GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6448
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

SUMMARY REPORT

SUBSURFACE MAPPING SURVEY TO DETECT UNDERGROUND STORAGE TANKS

City of McMinnville
3rd Street Streetscape Improvement Project
McMinnville, Oregon

CLIENT

Haley & Aldrich, Inc.
6420 S Macadam Avenue, Suite 100
Portland, Oregon 97239

DATE OF SURVEY

November 13&15, 2023

GeoPotential Project Number: 1568

CONTENTS

FIGURES

APPENDICES

SUMMARY

A Subsurface Mapping Survey (SMS) was conducted over eleven sidewalk sites located along NE 3rd Street in McMinnville, Oregon to search for possible Underground Storage Tanks (USTS) (see Figures).

Electromagnetic Surveys, Ground Penetrating Radar (GPR) Surveys and hand held magnetic and electromagnetic scanners were used for the project.

Three possible Underground Storage Tanks were mapped by the SMS.

INTRODUCTION

Ralph Soule & Tarek Zaher of GeoPotential conducted the Subsurface Mapping Survey. Colby Hunt was the representative for Haley & Aldrich, Inc. Fieldwork was conducted on November 13 & 15, 2023. The report was completed and e-mailed to Haley & Aldrich, Inc. November 18, 2023.

Subsurface mapping surveys are geophysical surveys utilizing geophysical methods and data to detect and locate natural and manmade subsurface features. Electromagnetic Surveys (EM Surveys) are used to detect and map the locations of buried metallic objects (see Appendix A). Ground Penetrating Radar (GPR) Surveys are used to map both natural and manmade subsurface features such as USTs, utilities, backfilled pits, etc. (see Appendix B.). Pipe and cable locators are used to map the locations of buried utilities and piping.

Once subsurface ferrous objects are detected from a magnetic survey then hand held scanners and GPR surveys are used to map the locations, depths, sizes and shapes of the objects.

SURVEY OBJECTIVES

The objective of this SMS survey was:

1. Search for USTS.

SURVEY SITE

The SMS Sites consisted of concrete covered city sidewalks (see Figures 1 & 2) at 11 SMS Sites. Historical information provided by Haley & Aldrich, Inc indicated USTS had possibly previously occupied portions of the Sites. Surface features consisted of two vent pipes at SMS Sites A-2A and A-5A. There were no other surface indications of USTS.

SURVEY EQUIPMENT

The following geophysical instruments were used to conduct the survey:

- GEONICS EM61 Metal Detector (EM Survey).
- Mala RAMAC Ground Penetrating Radar System with a 450 MHz antenna (GPR Survey).
- Schonstedt GA52 Magnetic Gradiometer.
- Aqua-Tronics A6 Pipe & Cable locator.
- Heath Sure Lock pipe & Cable locator.

This equipment and the procedures used to meet the survey objectives of this project have been proven effective in detecting metallic objects and mapping non-metallic features such as disturbed soil from backfilled pits.

Geophysical techniques are excellent at detecting changes in the subsurface caused by natural and manmade objects; however, they are poor at actually identifying subsurface features. Complementary methods may be used to assist in the interpretation; however, the only sure way of identifying a buried feature is by excavation.

Brief descriptions of the magnetic method and the radar method are included in the Appendices.

PROCEDURE

Magnetic Survey

The Magnetic Surveys consisted of acquiring magnetic readings along traverses using a 5 foot spacing between traverses over the Sites where it was considered necessary to search for the occurrence of USTS. A rectangular grid was laid out over each Site and magnetic data recorded along traverses. Magnetic data were downloaded to a computer, processed and contoured to produce a Magnetic Map for each Site. The Magnetic Maps are plotted at a Contour Interval of 500 nT (nannoTesla). Magnetic Anomalies indicating possible USTS are designated as M1, M2 or M3 on SMS Site Maps. The results of the Interpretation of Magnetic Anomalies are discussed in the RESULTS section of this Report and shown on SMS Site Maps.

Ground Penetrating Radar Surveys

Over areas that contained suspect USTs GPR Profiles were acquired using a 450 MHz antenna. The data were processed and interpreted as discussed below.

Pipe and Cable Survey

Hand held magnetic and electromagnetic scanners were used to help identify USTs and vent and product lines.

RESULTS

Results are shown on Figures 3 through 12. Results were marked on the Site with white marking paint.

USTS were interpreted to occur on three SMS Sites; A-2A, A-5A and A-7A (discussed below). All other possible UST Magnetic Anomalies were interpreted to be caused by Surface features or Subsurface utilities and minor ferric debris.

SMS Site A-2A (Figure 3)

During the course of the SMS the owner of the adjacent business verbally informed us that a UST lies under the sidewalk and can be accessed by an entrance in the basement of the adjacent building. The GPR Survey produced a 11x8 foot anomaly interpreted to be the room containing the UST. Tracing the vent pipe on the Southwest corner of the building agreed with the location of the UST. Consequently it was deemed unnecessary to conduct a Magnetic Survey over this SMS Site.

SMS Site A-5A (Figure 4)

Magnetic Anomaly M1 is interpreted to be caused by the remnants of a UST 5X8 by feet bgs. A vent pipe is exposed along the wall of the adjacent building and a possible remote fill line is interpreted to occur as shown on Figure 4. A backfilled excavation 13X5 by 8 feet bgs is interpreted to be located to the South of the UST remnants. This is interpreted to indicate that a portion of the UST and been removed from this SMS Site but ferric remnants remain along the North end of the former UST.

SMS Site A-7A (Figure 8)

Magnetic Anomaly M1 is interpreted to be caused by a possible UST 6X16 by 3 feet bgs). However this feature trends toward a Sewer Manhole to the Southwest of the possible UST. An alternative interpretation is that this feature is a large metal conduit rather than a UST. Direct Subsurface excavation is necessary to determine whether this feature is a UST or metal conduit.

LIMITATIONS

Limitations of magnetometer and GPR surveys can be seen in the Appendices.

Geophysical surveys consist of interpreting geophysical responses from subsurface features. Since a variety of subsurface features can produce identical geophysical responses, it is necessary to confirm the geophysical interpretation with intrusive investigations such as excavating or drilling. In addition, many subsurface features may produce no geophysical response.

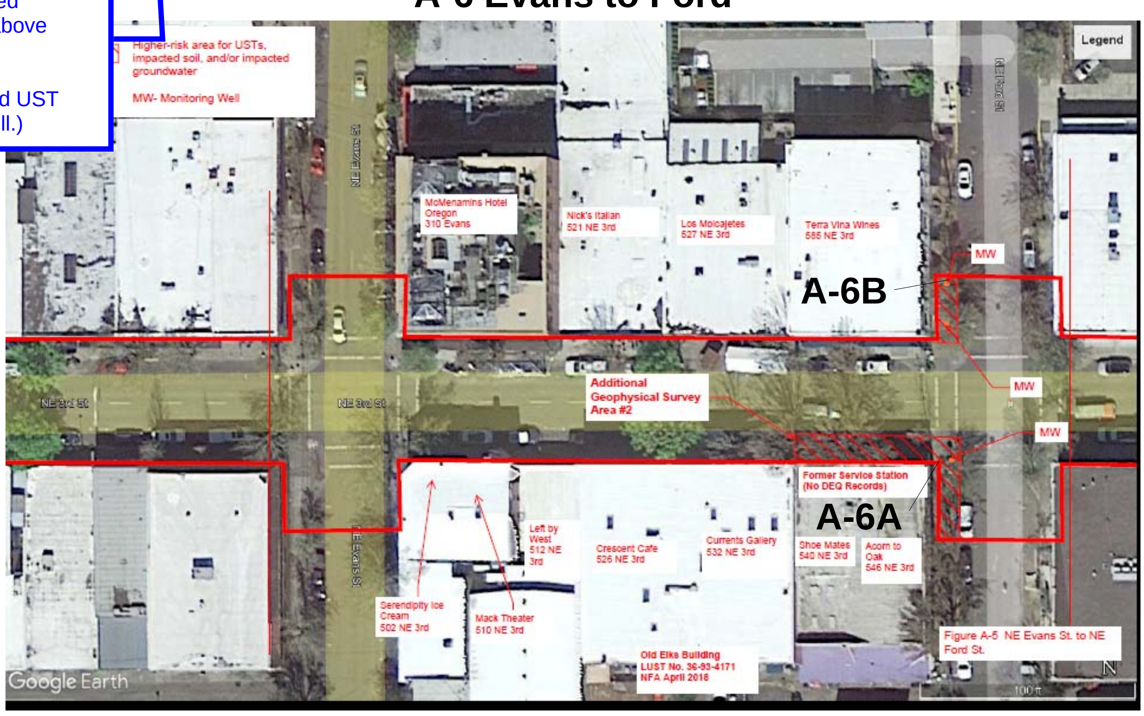
Ralph Soule

Ralph Soule **November 18, 2023**
GeoPotential

A-2 Adams to Baker

A-5 Davis to Evans

A-6 Evans to Ford



GeoPotential — ENVIRONMENTAL & EXPLORATION GEOPHYSICS 330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449 WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz	LOCATION: Subsurface Mapping Surveys 3rd Street McMinnville, Oregon	Figure 1: Subsurface Mapping Surveys SMS Sites; A-2, A-5 & A-6
DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568	CLIENT: Haley & Aldrich, Inc.	

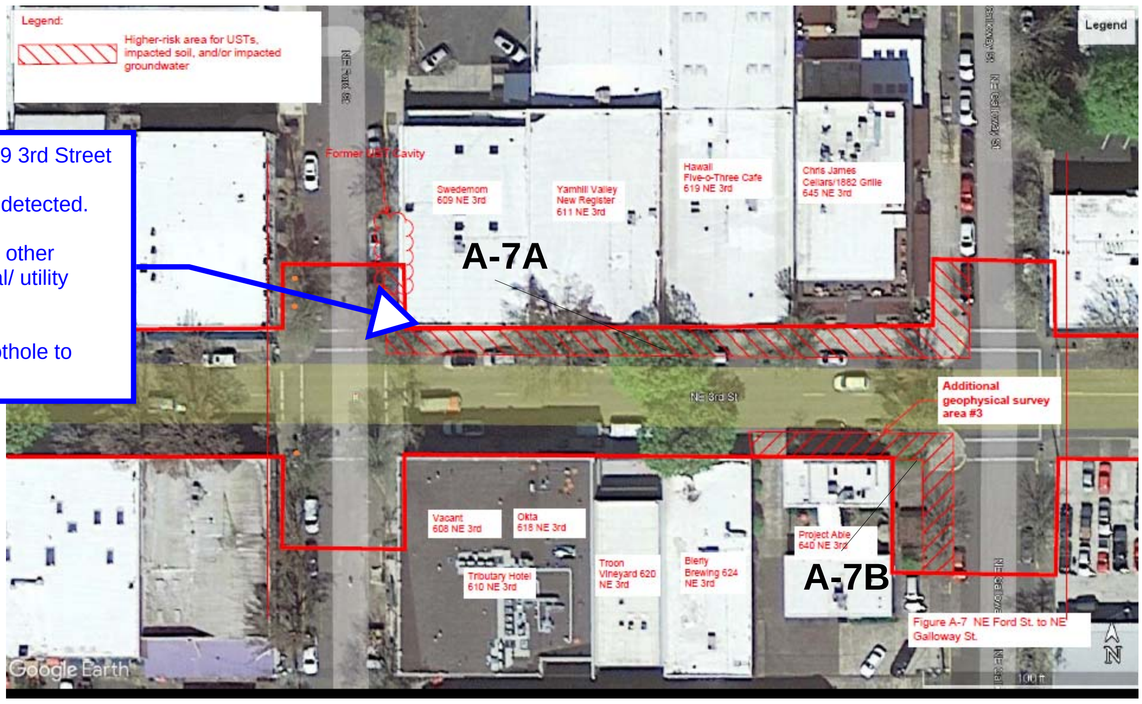
A-7 Ford to Galloway 3

A-7A @ NE 609 3rd Street

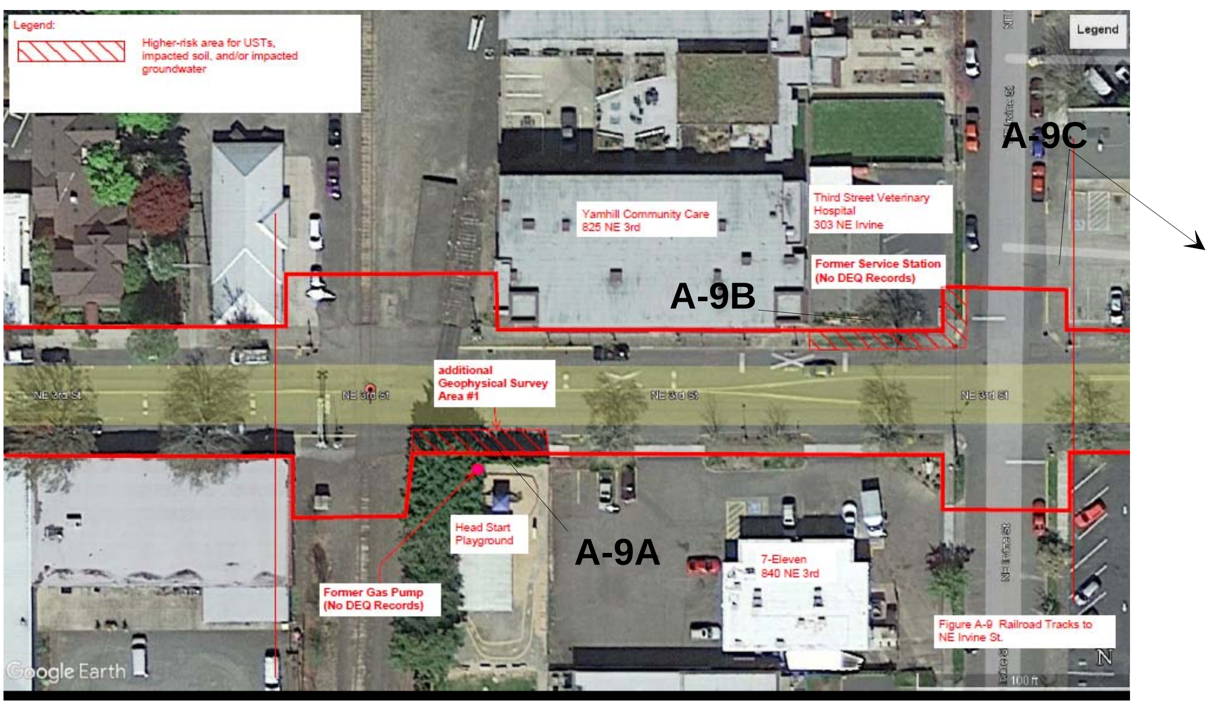
Apparent UST detected.

Could be other other ferrous material/ utility conduit.

Excavation/ Pothole to confirm.



A-9 RR to Irvine



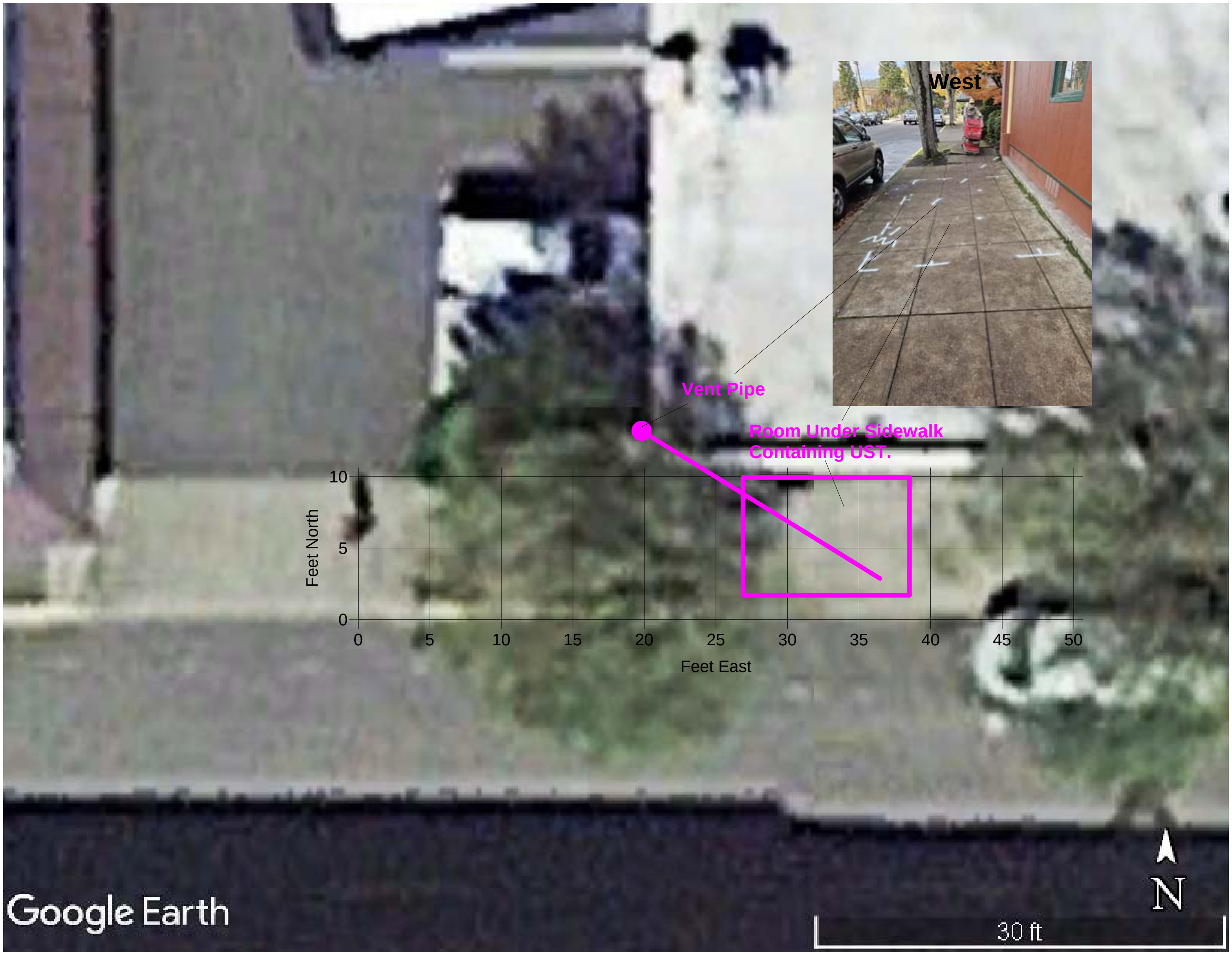
GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568

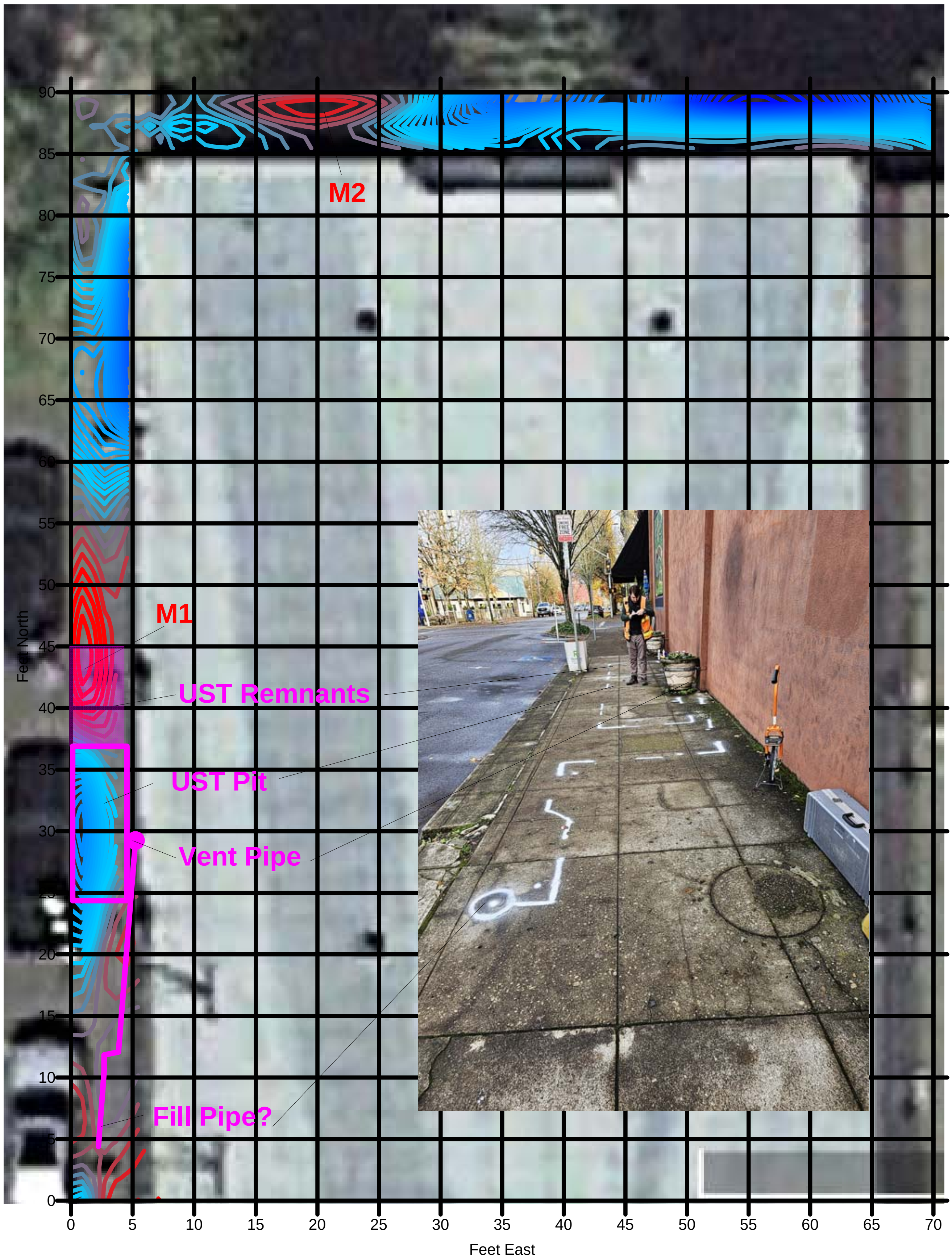
LOCATION: Subsurface Mapping Surveys
3rd Street
McMinnville, Oregon

CLIENT: Haley & Aldrich, Inc.

Figure 2: Subsurface Mapping Surveys SMS Sites; A-7, A-9

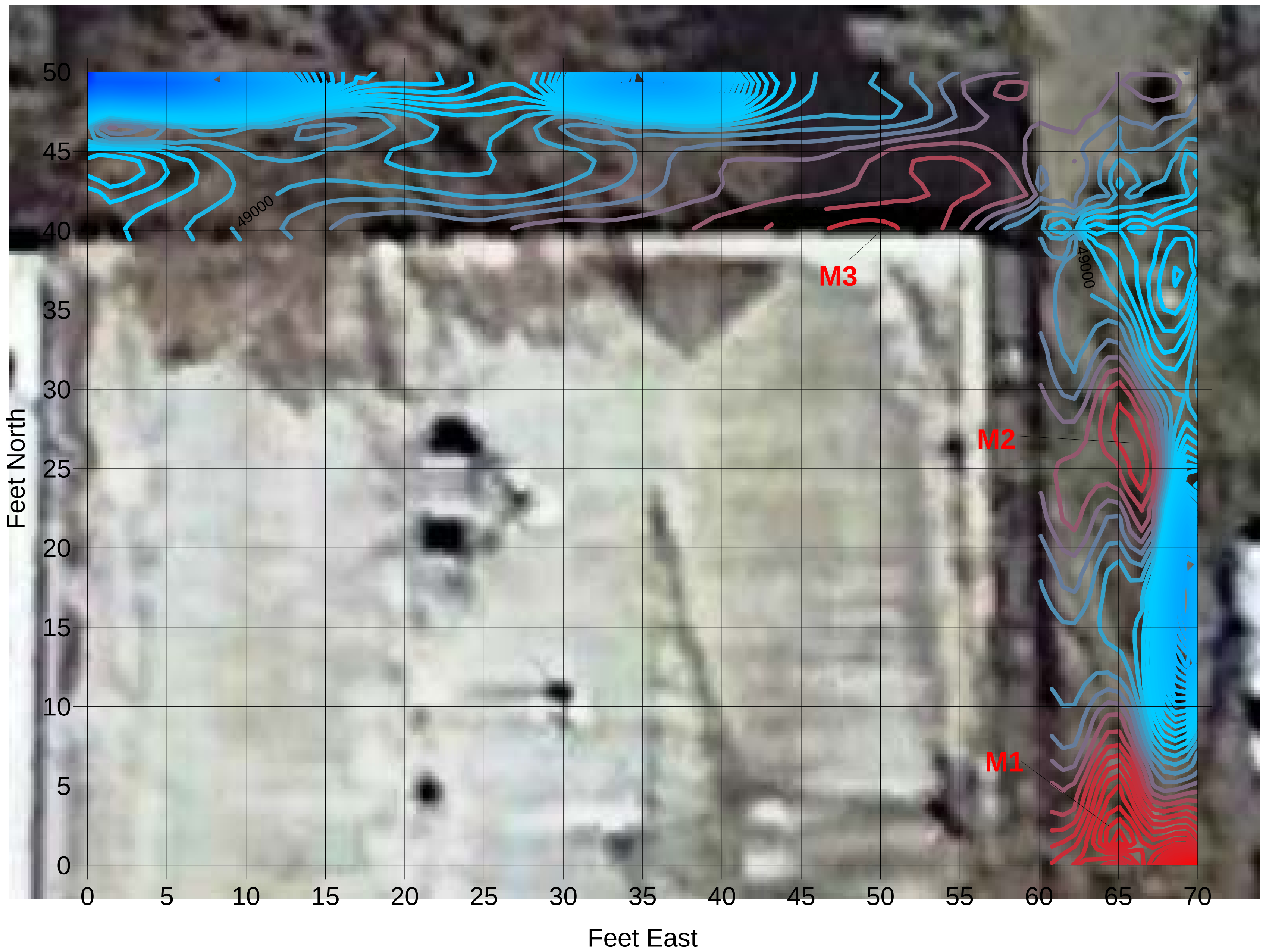


GeoPotential ENVIRONMENTAL & EXPLORATION GEOPHYSICS 330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449 WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz	LOCATION: Subsurface Mapping Surveys 3rd Street McMinnville, Oregon	Figure 3: SMS Site A-2A
DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568	CLIENT: Haley & Aldrich, Inc.	



GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

LOCATION: Subsurface Mapping Surveys 3rd Street McMinnville, Oregon		**Figure 4: SMS Site A-5A**
DATE: November, 2023	***SUBSURFACE MAPPING SURVEY***	PROJECT No. 1568
CLIENT: Haley & Aldrich, Inc.		



GeoPotential ENVIRONMENTAL & EXPLORATION GEOPHYSICS 330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449 WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz	LOCATION: Subsurface Mapping Surveys 3rd Street McMinnville, Oregon	Figure 4: SMS Site A-6A
DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568	CLIENT: Haley & Aldrich, Inc.	

GeoPotential

ENVIRONMENTAL & EXPLORATION GEOPHYSICS

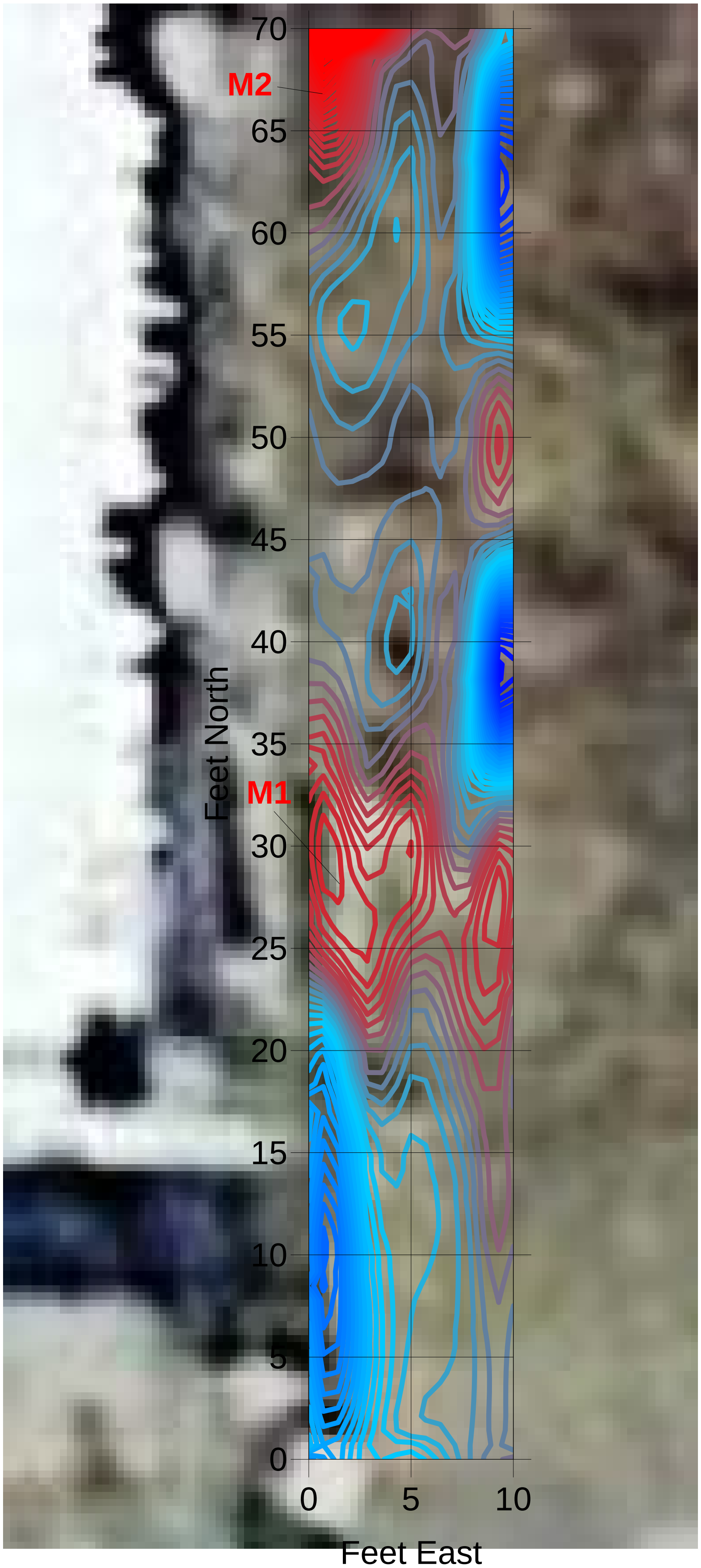
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1561

LOCATION: Subsurface Mapping Surveys
3rd Street
McMinnville, Oregon

CLIENT: Haley & Aldrich, Inc.

Figure 5: SMS Site A-5B, A-5C



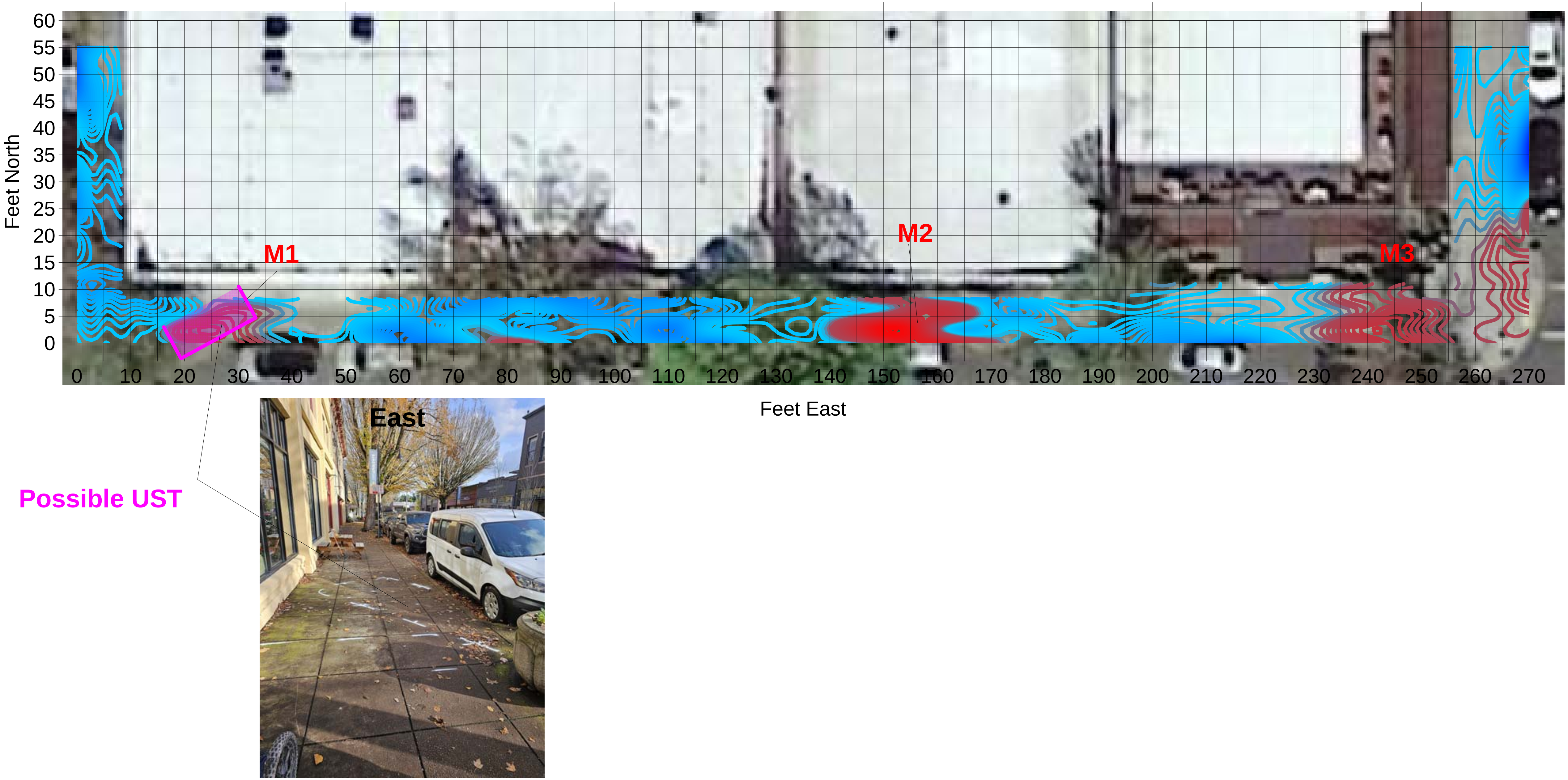
GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568

LOCATION: Subsurface Mapping Surveys
3rd Street
McMinnville, Oregon

CLIENT: Haley & Aldrich, Inc.

Figure 7: SMS Site A-6B



GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

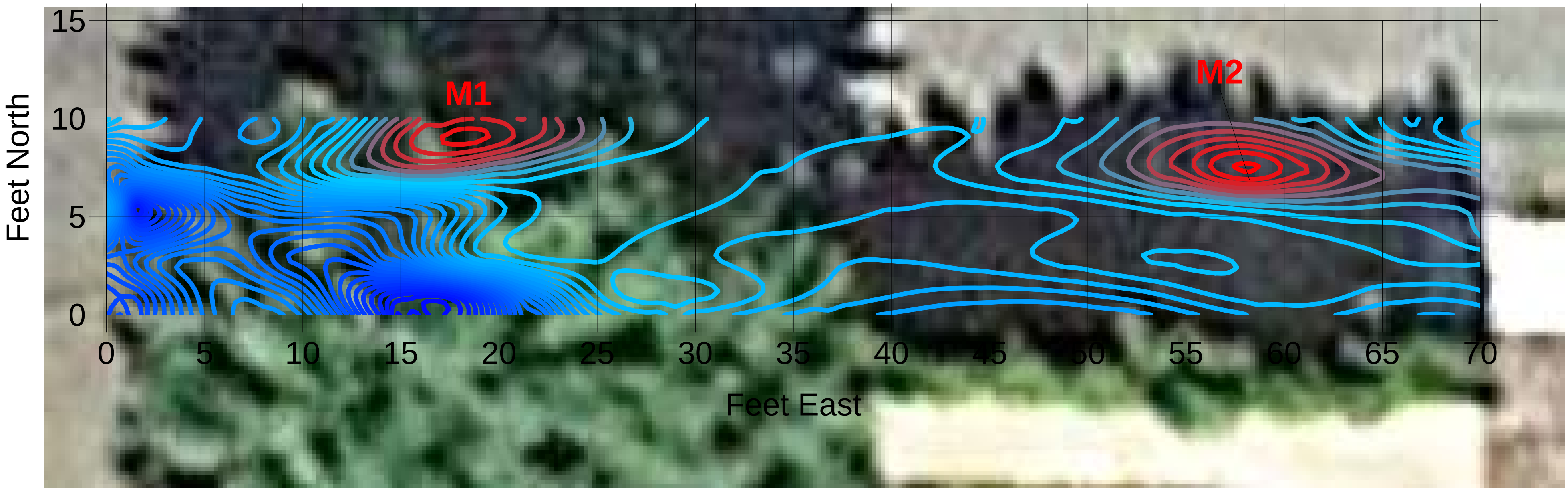
DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568

LOCATION: Subsurface Mapping Surveys
3rd Street
McMinnville, Oregon

CLIENT: Haley & Aldrich, Inc.

Figure 8: SMS Site A-7A

GeoPotential ENVIRONMENTAL & EXPLORATION GEOPHYSICS 330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449 WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz	LOCATION: Subsurface Mapping Surveys 3rd Street McMinnville, Oregon	Figure 9: SMS Site A-7B
DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568	CLIENT: Haley & Aldrich, Inc.	



GeoPotential

ENVIRONMENTAL & EXPLORATION GEOPHYSICS

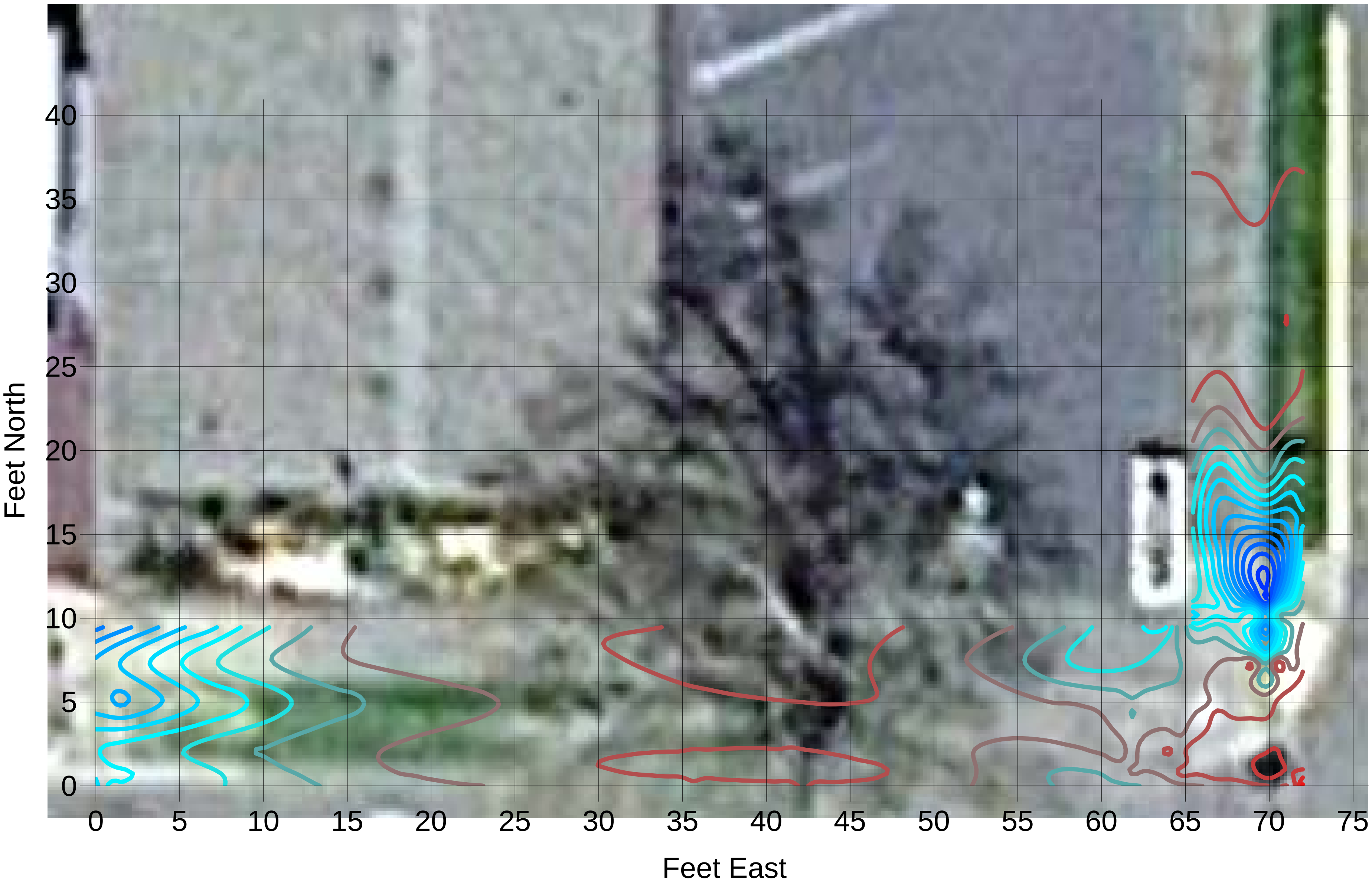
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568

LOCATION:
Subsurface Mapping Surveys
3rd Street
McMinnville, Oregon

CLIENT: Haley & Aldrich, Inc.

Figure 10: SMS Site A-9A



GeoPotential

ENVIRONMENTAL & EXPLORATION GEOPHYSICS

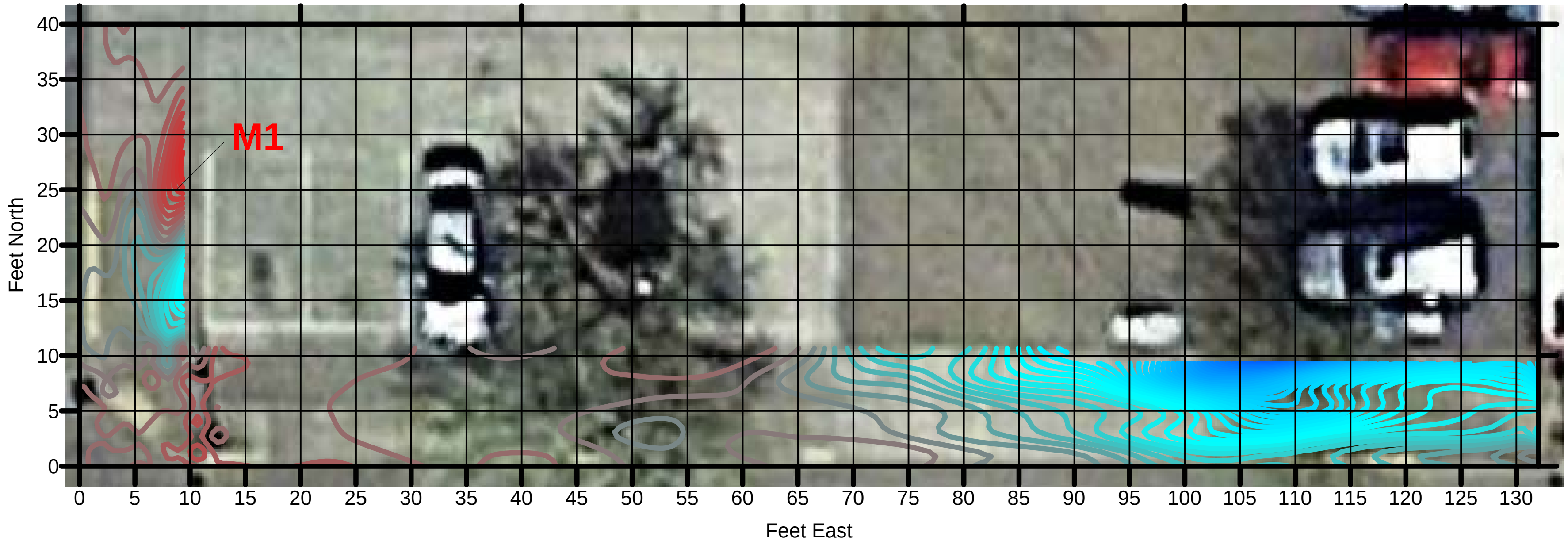
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568

LOCATION:
Subsurface Mapping Surveys
3rd Street
McMinnville, Oregon

CLIENT: Haley & Aldrich, Inc.

Figure 11: SMS Site A-9B



GeoPotential ENVIRONMENTAL & EXPLORATION GEOPHYSICS 330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (503) 912-6449 WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz	LOCATION: Subsurface Mapping Surveys 3rd Street McMinnville, Oregon	Figure 12: SMS Site A-9C
DATE: November, 2023 *SUBSURFACE MAPPING SURVEY* PROJECT No. 1568	CLIENT: Haley & Aldrich, Inc.	

GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (603) 912-6448
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

APPENDIX A

MAGNETOMETER SURVEYS

The earth's magnetic field, measured in "nano Teslas" (nT), behaves like a bar magnet (a dipolar field), with the strongest magnetic field located at the poles, and the weakest field located near the equator. In the continental United States, the average field intensity varies widely, however, the average value is about 50,000 nT. Also, like the magnetic field around the bar magnet, the earth's magnetic field is inclined. This inclination in the continental United States varies between 60 and 75 degrees, generally depending upon the latitude of the measuring location. The earth's magnetic field varies constantly and, during sunspot activity, quite dramatically. A magnetometer is an electronic device that measures the intensity of the earth's magnetic field.

Naturally occurring geologic features and buried ferrous metal objects such as underground storage tanks, drums, ordnance, pipes and debris filled trenches produce both horizontal and vertical disturbances to the earth's local magnetic field. The objects causing these "anomalies" can be detected quickly and reliably using portable magnetometers.

The intensity of an anomaly is a function of the size, depth of burial and magnetic susceptibility of the object. As a rule of thumb, single drums buried several feet below the surface produce anomalies of about 200 nT relative to the normal undisturbed background and can be detected at a horizontal distance of about 15 feet, while large caches of drums can produce anomalies of many thousands of nT and may be detectable 50 feet away.

Magnetometers generally measure total intensity of the local magnetic field. A magnetic gradiometer is a variant of the magnetometer that measures both the horizontal and the vertical magnetic field at each survey point. It consists of two identical sensors located vertically on a staff and having a fixed separation. The intensity of the magnetic field caused by a buried metal object varies inversely with the distance between the object and the sensor. The relative intensities measured simultaneously at each sensor are used to determine the relative depth of burial of an object.

Relative depth estimates of buried metal objects can be made using a single sensor. In general, for a given object, the deeper the object is buried, the lower the amplitude and the wider the anomaly. Shallowly buried objects produce higher amplitude anomalies with closely spaced contour lines.

Magnetic surveys can only detect **ferrous metal** objects and cannot be used to identify the buried object. Estimates of the total mass of a buried object are difficult due to the physical properties of the object and other factors. Interference caused by observed surface metal objects limits the accuracy of the survey. The anomalies produced by fences, power lines, cars and buildings can easily mask the anomaly caused by an underground target.

Magnetic surveys are cost effective. Using the standard "step and wait" magnetometer, data from approximately 1000 points can be obtained in one field day corresponding to between 1 acre and about 5 acres depending on site conditions and survey goals. More modern cesium magnetometers collect up to 10 readings per second continuously, thus the operator can proceed without stopping. Many modern magnetometers use an audible signal to call attention to anomalous data as it is obtained. At some sites metallic objects can be detected and marked in the field at the time of the survey.

The use of a second, automatically recording "base station" magnetometer is highly recommended due to temporal variations in the earth's magnetic field. These changes must be removed from the field data before an accurate interpretation can be made, particularly when searching for small-buried objects.

Magnetic data are most commonly presented in two contour maps. The TOTAL MAGNETIC FIELD CONTOUR MAP shows the horizontal variation of the total intensity of the magnetic field and, therefore, the areal extent of anomalies. The GRADIOMETER CONTOUR MAPS show the horizontal variation of the vertical gradient of the magnetic field and indicate the relative depth of burial of the objects causing those anomalies. Color versions of these maps may be produced showing only the magnetic highs and lows.

GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
330 Creekside Terrace, Fairview, OR 97024 Phone: (503) 912-6441 Fax: (603) 912-6448
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

APPENDIX B

GROUND PENETRATING RADAR SURVEYS

Ground Penetrating Radar (GPR) can be a valuable tool to accurately locate both metallic and non-metallic UST's and utilities, buried drums and hazardous material at some sites. It may detect objects below reinforced concrete floors and slabs. GPR may delineate trenches and excavations and, under some conditions, it may be used to locate contaminant plumes. It has been used as an archaeological tool to look for buried artifacts. It may accurately profile fresh water lake bottoms either from a boat or from a frozen lake surface. GPR may be used to locate voids below roads and runways. GPR has numerous engineering applications. It can be used in non-destructive testing of engineering material, for example, locating rebar in concrete structures and determining the thickness of concrete and other structural material.

GPR uses short impulses of high frequency radio waves directed into the ground to acquire information about the subsurface. The energy radiated into the ground is reflected back to the antenna by features having different electrical properties to that of the surrounding material. The greater the contrast, the stronger the reflection. Typical reflectors include water table, bedrock, bedding, fractures, voids, contaminant plumes and man-made objects such as UST's and metal and plastic utilities. Materials having little electrical contrast like clay and concrete pipes may not produce strong reflections and may not be seen. Data are digitally recorded or downloaded to a laptop computer for filtering and processing.

The frequency of the radar signal used for a survey is a trade off. Low frequencies (250 MHz – 50 MHz) give better penetration but low resolution so that pipes and utilities may not be seen. Pipes and utilities may be seen using higher frequencies (500 MHz) but the depth of penetration may be limited to only a few feet especially in the wet, clayey soils found in many areas of the NW USA. The GPR frequency is dependent upon the antenna. Once an antenna is selected, nothing the operator can do can increase the depth of penetration.

Radar data is ambiguous. Many buried objects produce echoes that may be similar to the echo expected from the target object. Boulders and debris produce reflections that are similar to pipes and tanks. Subtle changes in the electrical properties along a traverse caused by changes in soil type, mineralogy, grain size, and moisture content all produce “noise” that can make interpretation difficult. Interpreting radargrams is an art as much as a science.

Under some conditions, although a UST itself may not be clearly visible in a GPR record, the excavation or trench in which the UST is buried is evident. Usually GPR data is used to compliment data from other “tools”. For example, a trench-like reflection but no clear UST reflection, combined with a “tank” shaped magnetic anomaly suggests the presence of a UST. Although the UST itself could not be seen using GPR, the radar showed a trench-like reflection. The magnetic data showed a large ferrous object. We would report a possible UST at that location.

GPR is often used in conjunction with magnetometer surveys. Magnetometer Surveys are very fast and large areas can be covered cost effectively. Magnetic anomalies are marked in the field, and then may be further investigated using radar.

GPR, like other geophysical tools, is excellent at detecting changes across a site, but it is poor at actually identifying the cause of the change. **The only definite way to identify buried objects is through excavation.**

ADVANTAGES - General

- When GPR data is properly interpreted subsurface objects can usually be confidently identified. This often requires the GPR data be combined with other geophysical data, surface features and historical information.
- GPR provides continuous records along traverses which, depending on the goal of the survey, may be interpreted in the field.
- At flat, open sites, for reconnaissance purposes, the antenna can be towed behind a vehicle at several mph.
- Many GPR antennas are shielded and are unaffected by surface and overhead objects and power lines.
- GPR can be used in conjunction with magnetic or EM surveys to accurately locate buried objects.

ADVANTAGES – Site specific

- With a low frequency antenna, in clean, dry, sandy soil, reflections from targets as deep as 100 feet are possible. Geologic features such as bedrock and cross bedding may be seen at some sites.
- The resolution of data is very high particularly for high frequency antennas.
- Shallow, man-made objects generally can be detected.
- Fiberglass UST's and plastic pipes can be detected using GPR.

LIMITATIONS - General

- To acquire the highest quality data, proper coupling between the antenna and the ground surface is necessary. Poor data may be obtained at sites covered with debris, an uneven surface, tall grass and brush. Objects located at curbs are difficult to see.
- Acquiring GPR data is slow. The antenna must be over the target. The signal from the antenna is cone-shaped. Reflections from objects to the side of the antenna may be seen, but their actual location relative to the antenna is not obvious.
- Penetration of the GPR signal is "site specific" and its depth of penetration at a particular site cannot be predicted ahead of time. Near surface conductive material, such as salty or contaminated ground water and wet, clay-rich soil, may attenuate the radar signal, limiting the

effective depth of the survey to several feet. Reinforced concrete also can attenuate the signal. Rebar may produce reflections that look like pipes.

- GPR may not be cost-effective for some projects. For a detailed survey mapping underground storage tanks and utilities, it may be necessary to collect data in orthogonal directions at 5-foot line spacing.

<u>LIMITATIONS – Interpretation</u>

- Interpretation can be difficult. Radar data are ambiguous. Subsurface objects can be detected but, in general, they cannot be identified. USTs and utilities have a characteristic reflection, however, large rocks and boulders have a similar reflection.

- The reflection visible in a GPR record is very complex and may be caused by small changes in the electrical properties of the soil. The target in mind may not produce the reflection. Due to “noise”, the target may be missed. USTs and deep utilities may be missed if they are under debris and/or other pipes.

- Other methods may be necessary to aid in the interpretation of the data (use a magnetometer to detect a large metallic mass, then GPR to determine if the object is tank-like, or a utility locator to determine if there are feed lines and fill pipes leading to the object).

- Adequate contrast between the ground and the target is required to obtain reflections. UST’s may be missed if they are badly corroded. Utilities made of “earth” materials like clay and concrete may not be detected since their electrical properties are similar to the surrounding soil.

- To determine the depth to an object without "ground truth", assumptions must be made regarding soil properties. Even with ground truth at several locations on the same site, changes in material across a site (therefore changes in signal velocity) can cause errors in depth measurements at other locations.