line 2 profile shows a potential stratigraphic contact approximately 3–6 m below ground surface (Figure GS2024-26-4a, b).

## Future work

Since the initial DC-resistivity survey did not fully capture the lateral extent of the anomalies, an additional DC-resistivity

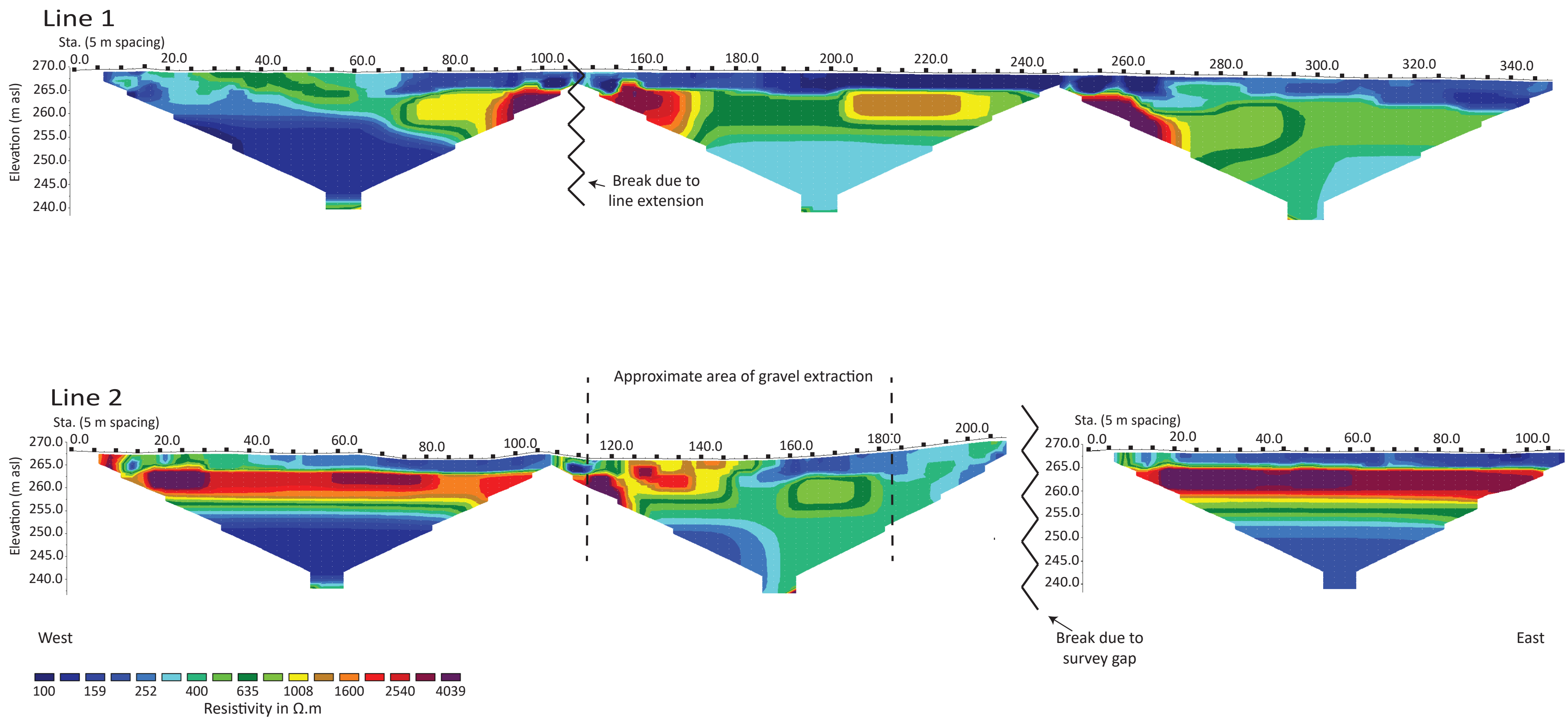


***Figure GS2024-26-3:*** *Inversion results of the direct-current resistivity survey along both lines 1 and 2, Monominto gravel pit, southeastern Manitoba. See Figure GS2024-26-1 for location of lines. Abbreviations: Ω•m, ohm-metre; m asl, metres above sea level; Sta., station.*

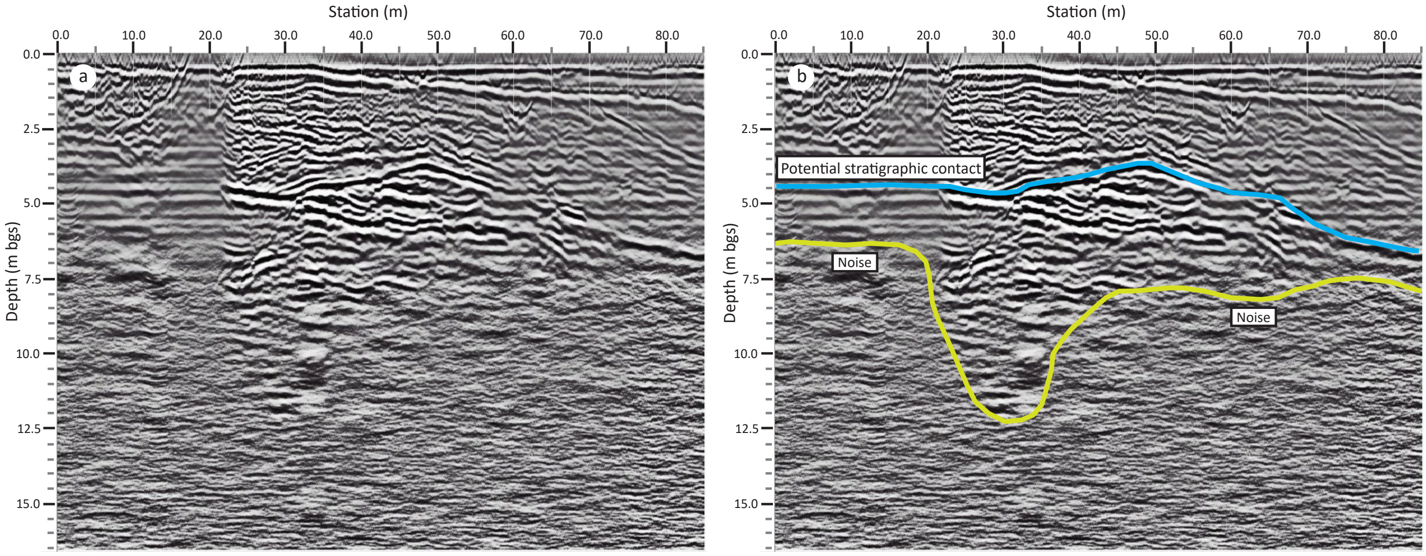


***Figure GS2024-26-4:*** *Ground-penetrating radar (GPR) survey results from the eastern part of survey line 2, Monominto pit, southeastern Manitoba:* ***a)*** *unannotated GPR results (200 megahertz frequency);* ***b)*** *annotation of potential stratigraphic contact. Yellow line indicates limit of resolution. See Figure GS2024-26-1 for location of line 2. Abbreviation: bgs, below ground surface.*

survey was completed by the MGS in August 2024 (Marks and Rentz, 2024). The next steps are to reconcile and interpret the results of all of the geophysical surveys and integrate them with field observations.

## Economic considerations

Aggregate is an essential resource for road construction, foundation construction and railroad base and concrete/asphalt formation. The increasing demand for aggregate, especially from the Winnipeg Metropolitan Region, dictates that additional resources need to be identified. Past estimations predicted that high-quality aggregate deposits within the metropolitan region may be depleted as early as the year 2026, therefore, it is imperative that new and existing aggregate resources are fully identified to facilitate future growth in the metropolitan region.


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