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LETTER REPORT

LINEAMENT ANALYSIS

at

NIAGARA FALLS ARS, SITE 3
Niagara Falls, New York

Submitted to:

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February, 1999

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1. PROJECT OVERVIEW

1.1 INTRODUCTION

Resolution Resources, Inc. (RRI) performed a lineament analysis from stereographic pairs of aerial photographs and a background review of the site history, geology and hydrology at Site 3 Landfill, located in the northeastern corner of Niagara Falls ARS, Niagara Falls, New York. The site extends beyond the installation boundary onto Niagara Frontier Transportation Authority (NFTA). The work consisted of the following tasks:

TASK 1: Stereo Photograph Search - library search for existing photographs.

TASK 2: Review Background Information on the site history, geology, and hydrogeology.

TASK 3: Perform a Fracture Trace Analysis on the optimum existing photographs.

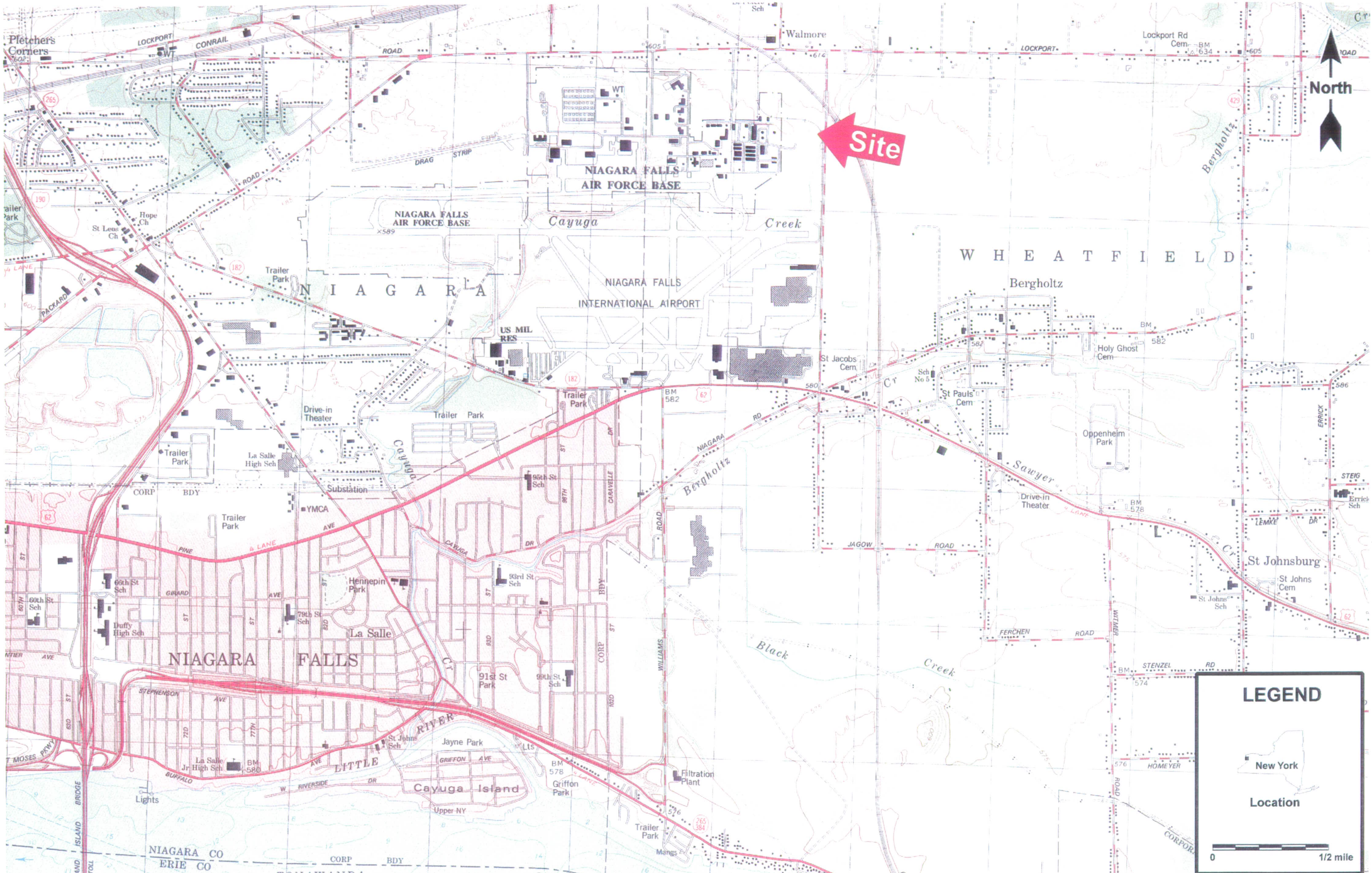
TASK 4: Produce two copies of a brief Letter Report, with aerial photographs, lineament analysis, and a discussion of the findings.

1.2 SITE BACKGROUND

Niagara Falls ARS is located in northwestern New York State, north of the Niagara River and the City of Niagara Falls, as shown on the topographic map in **Figure 1** (USGS, 1980). Site 3 Landfill, which is the area of interest for this report, is located in the northeastern part of the installation.

The currently inactive landfill consists of about nine acres, adjacent to the west bank of Cayuga Creek. The landfill was in operation from the 1950's until 1969. At present Site 3 is characterized by gently sloping terrain that is covered with grass and some trees. Originally it was a low-lying, marsh within the Cayuga Creek flood plain. It was reportedly filled to a depth of 8-10 feet with solid wastes, some of which were potentially hazardous. In 1969 the landfill was regraded and capped.

Site 3 was identified in 1983 during the Phase I Record Search for potential environmental contamination. In 1986, during the Phase II investigation, monitor wells were installed and groundwater, surface water, and sediment samples were collected. Based on these results an RI/FS was performed between 1987 to 1990. Results from the previous investigations have shown that contaminants include TCE, vinyl chloride, benzene, PCE, carbon tetrachloride, zinc, and lead. Sixteen monitor wells have been installed at the site.



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Title	Reference	Figure No.
Topographic Map	USGS (1980)	1

1.3 SITE GEOLOGY & HYDROLOGY

Site 3 is underlain by an overburden of fill, lacustrine sediments, and glacial till on top of fractured Lockport dolostone. The land slopes gently to the east-southeast and the overburden thickness ranges from 3 feet in the south and southeast near Cayuga Creek, to 14 feet in the northwest. The lacustrine sediments consist of clay with silt, sand and gravel. The glacial till ranges from 0-4 feet in thickness, and consists of a mixture of clay to cobble-sized sediments.

Groundwater is encountered within the overburden in the basal till layer and in the bedrock. Recharge to the aquifer is via precipitation, although during the dry season Cayuga Creek may behave as a losing stream. Water level measurements show that flow in the overburden is to the southeast toward Cayuga Creek. The groundwater in the overburden is in direct contact with Cayuga Creek, where the bedrock is exposed.

The Lockport dolostone produces water in high enough yields for residential and commercial use. Permeability is found in fractures rather than in the rock matrix. Flow in the shallow bedrock is also to the south-southeast.

2. FRACTURE TRACE ANALYSIS

It is well known that fractures and faults in consolidated formations transmit water. Also in many cases, faults in basement rock are propagated up through unconsolidated sediments to the surface as failure planes. This may be a result of occasional activity along the fault. These features often have subtle surface expressions that reveal their subsurface existence and can often be seen in aerial photographs. Lineaments were identified primarily based upon subtle changes in the shading and in the topography at the ground surface. Lineaments cut across different surface terrain and often display a topographic expression where one side of the lineament is slightly higher than the other side, as though offset has occurred. Materials that infill faults or fractures frequently have different shading than the surrounding surfaces that have never been fractured.

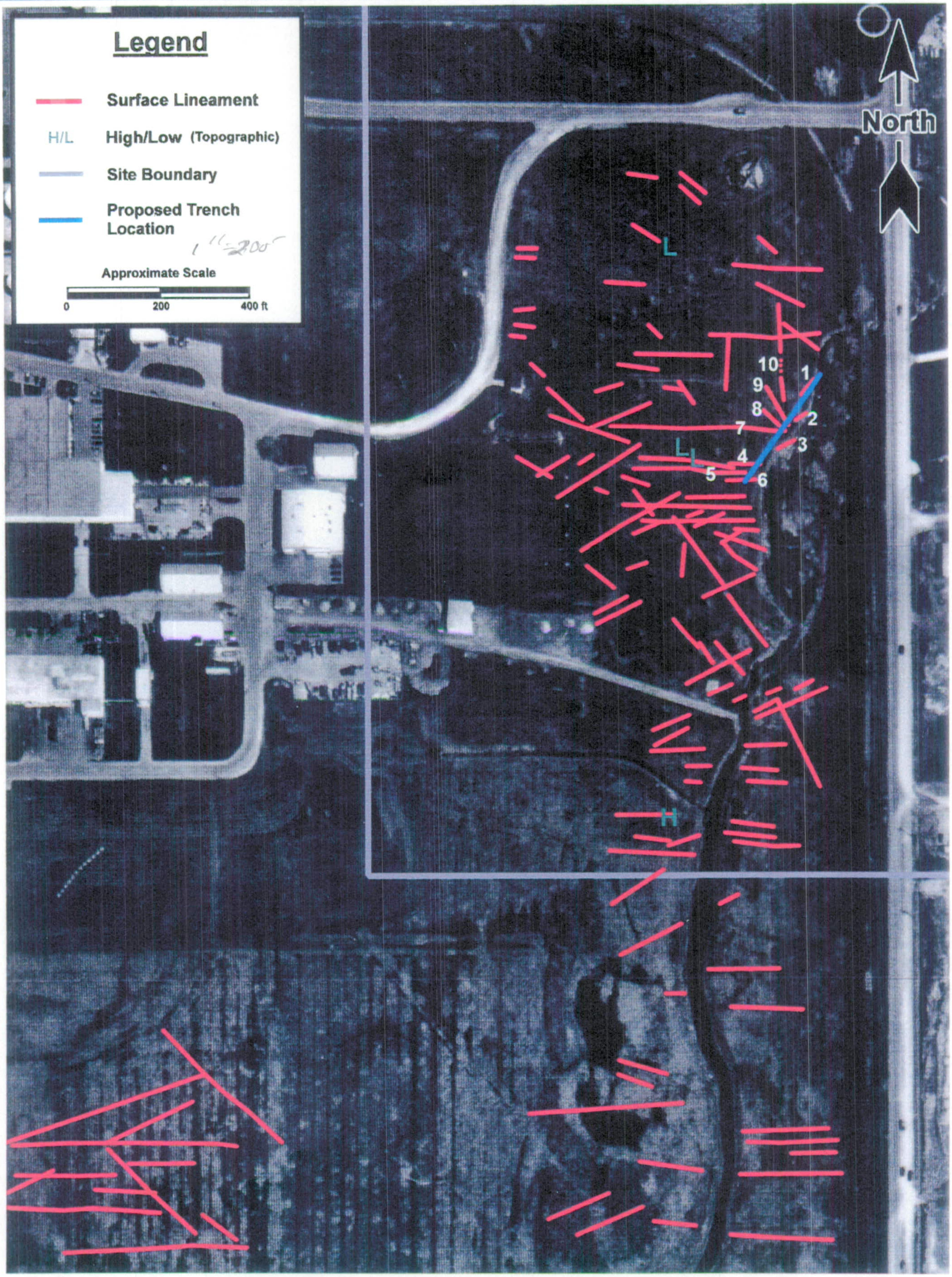
Investigators (Culbreth, 1988; Wobber, 1967; Parizek, 1977; Rumsey 1971) have found that lineaments can be identified in aerial photographs, even when sediments overlie the bedrock for hundreds of feet, and that they are manifestations of fractures or faults that have been propagated from bedrock to the surface through unconsolidated sediments and soil. The lineaments can be expressed by a variety of features (Hough, 1960) such as tonal changes in soil, changes in the directions of streams, straight segments in drainage patterns, or alignment of vegetation (since fractures are often more permeable, more water is available for enhanced growth of the plants). As a result of their work on LandSat imagery, compared to outcrop patterns and geophysical data in Montana and Wyoming, Marrs and Rains (1984) concluded that the lineaments represented the surface expression of boundaries of crustal blocks that have been activated throughout time.

Normally photographs are examined for the highest sun angle, greatest vertical exaggeration, and scale. However, budget constraints required having a library search performed for existing photographs, and then choosing what appeared to be the best scales. Of the photographs that were available the larger scale photographs were initially consulted to obtain a more regional trend. The photographs taken in 4/16/95, frames 2-6 and 2-7, were obtained from the New York State Department of Transportation at a scale of 1:40,000 and are included in **Appendix A**. The photographs show an area with little difference in relief, however, there is not enough resolution to identify details on the site. Photographs from 1974, at a scale of 1:24,000 were also examined, but the vertical exaggeration and scale made it difficult to evaluate them on a site basis as well. They are also included in Appendix A. The detailed fracture trace analysis was performed on photographs from 1992 at a scale of 1:9600 (Appendix A). These photographs were then enlarged 400% (1 inch ≈ 200 feet).

Figure 2 shows the detailed fracture trace analysis, which was performed on the enlarged 1992 photographs. As can be seen from the photographs, the most prominent direction that can be discerned on this set of photographs is lineaments that are oriented east-west. This orientation is not surprising, since there is a major east trend, which is the Niagara River south of the site, and the topographic contours show east-trending blocks at the surface of the earth. In addition to this prominent trend, north-south, northwest to southeast, and northeast-southwest trending lineaments have also been identified.

Aerial photography is most useful in identifying fracture orientations that are vertical or nearly vertical. This limitation of the photoanalytic technique is an advantage when analyzing lineaments or fractures that are vertical. This is because the drilling information taken from vertical holes makes it difficult to recognize vertical or nearly vertical fracture systems. However at this site it was difficult to identify lineaments in areas recently reworked by man, such as in plowed fields. Lineaments should be field verified whenever possible, since some linear anomalies may actually represent man-made features such as buried utilities.

When selecting a groundwater or soil sampling point, the photoanalysis can be used to select and justify a location. Hydraulic conductivity is normally calculated as porous flow. However hydraulic conductivity and interconnectivity can be enhanced by locating sampling points at the juncture of two or more lineaments identified in a photograph. These lineaments often represent fractures. This concept is illustrated in **Figure 3**, which shows the juncture of two fractures as a more permeable zone than either single fracture on the surrounding area.



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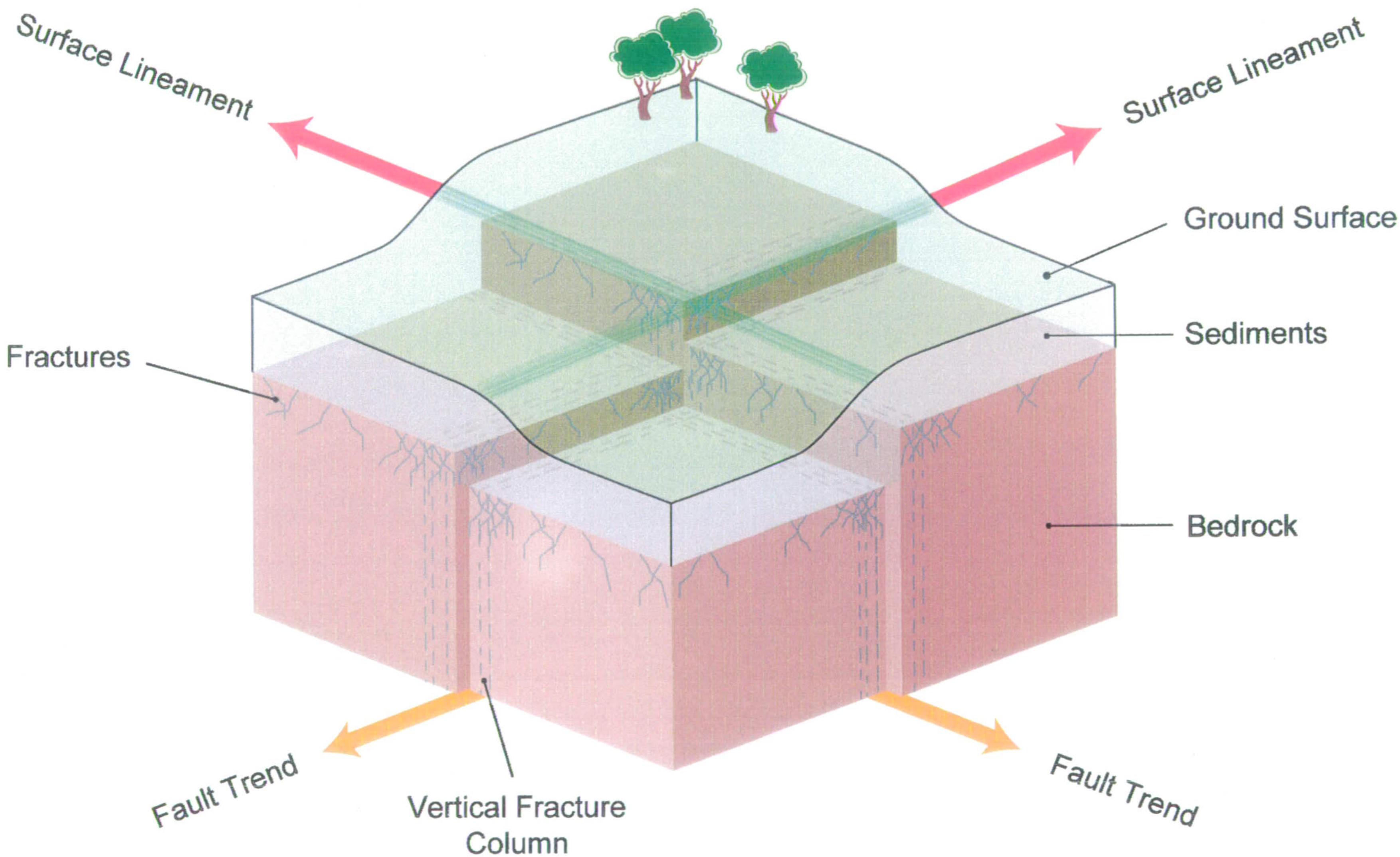
Title	Reference	Figure No.
Fracture Trace Analysis: 1992 Photographs		2



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Title

Fault Blocks & Lineaments Schematic

Reference

Figure No.
3

3. RECOMMENDATIONS

The photographic evidence suggests that the site is fractured in blocks controlled by two grids. These grids are common and have been identified with varying degrees of resolution at every site where RRI has performed a fracture trace analysis. One prominent grid is defined as a set of lineaments, fractures, or faults that trend east to west and a second set at about 90° that trends north to south. A second prevalent grid set trends northwest to southeast and northeast to southwest at about 90° to each other. Sampling points located at the juncture of these linear features may be more permeable, and when located near or along pathways from the source areas, would be more likely to detect contaminants.

Since a trench, rather than well heads, is to be installed at this site, a blue line, about 200 feet long, has been placed on the photograph in Figure 2. This is the best location for the trench, based on the photographic work. Low areas have been indicated in green, with an "L". A trench located anywhere along this line would be within Lineament 1; and would intercept northeast trending Lineaments 2 and 3. The trench would begin in a low created by east-trending Lineaments 4, 5, 6 and also intercept east-trending Lineament 7, northwest trending Lineaments 8 and 9 and north-trending Lineament 10. If the trench is limited to 100 feet in length, it will not intercept all lineaments, but can be best positioned, based on the remedial objectives, at an interval along the blue line.

4. REFERENCES

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Parizek, R.R. (1976), On the Nature and Significance of Fracture Traces and Lineaments in Carbonate and Other Terrains: in Karst Hydrogeology and Water Resources; Proc. US-Yugoslav Symposium, Drebovnik, Water Resources Publication, V.1, p. 47-108.

Rumsey, I.A.P. (1971), Relationship of Fractures in Unconsolidated Surficial Deposits to Those in Underlying Bedrock; Modern Geology V. 3, p. 25-41.

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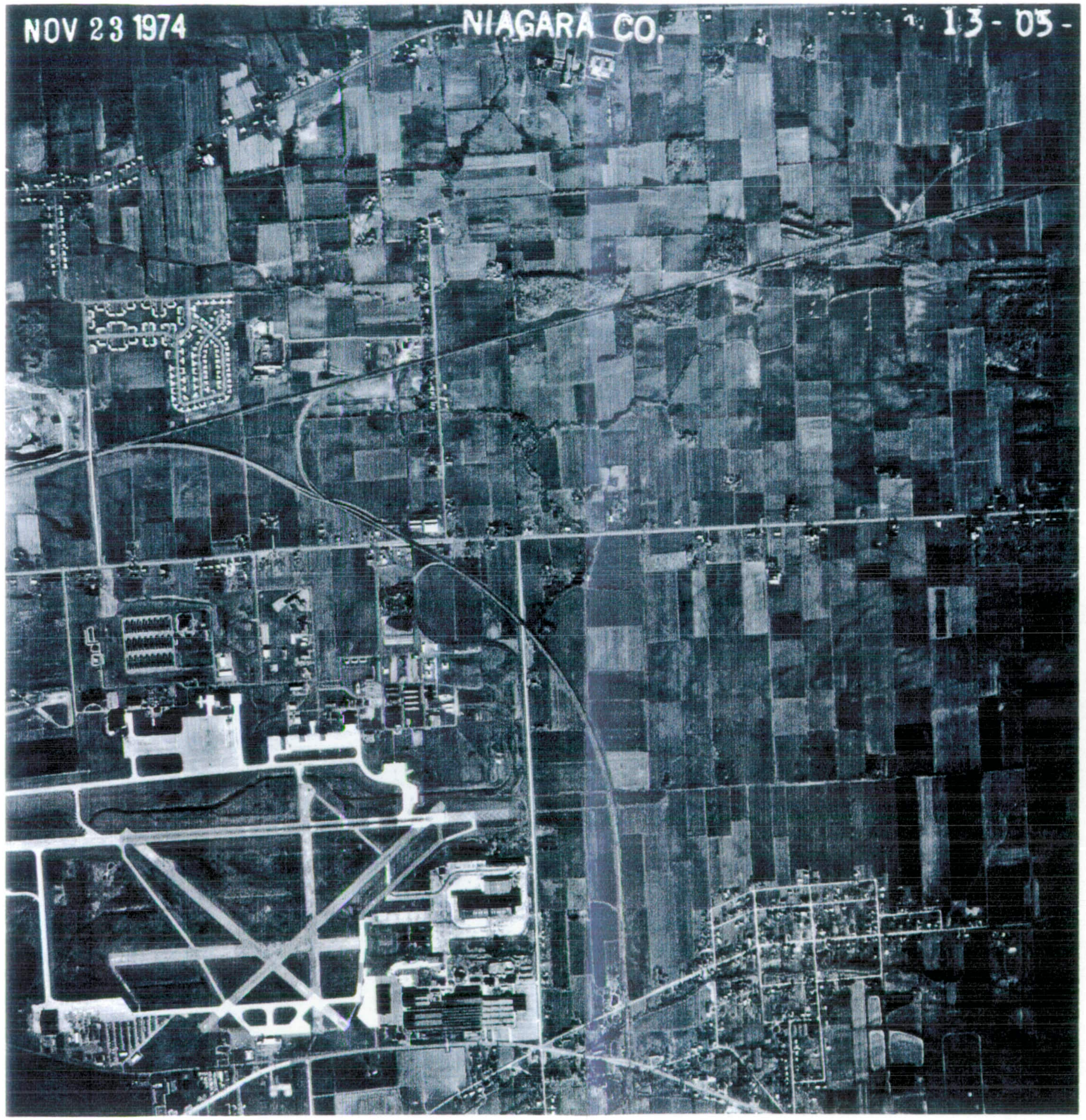
Wobber, F.J. (1967), "Fracture Traces in Illinois: Photogrammetric Engineering V. 33, p. 499-506.

APPENDIX A

UNINTERPRETED AERIAL PHOTOGRAPHS

North



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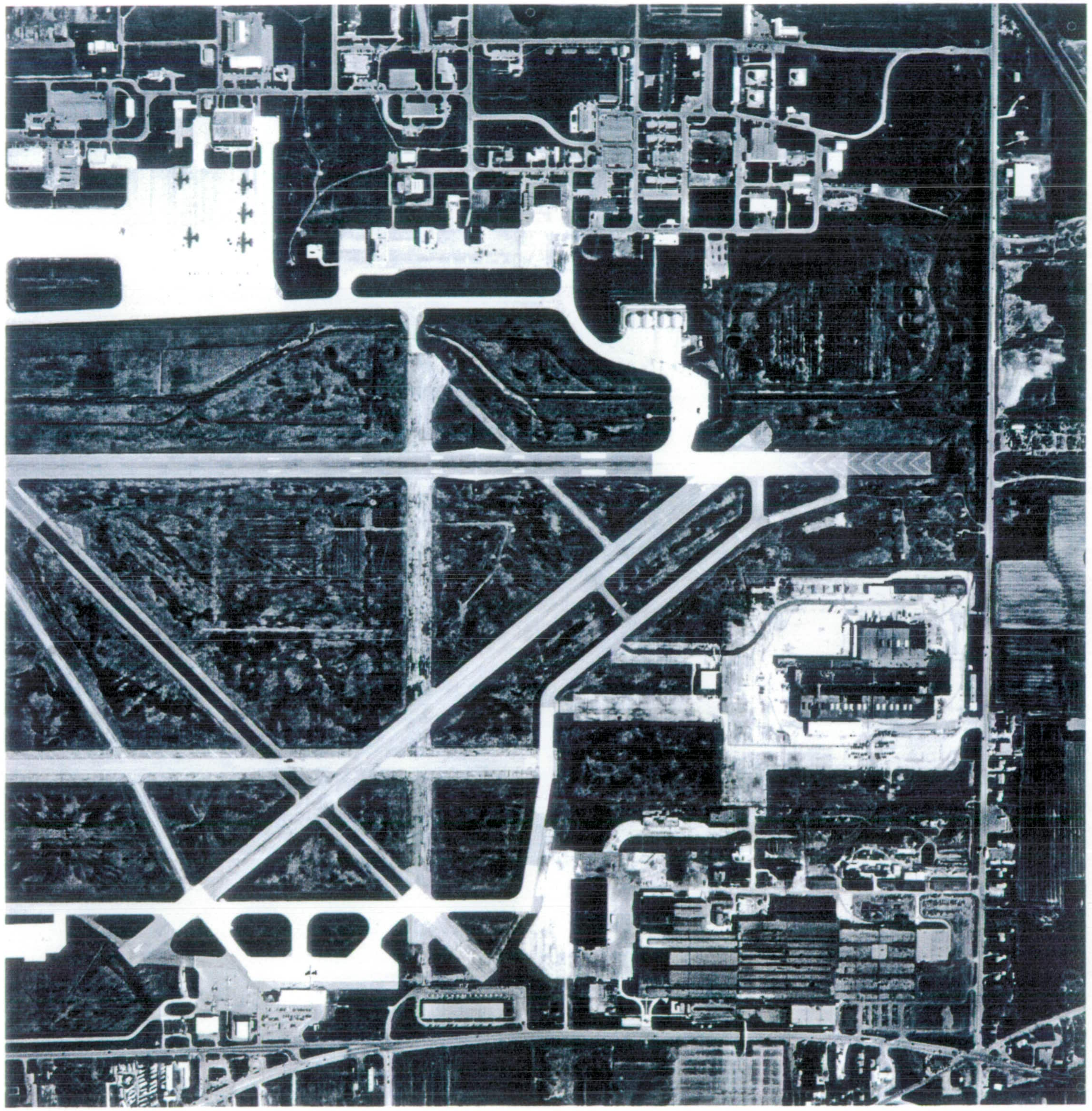
Title

Stereogram of 1974 Aerial Photographs

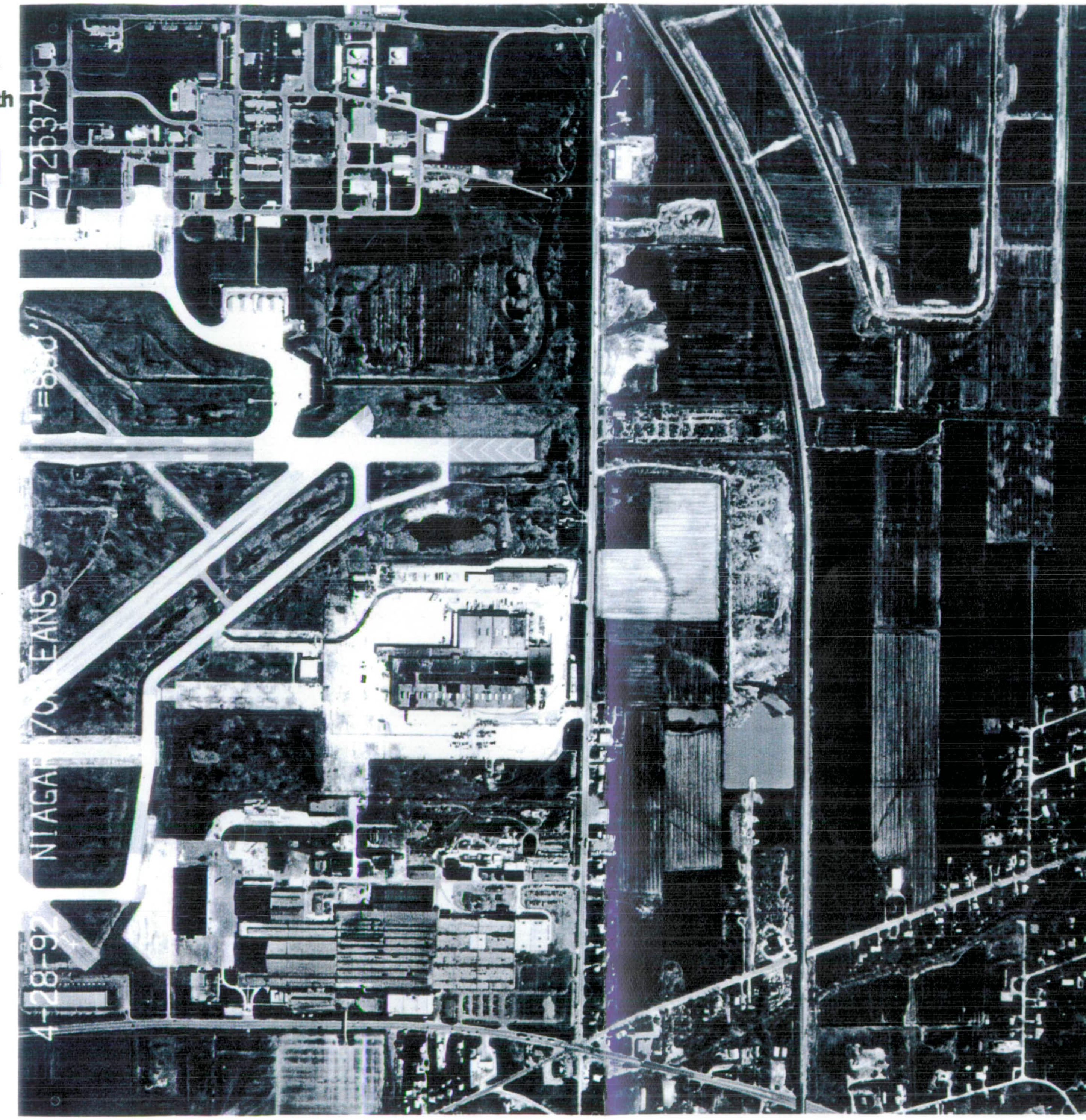
Reference

Figure No.

A1



North



Resolution Resources, Inc. 3D Acoustic Imaging for the Environment 3636 Goodwin Road Ionia, MI 48846 Tel: (517) 647-1832 Fax: (517) 647-2862	Title Stereogram of 1992 Aerial Photographs	Reference	Figure No. A2

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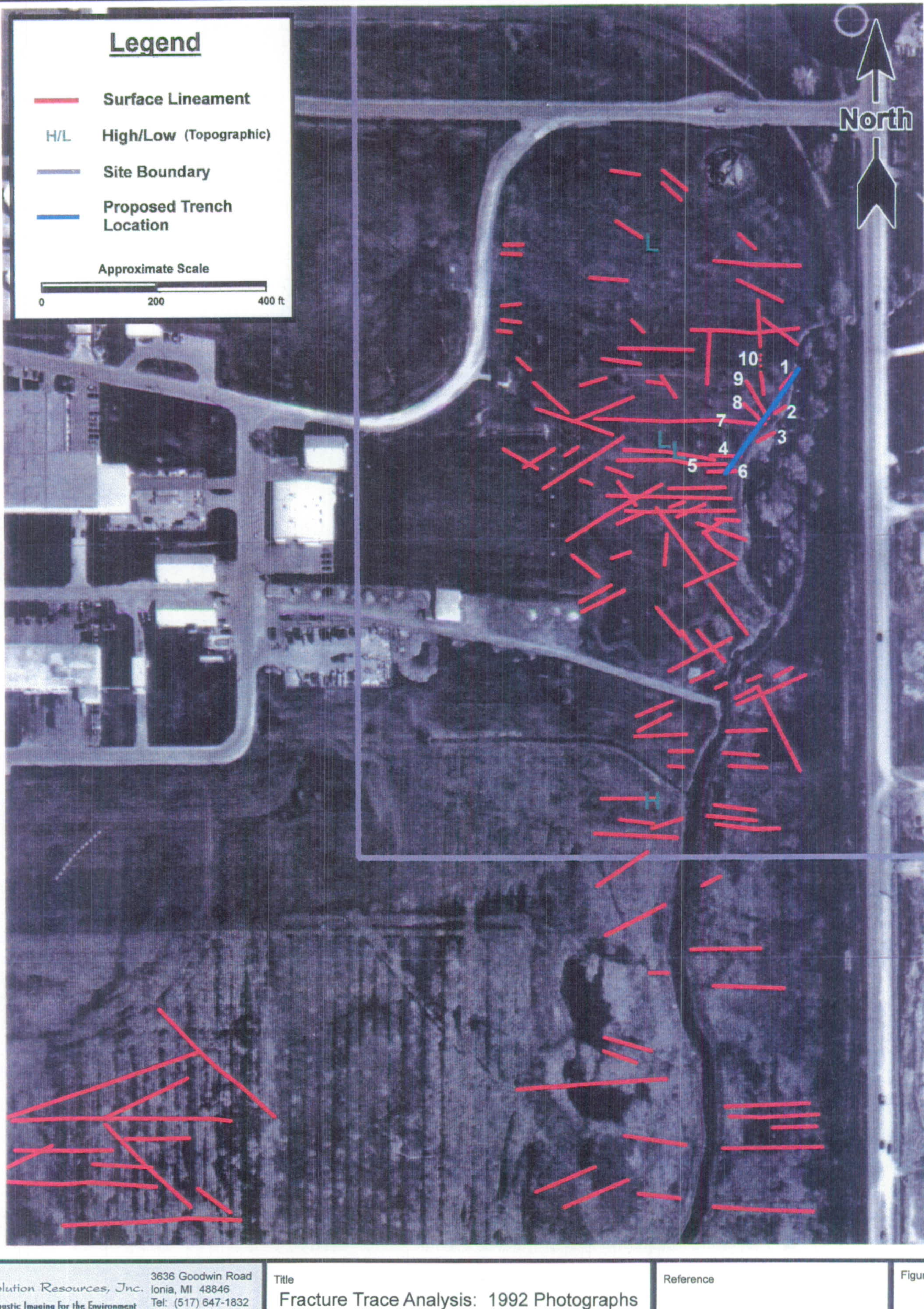
Title

Stereogram of 1995 Aerial Photographs

Reference

Figure No.

A3



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Title
Fracture Trace Analysis: 1992 Photographs

Reference

Figure No.
2