# GPR investigation on the Chemours terrain in Dordrecht

Ground Penetrating Radar investigation for utility and obstacle detection on the Chemours terrain in Dordrecht, The Netherlands

1520-182933 | 01-02-2021

Draft report

# Management

## Document information

| | |
|---|---|
| Project name | GPR investigation on the Chemours terrain in Dordrecht |
| Document name | Ground Penetrating Radar investigation for utility and obstacle detection on the Chemours terrain in Dordrecht, The Netherlands |
| Fugro project No. | 1520-182933 |
| Fugro document No. | 1520-182933.R01 |
| Version | [1.0] |
| Version status | Draft report |
| Fugro entity | Fugro NL Land B.V. |
| Fugro Office Address | Veurse Achterweg 10<br>Mailbox 63<br>2260 AB Leidschendam<br>T 070 31 11333 |

## Customer

| | |
|---|---|
| Customer | Fluor Consultants B.V. |
| Customer Address | Postbus 168, 4600 AD Bergen op Zoom |
| Customer Contact | [redacted] |
| Documentnr. Customer | [Documentnr. customer] |

## Versioning

| Version | Date | Status | Description | Prepared by | Checked by | Approved by |
|---|---|---|---|---|---|---|
| 01 | 1/2/2021 | Concept | | TD | CVI | VST |
| | | Choose an item. | | | | |

## Project team

| Initials | Name | Role |
|---|---|---|
| CVI | [redacted] | Senior Advisor Geophysics |
| TD | [redacted] | [redacted] |
| VST | [redacted] | Geophysics |

# Table of contents

# 1. Introduction

On the 27th of January 2021, Fugro has carried out a Ground Penetrating Radar survey on the terrain of Chemours Netherlands B.V. in Dordrecht on behalf of Fluor Consultants B.V.. The objective of the survey is to detect utilities and obstacles in the subsurface. The study area encompasses a total area of 300m² of mainly gravel, but also areas of pavement and asphalt pavement. Parts of the study area are not accessible for a Ground Radar survey due to the presence of utilities and other obstacles above ground level.


Figure 1: The study area, indicated with red contour line. Inset on the lower right shows the location of the study area within the terrain of Chemours in Dordrecht, the Netherlands.

## 2. Method of ground radar measurements

The ground radar measurements were carried out on the 27th of January 2021. The objective of the research was to map underground utilities. The measurements were carried out with an IDS RIS Hi-Mod 2 antennae ground radar array. This array was fitted onto on a hand-pushed cart.

In order to obtain a 3D image of the subsurface the measurements were performed in a grid of 0.5 m x 0.5 m. During acquisition 2 parallel profiles were measured, each with low- and medium frequency (250 – 600 MHz). Figure 2 shows an image of all measured GPR lines. Some parts of the study contained utilities above ground and other obstructions, which made it impossible to measure on those locations.

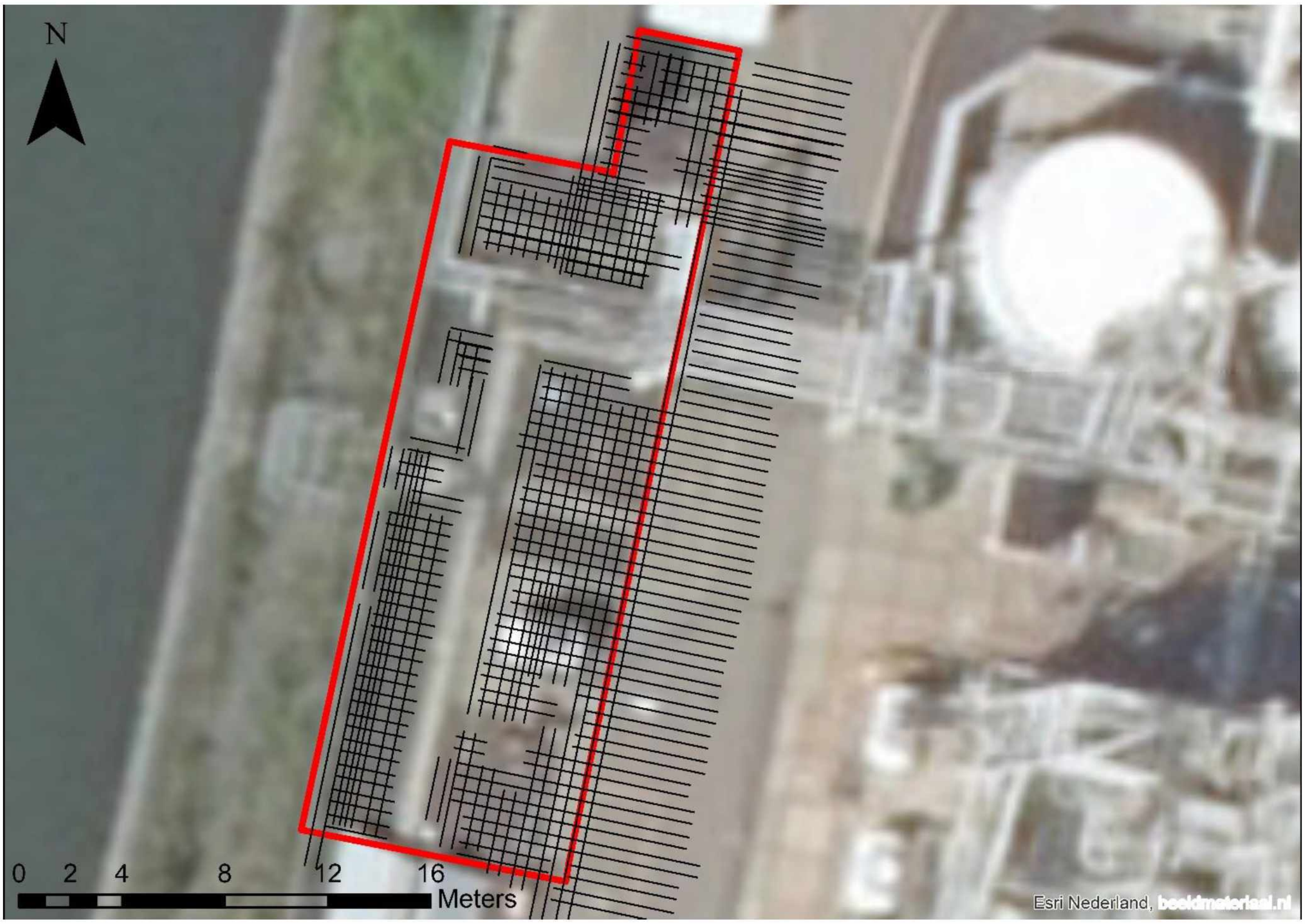



**Figure 2, The study area indicated with red contour line, and measured GPR profile lines in black.**

# 3. Results of ground radar measurements

The raw ground radar profiles have been filtered in accordance with the procedure provided by the supplier of the ground radar. The filtered data is subsequently focused with a so-called migration algorithm, which has been used to create the depth sections. During the interpretation, all ground radar profiles and depth sections were studied searching for typical images of obstructions, cables, pipelines, and other possible underground utilities. Figure 3 shows two examples of interpreted ground radar profiles in the study area. A more extensive description of the interpretation method is included in Appendix [redacted] penetration depth of the ground radar was approximately 2.0 m-mv, sometimes up to 2,5m-mv. The ground radar signals usually did not penetrate deeper, due to the electrically conductive properties of the subsurface.

All depth sections are included in Appendix B (pdf scroll). The main product of this investigation is a CAD drawing including all mapped utilities, which are included in Appendix [redacted] map is referenced in both the RD coordinate system as well as in the local plant coordinate system. The depth of the mapped utilities is indicated as well.

For reference, the location of some objects and obstructions above ground level were measured as well, such as cable trenches, pipelines, concrete plates etc. These measured objects are indicated on the CAD drawing as well. This map contains the following types of mapped utilities, which include point and line features. Most, but not all point features could be interpolated into line features. Some line features were mapped based on the depth sections in Appendix B.

Most of the mapped utilities coincide with underground utilities indicated on the underground utility map provided by the client. The following types of Utilities were mapped:

**Lines features:**
**Utility - Possible Underground city water** – Line feature which coincides with Underground city water pipeline indicated on the utility map of the client.
**Utility - Possible Fire Protection Line** – Line feature which coincides with Fire Protection Line pipeline indicated on the utility map of the client.
**Utility – Unknown –** Line feature which does not coincide with a utility indicated on the utility map of the client.

**Point features**
**Local Anomaly - Possible Utility observed in longitudinal lines (NE-SW)**
**Local Anomaly - Possible Utility observed in cross lines (NW-SE)**
There is a small area in the northern part of the study area, indicated by a hatched polygon which contains so many local anomalies that they are not individually mapped, also see Figure 3b.

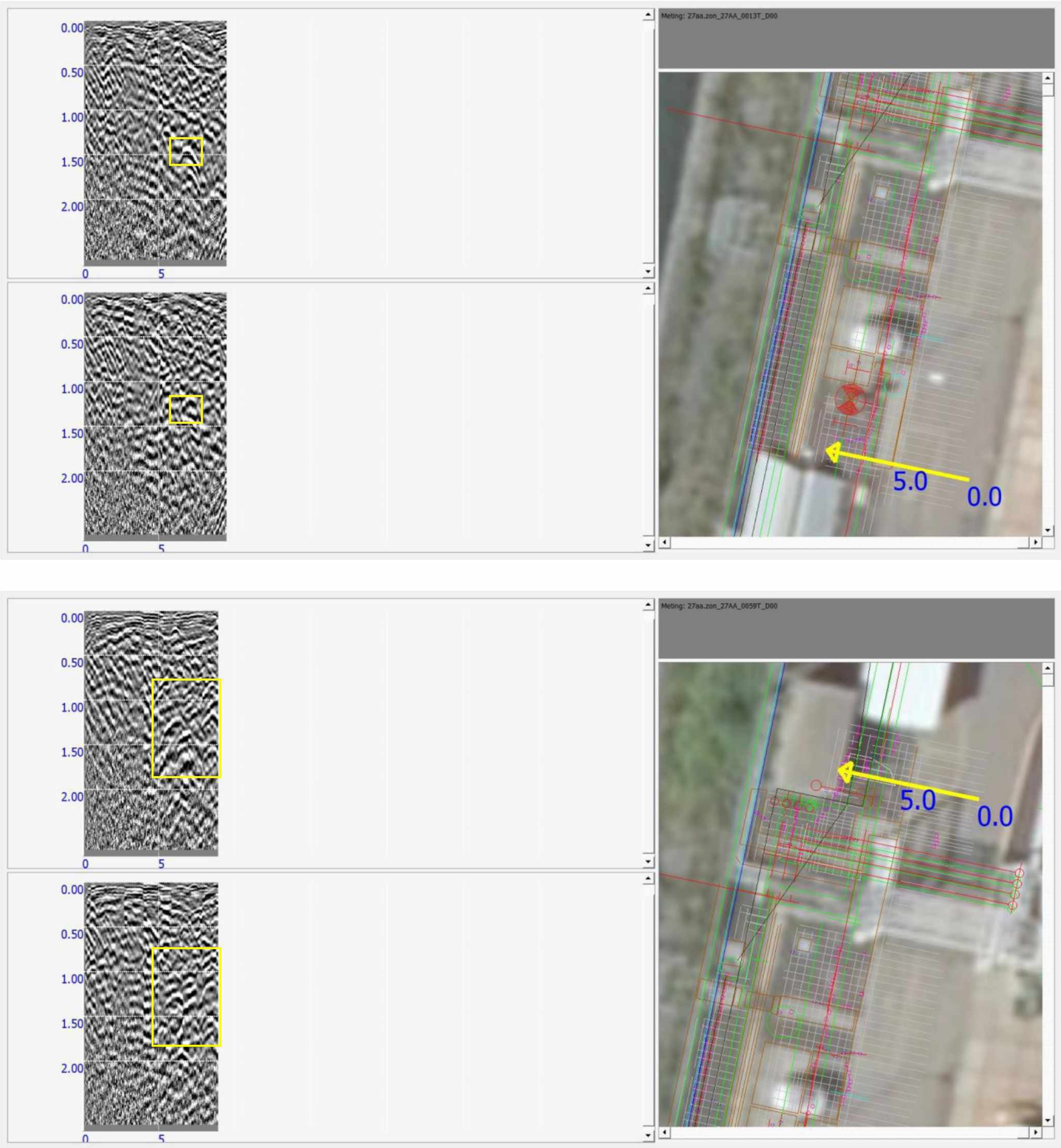



**Figure 3: Ground radar profile in the study area. 3a (Top): Anomaly interpreted as utility has been highlighted with a yellow box, in this case a possible fire protection line. 3b (Bottom): large area with many utilities has been highlighted with a large yellow box, and on the CAD map this area is indicated with a hatched polygon.**

# 4. Conclusion

With the RIS Hi-Mod 2A ground radar array, we have obtained as much data as possible in order to obtain a 3D image of the subsurface on a 300m² large area of the Chemours terrain in Dordrecht, the Netherlands.

In general, a good picture of the subsoil is obtained. A large number of utilities have been mapped, which are included in a CAD drawing in appendix [redacted] penetration depth of the ground radar was approximately 2.0 m-surface, sometimes up to 2,5 m-surface. The ground radar signals usually did not penetrate deeper, due to the electrically conductive properties of the subsurface.

# Appendices

# Appendix A: Ground penetrating radar method statement

## A.1 GENERAL CONSIDERATIONS

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (50 MHz to 900 MHz in this case) of the radio spectrum, and detects the signals reflected from subsurface structures and/or contrasts. GPR can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures. It can detect objects, changes in material, and voids and cracks.

GPR uses high-frequency waves transmitting them into the ground. When the wave hits a buried object or a boundary with different dielectric constants, the receiving antenna records variations in the reflected return signal. The principle involved is similar to reflection seismic, except that electromagnetic energy is used instead of acoustic energy, and reflections appear at boundaries with different dielectric constants instead of acoustic impedances.

The depth range of GPR is limited by the electrical conductivity of the ground, the transmitted center frequency and the dynamic range of the instrument, which is defined as the ratio of the maximal to the minimal measurable signal level. As conductivity increases, the penetration depth decreases. This is because with the increase of conductivity the electromagnetic energy is more quickly dissipated into heat, causing a loss in signal strength at depth. Good penetration is typically achieved in dry sandy soils or massive dry materials such as granite, limestone, and concrete. In moist and/or clay-laden soils and soils with high electrical conductivity, penetration is sometimes limited to only a few centimeters.

Higher frequencies do not penetrate as far as lower frequencies, but give better resolution.

## A.2 2D IMAGES OF COMPACT OBJECTS

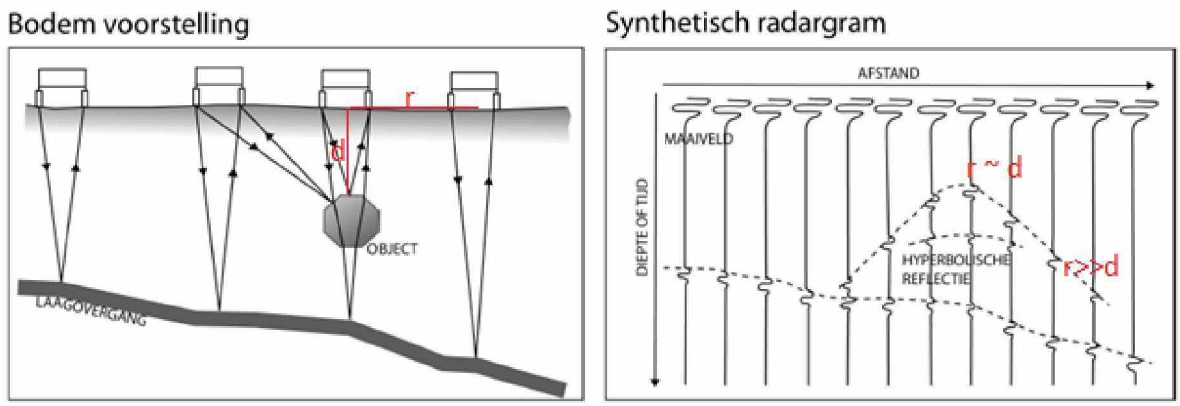



**Figure 2 Schematic depiction of GPR measurements; left: underground model, right: a synthetic radar profile.**

In a generic GPR profile every compact object being crossed leaves a hyperbolic trace (Figure 2). This is due to the change in arrival time of the main part of the reflected wave. This time $t$ depends on the velocity $v$ of the electromagnetic waves in the medium and the distance between the radar and the object. The latter can be split in horizontal, *r*, and vertical *d*, parts:

$$t = \frac{2}{v}\sqrt{r^2 + d^2}$$

This time is minimal when the radar is positioned directly above the object ($r = 0,\ t = 2d/v$ ) and grows with the distance between the this point and the radar ($r > 0$):

$$t = \frac{2r}{v}\sqrt{1 + \frac{d^2}{r^2}}$$

When $d \sim r$ the increase in time with distance depends on both parameters, hence the curved part of the image near the top of the hyperbole. Once $r \gg\ d$, this increase becomes nearly linear:

$$t \cong \frac{2r}{v}$$

which explains the linear parts of the hyperbolic image of a point target. The slope of these straight lines is fully defined by the effective velocity of the radar signal in the ground and is often used to estimate this velocity.

### A.3 2D IMAGES OF OBJECTS WITH SIGNIFICANT DIMENSIONS

Distance between the radar and a homogenous object with significant horizontal dimensions does not change while the radar is situated above it. Because of this, a larger object appears in a radar image not as a hyperbola, but as horizontally extended anomaly possibly with hyperbolic traces on both sides.

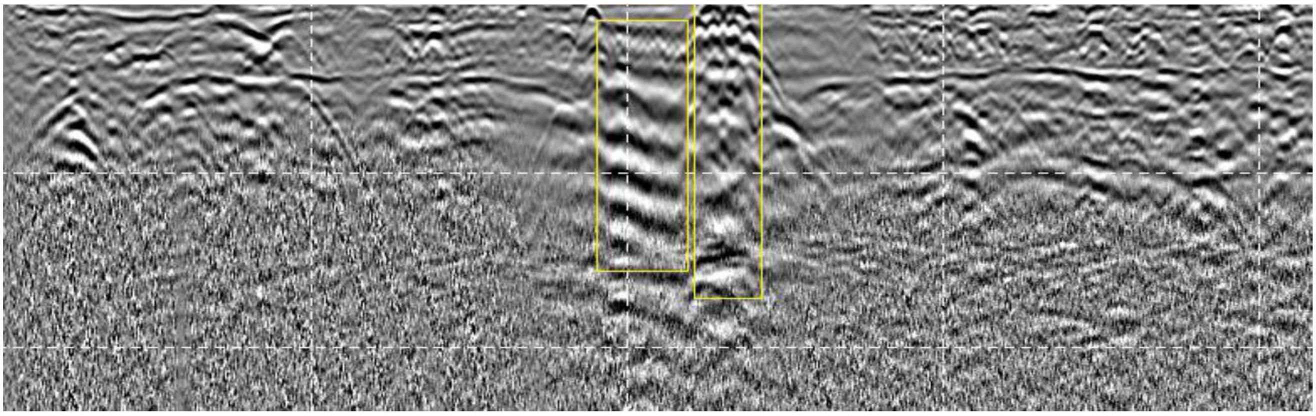


Figure 3 A concrete wall seen immediately underneath a surface.

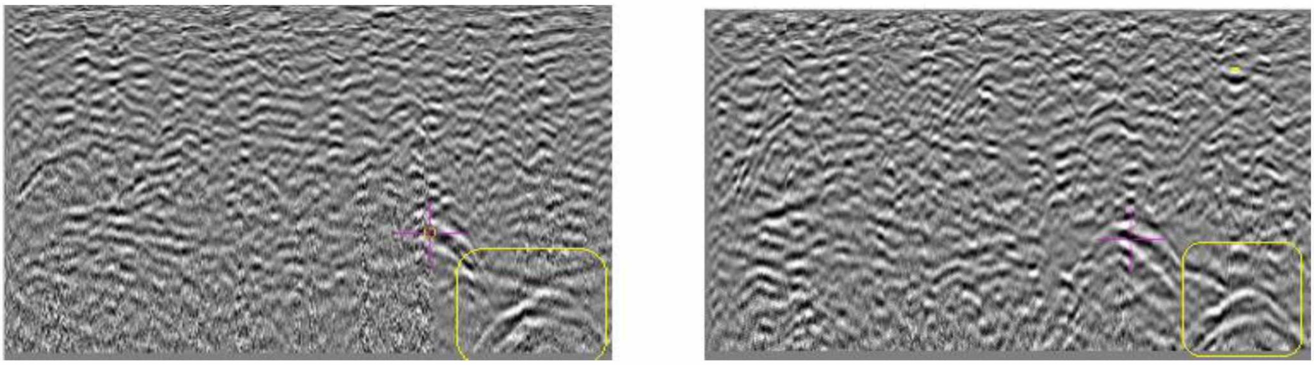


Figure 4 A large pipe visible at the depth of 2.2 m – ground level in sandy ground

Vertical extent of a large object can manifest itself as a repeating pattern of a high- and low-magnitude events. An example of a radar image of a large object (a concrete wall) is given in Figure 3. Large diameter pipes are visible as large hyperbolic traces with flattened tops (Figure 4). The relative structural simplicity of the inside of a pipe determines the simplified texture of its image in the vertical extent.

## A.4 UTILITIES

Utilities (cables and pipes) represent an economically important type of targets. Mapping of utilities using ground penetrating radar system is a well-established process with widely accept best practices and known limitations. Assuming the ground is amenable for GPR investigations, the key remaining challenge is distinguishing of hyperbolic responses of utilities from those of compact objects. To mitigate it several profiles measured parallel to each other are typically measured. Utilities, as opposed to compact objects, should appear in all parallel profiles, which allows to discriminate between compact objects and utilities.

The radar used by Fugro (RIS HiMod 2A) allows for speedy measurements of 2 parallel radar profiles. One dimensional infrastructure elements, like utilities, leave hyperbolic traces either at the same horizontal coordinate, or forming a diagonal line. This allows for robust discrimination of such objects from local inhomogeneities (rocks etc.)

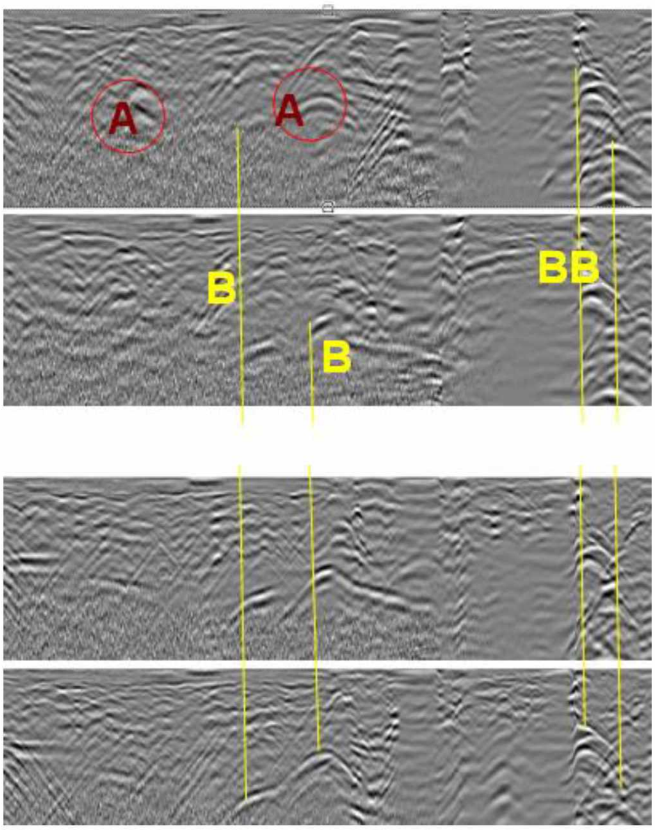



**Figure 5 Four parallel GPR profiles: A local objects, visible in one profile only; B – linear infrastructure, forming structural hyperbolic traces in four profiles.**

## A.5 VOIDS

In the vertical radargrams (profiles) voids appear as compact objects of a specific type. Sudden change in the velocity $v$ of the electromagnetic signal within the voids causes the corresponding change in the image texture. Air filled voids ($v = 0.3\frac{m}{ns}$) cause the apparent ground layers to become thinner than in the surrounding ground ($v = 0.1\frac{m}{ns}$), while in the water filled voids ($v = 0.033\frac{m}{ns}$) the layering appears strongly stretched.

Appearance of a repetitive wave pattern caused by the resonance is typical for voids. Manmade voids with vertical sidewalls also leave characteristic semi-hyperbolic traces in the data (Figure 6).

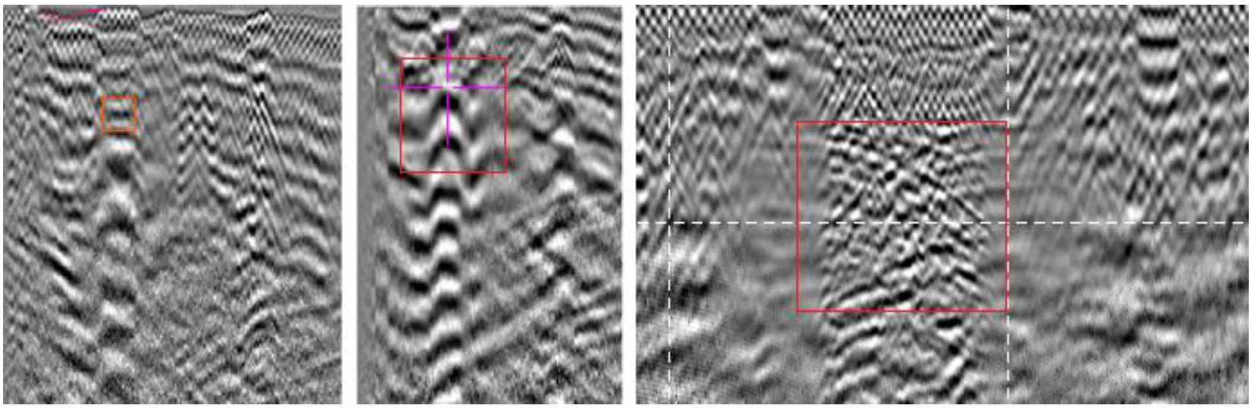


Figure 6 Typical radar image of a possible air-filled void under concrete (orange square in the image on the left). Left: 600MHz profile, center: 250MHz profile, same void; right: a man-made void (cellar) under a double concrete covering

## A.6 REINFORCED CONCRETE

Reinforcement mesh in concrete is easily recognizable as a row of small hyperbolas. Apparent bulging of the line of these reinforcement rods can be caused by surface water. In the absence of water or other external material that is significantly changing the velocity of the radar wave such bulging is most often caused by a significant subsidence of the surface, that had been equalized on the surface later on. This scenario in turn raises an alarm of the possibility of a void (Figure 7).

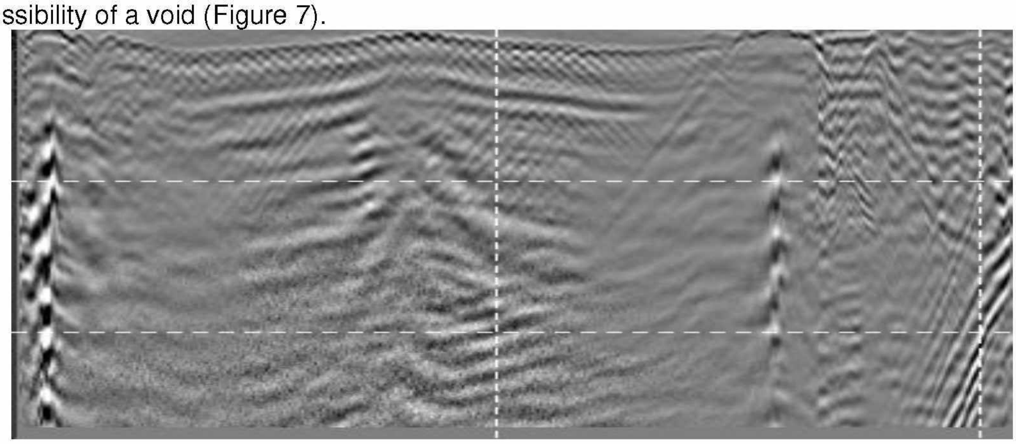


Figure 7 Apparently subsided reinforcement of a concrete plate

## A.7 DEPTH SLICES

Object other than layers in the ground tend to retain their physical shapes in the horizontal (depth) slices of the 3D data volumes, also known as DDS. Linear objects (pipes, cables), foundations, concrete plates and larger voids are easily recognizable in DDS.

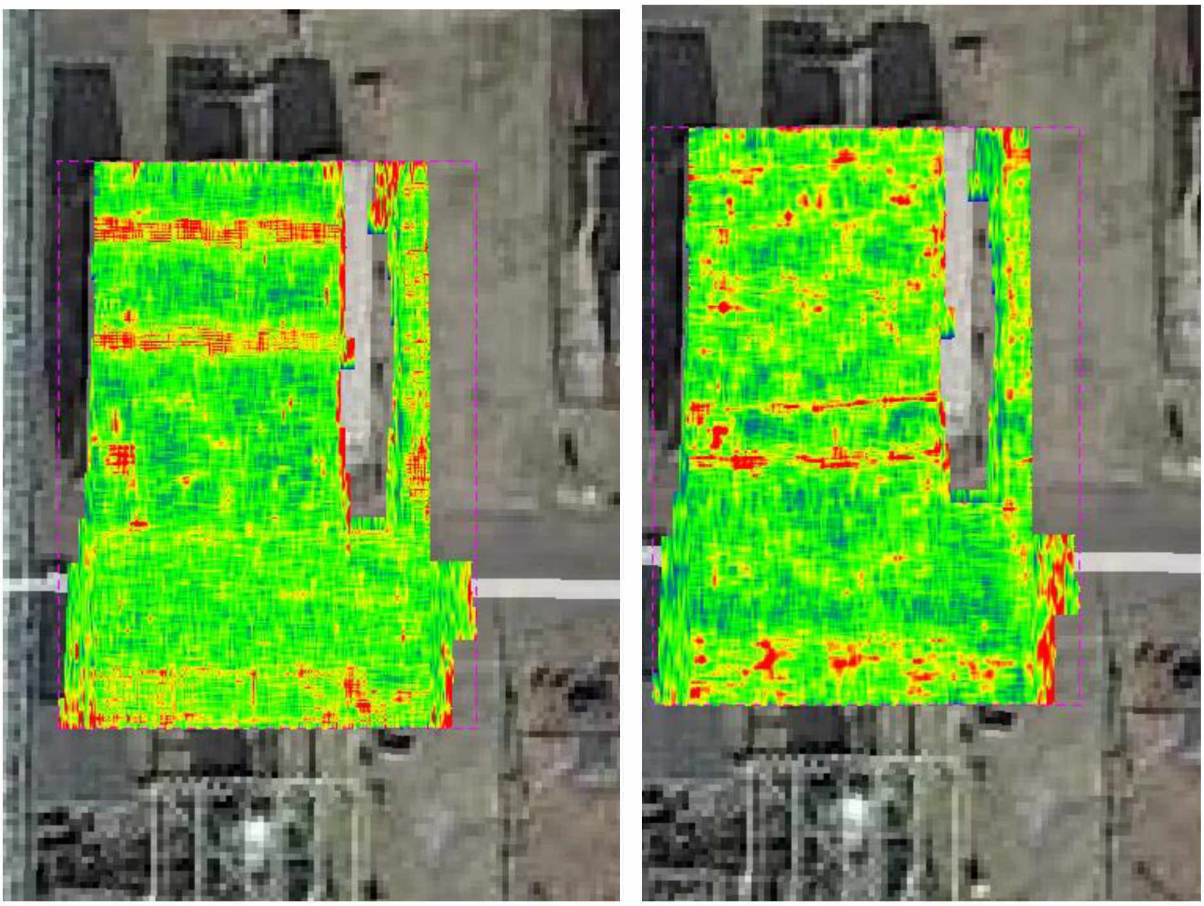
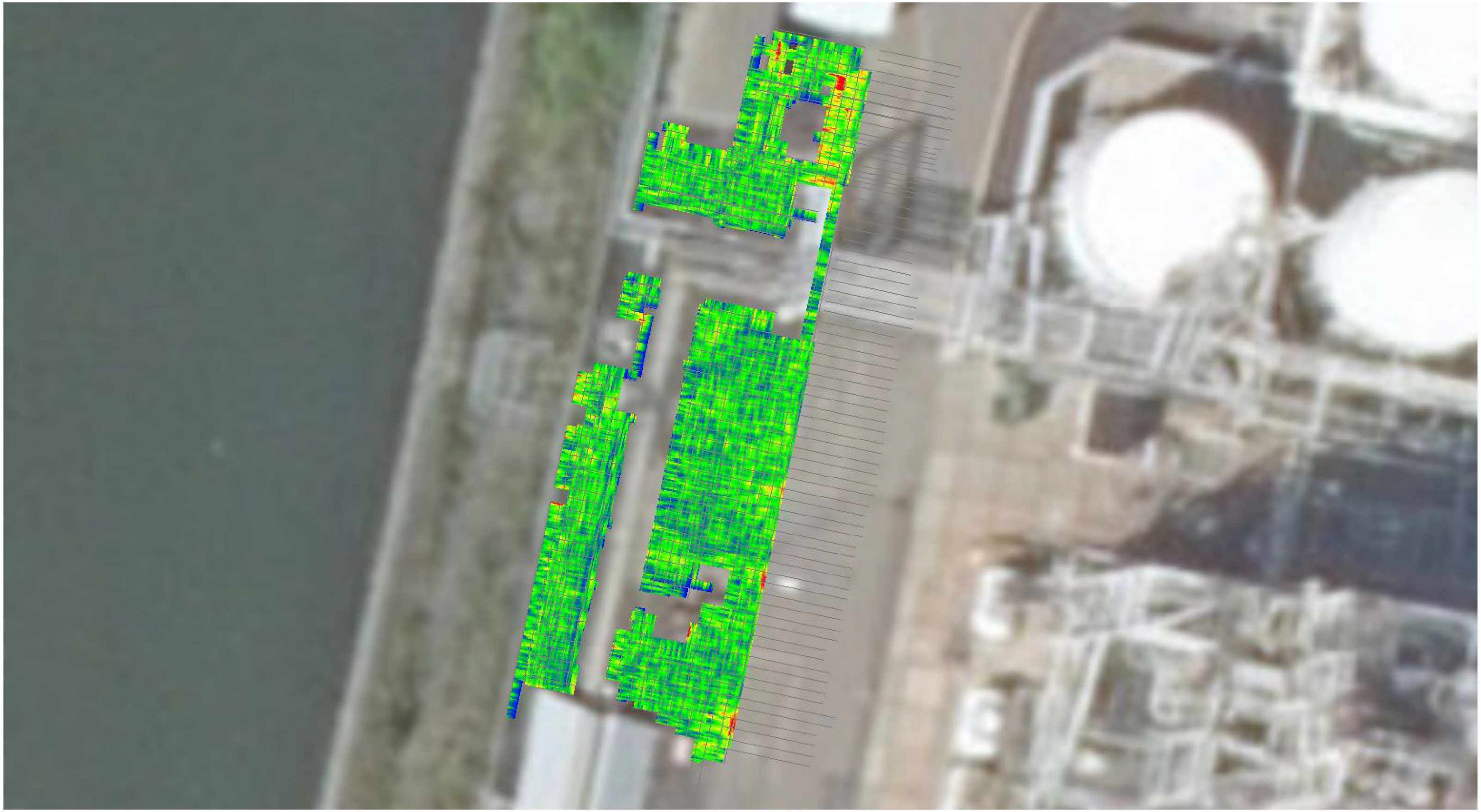


Figure 8 Depth slices of the data acquired in a project on industrial site. Left: slice at 20cm-surface showing reinforcement rods of concrete plates and concrete collector well. Right: slice at 100cm-surface showing two utilities connecting to the collector

# Appendix B: pdf scroll

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

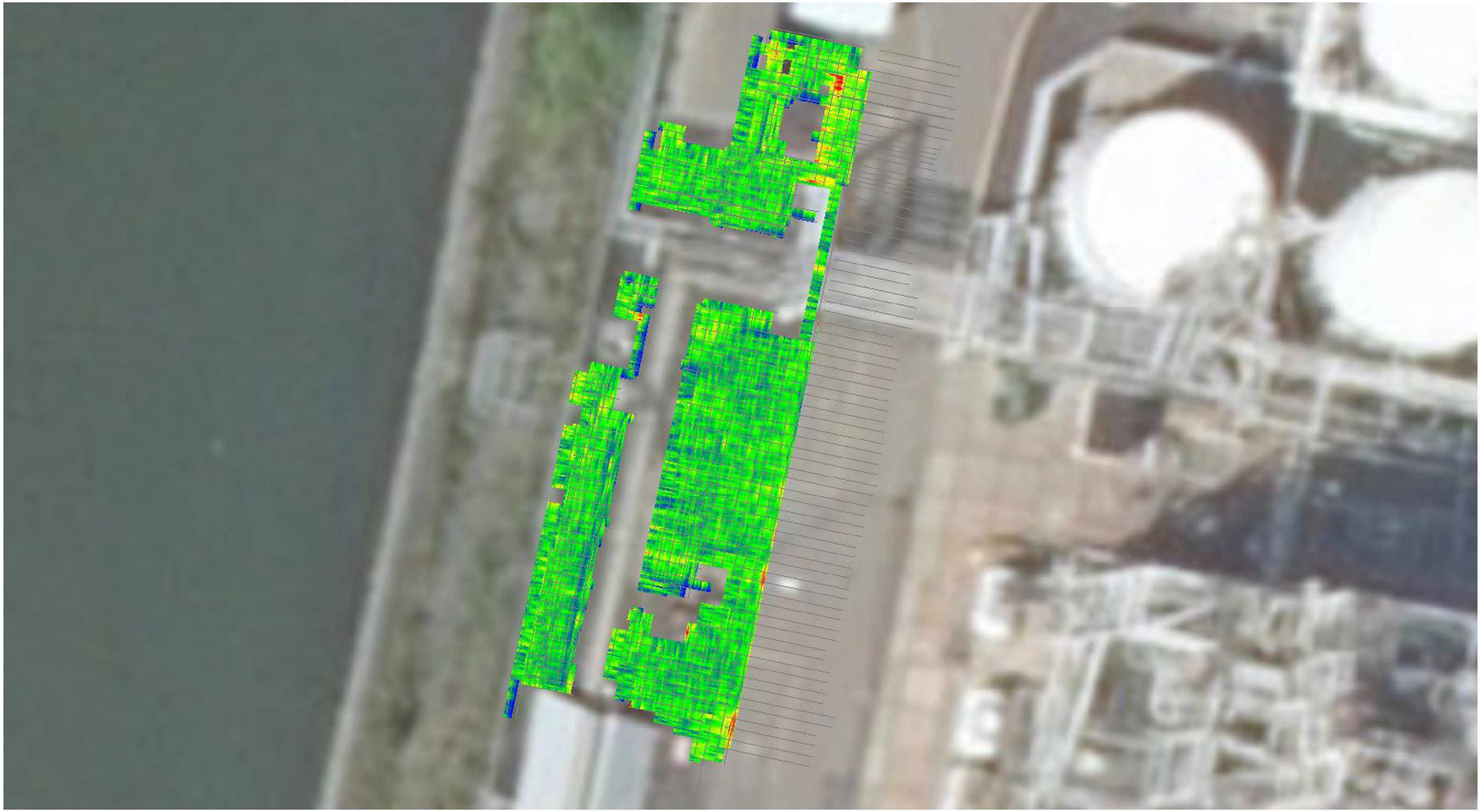
Depth Section @ 0.00m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

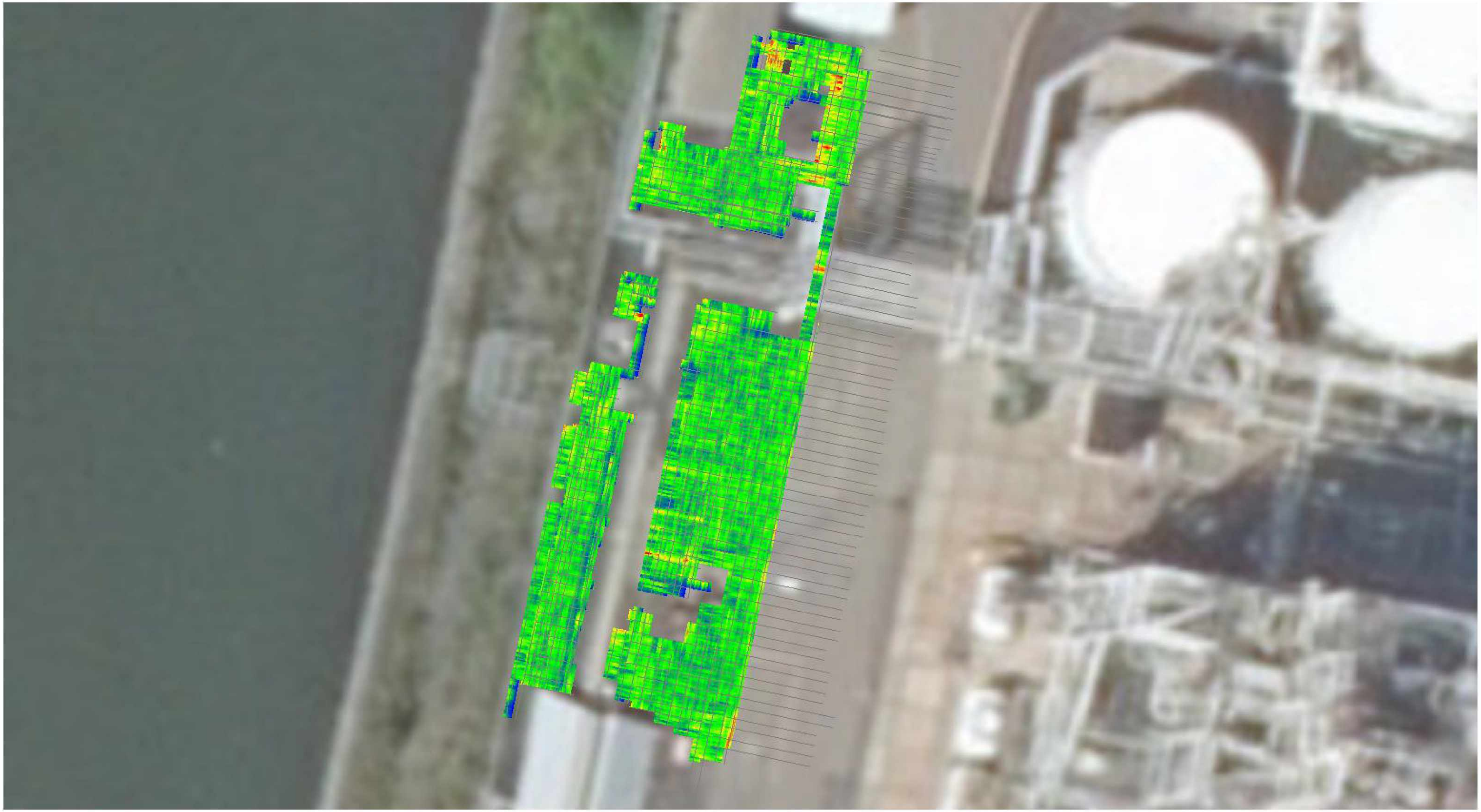
Depth Section @ 0.05m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

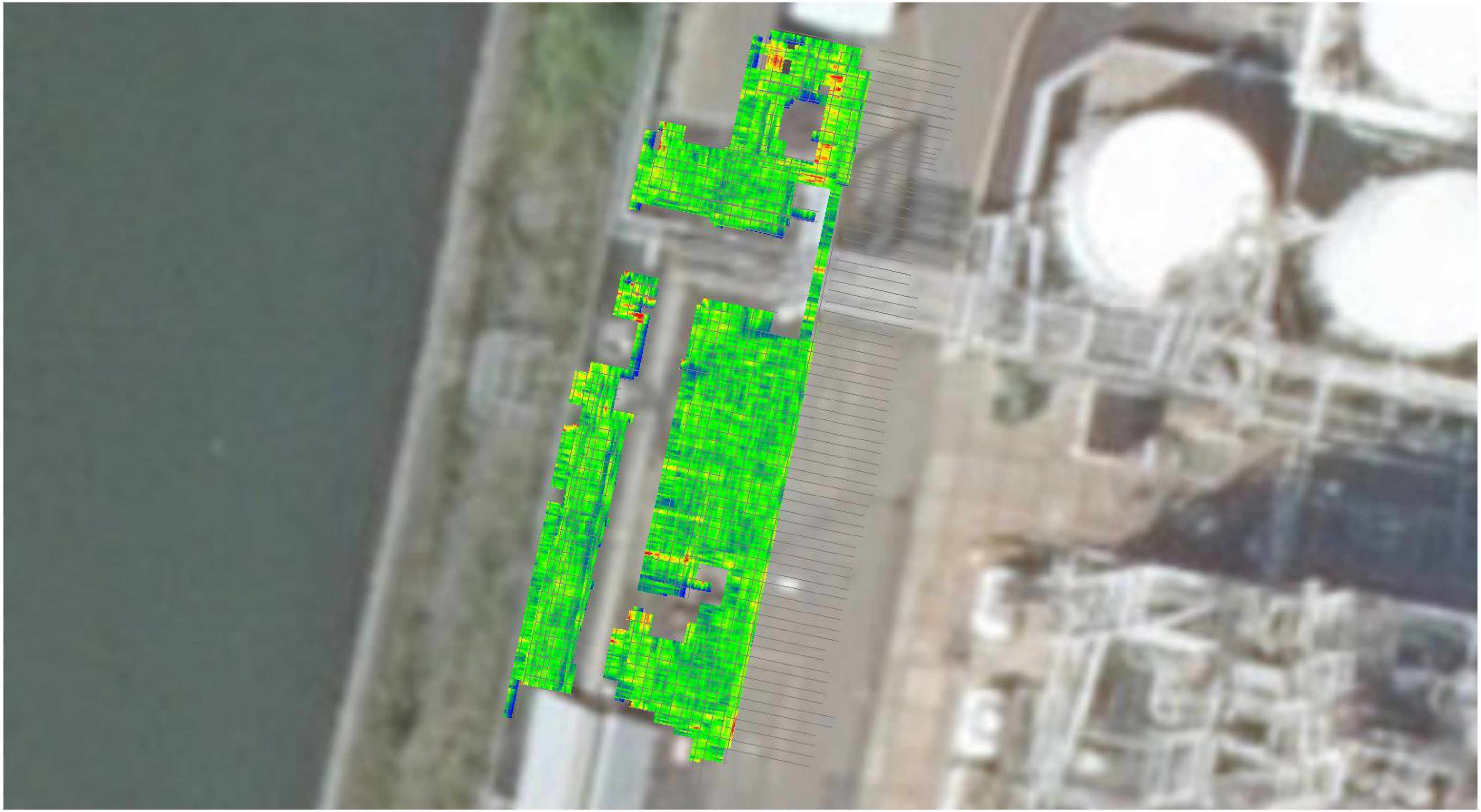
Depth Section @ 0.10m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

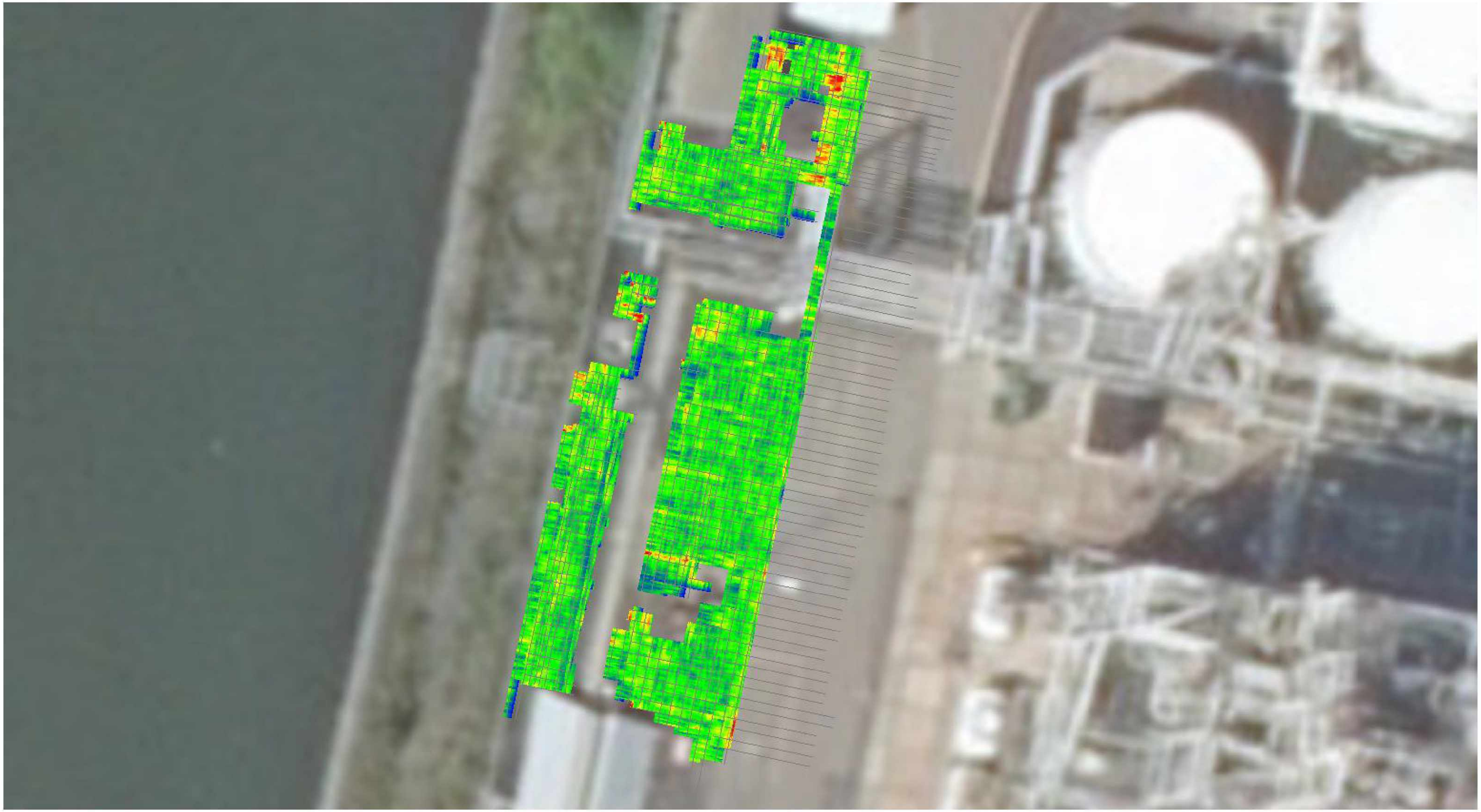
Depth Section @  0.15m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

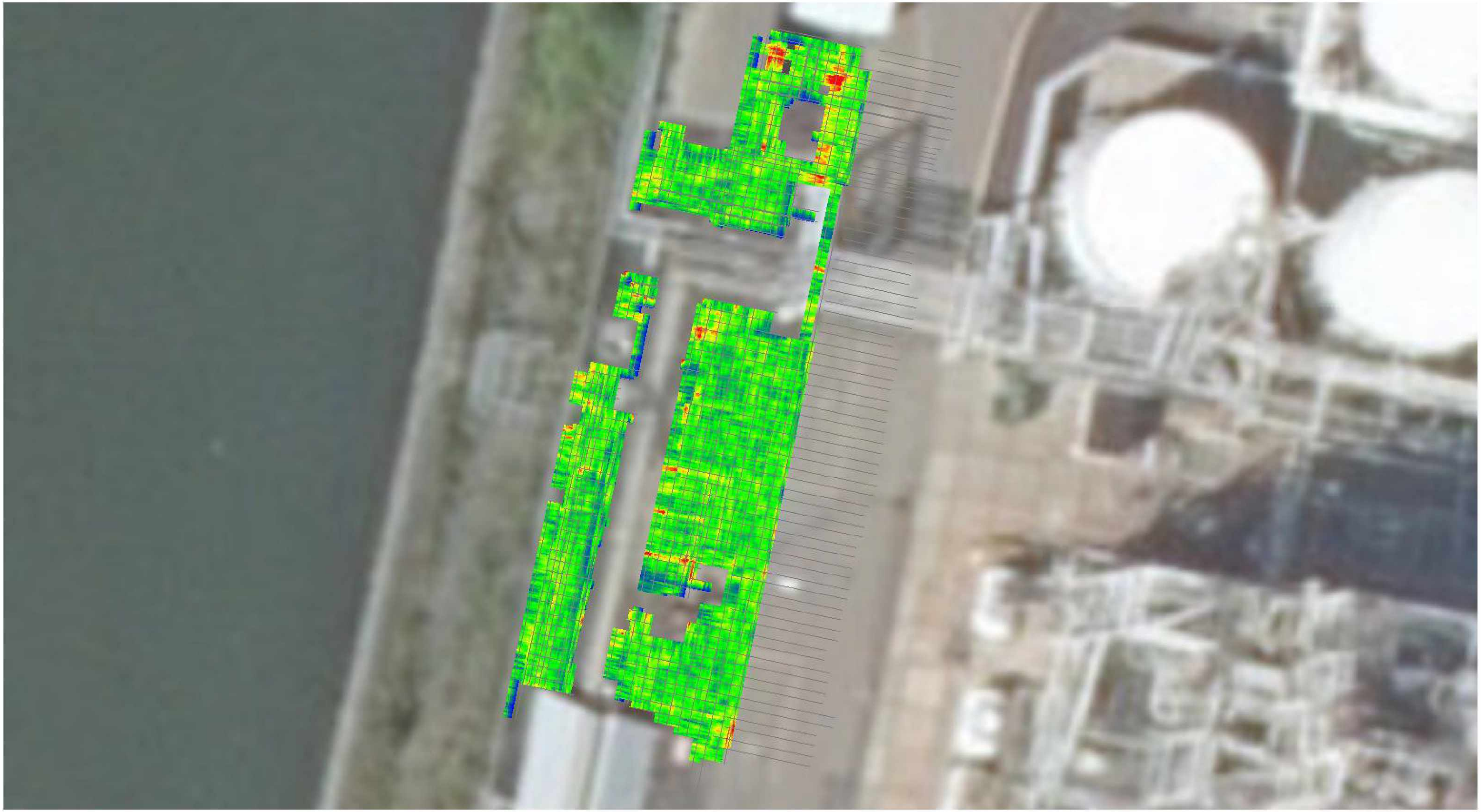
Depth Section @ 0.20m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

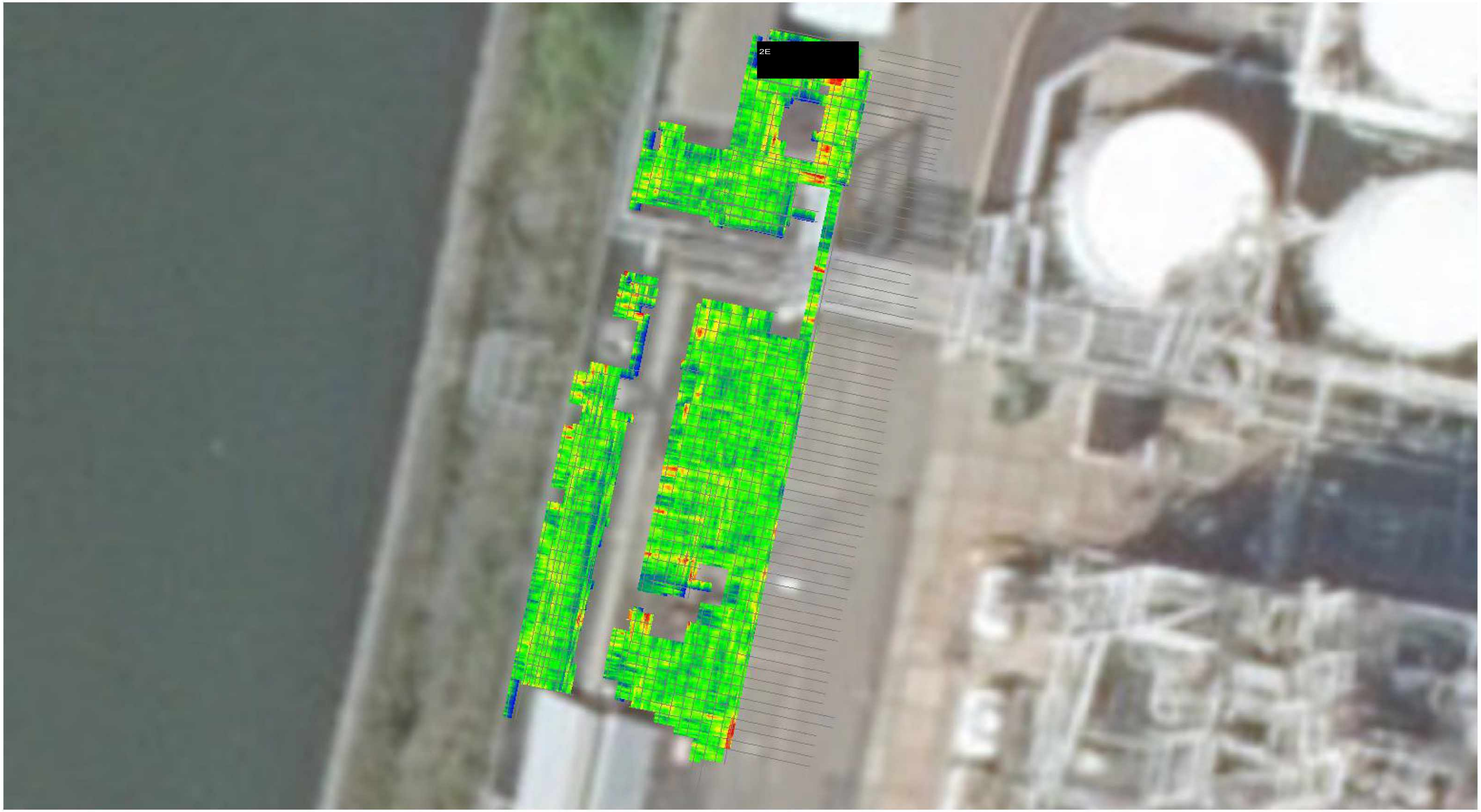
Depth Section @  0.25m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

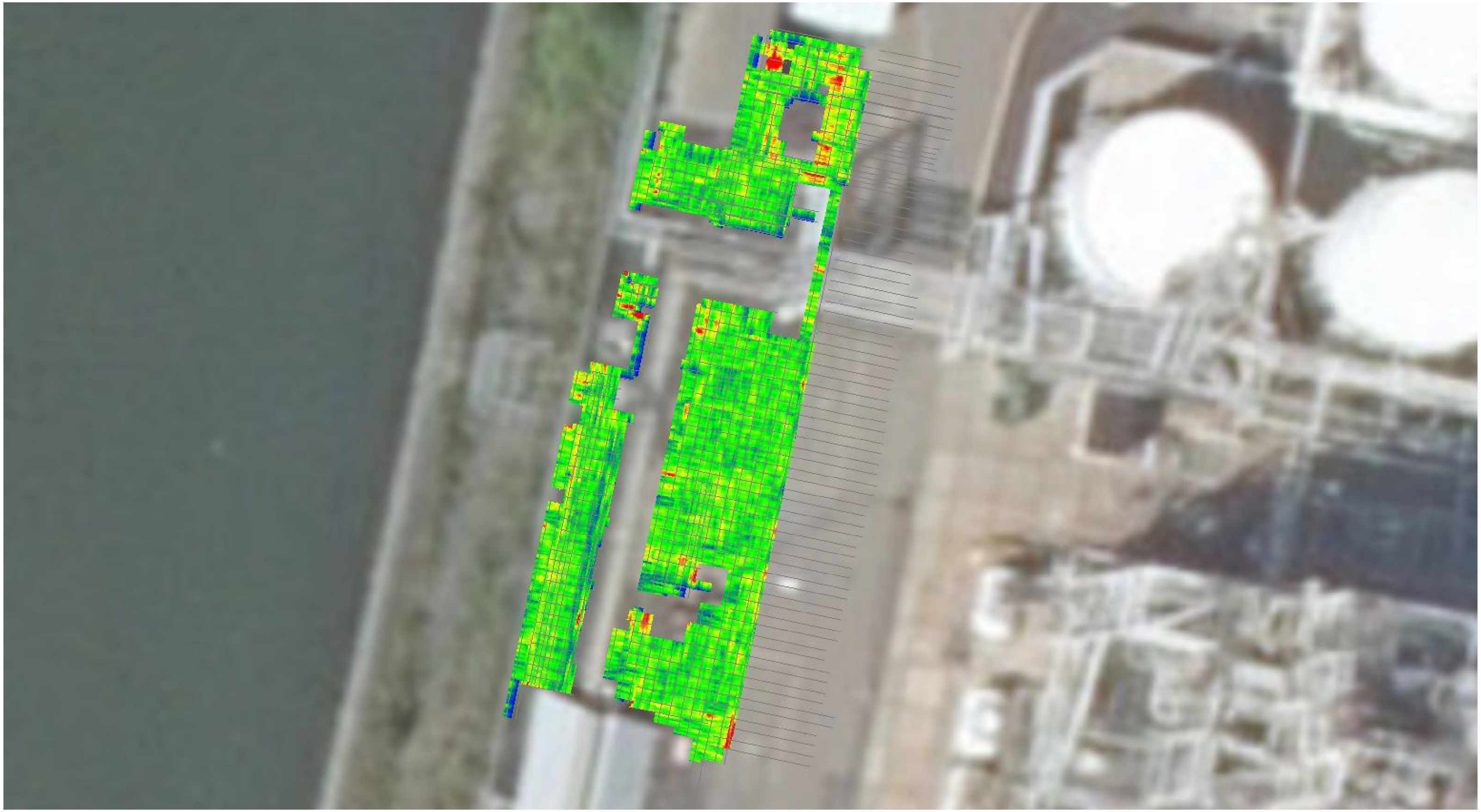
Depth Section @ 0.30m-Surface




Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

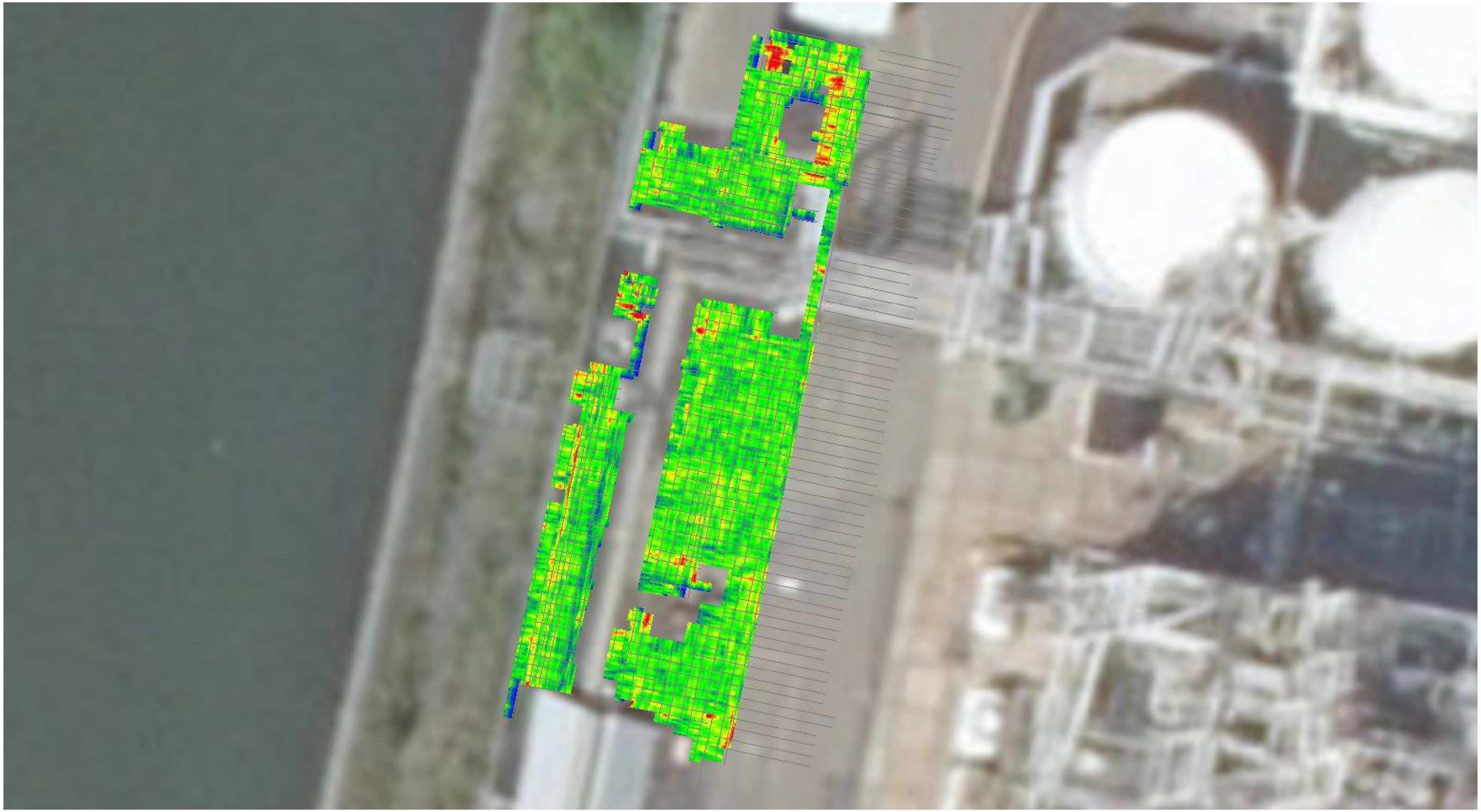
Depth Section @  0.35m-Surface



Red areas indicate areas with higher dielectric contrast

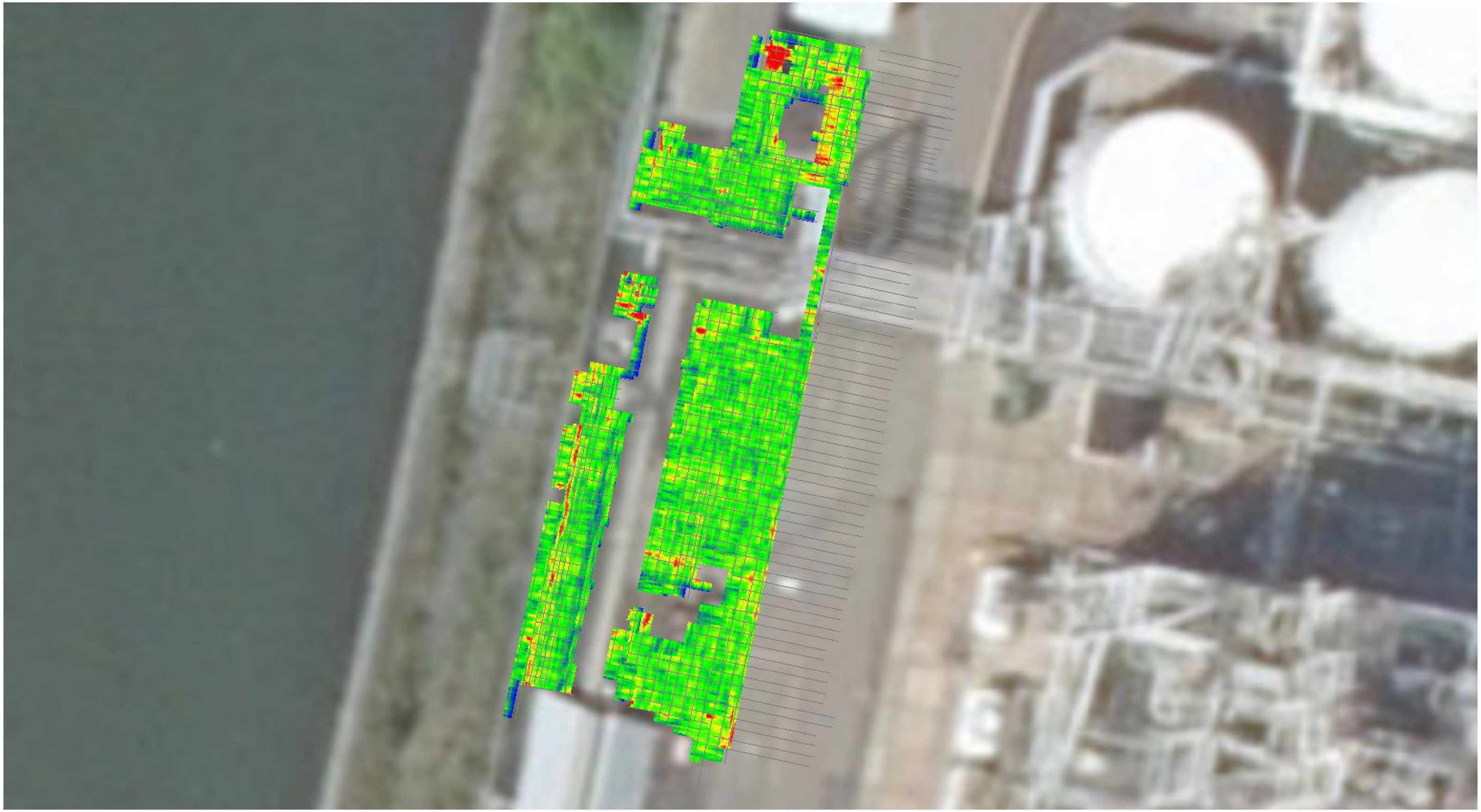
Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

Depth Section @  0.40m-Surface



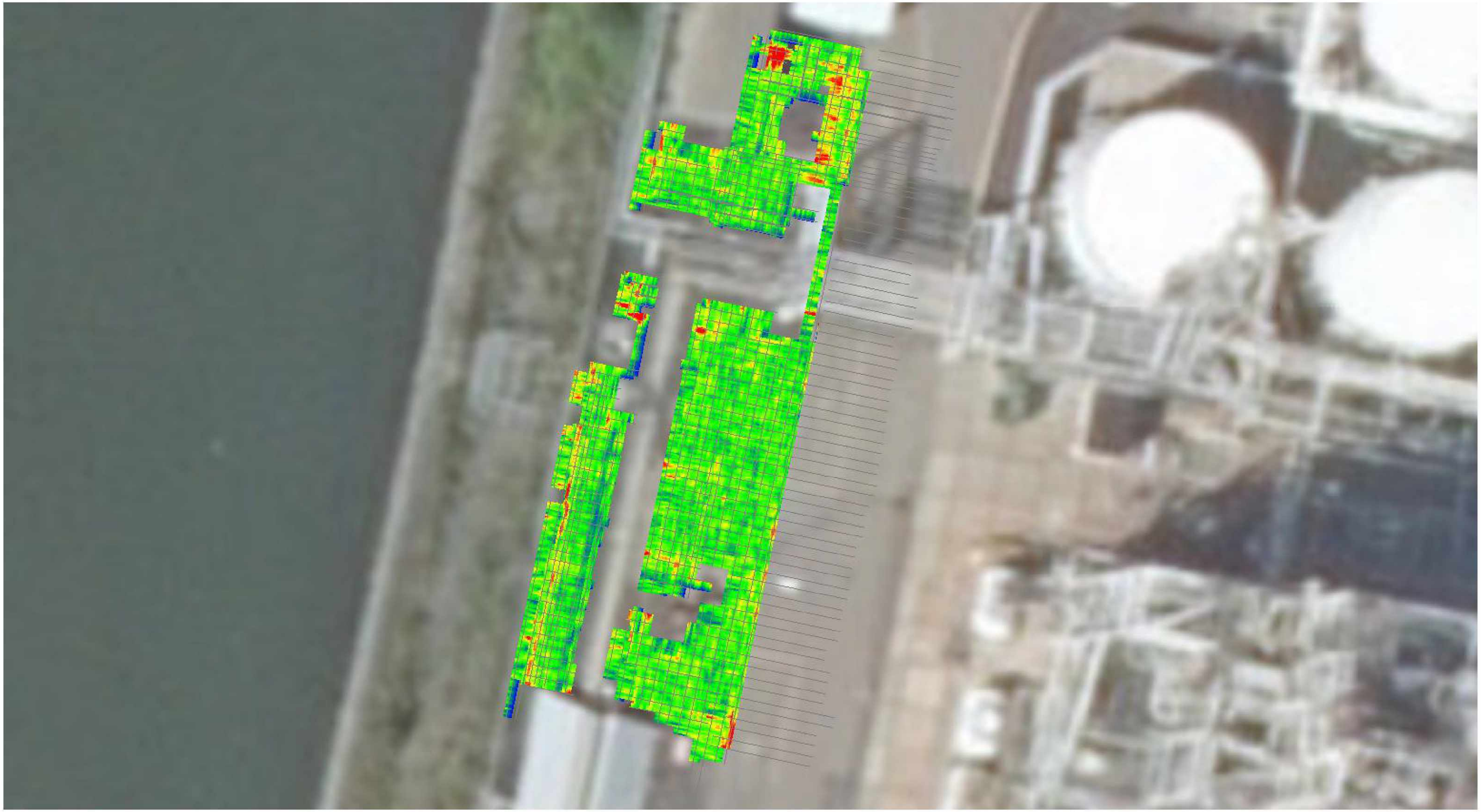
Red areas indicate areas with higher dielectric contrast

Depth Section @ 0.45m-Surface



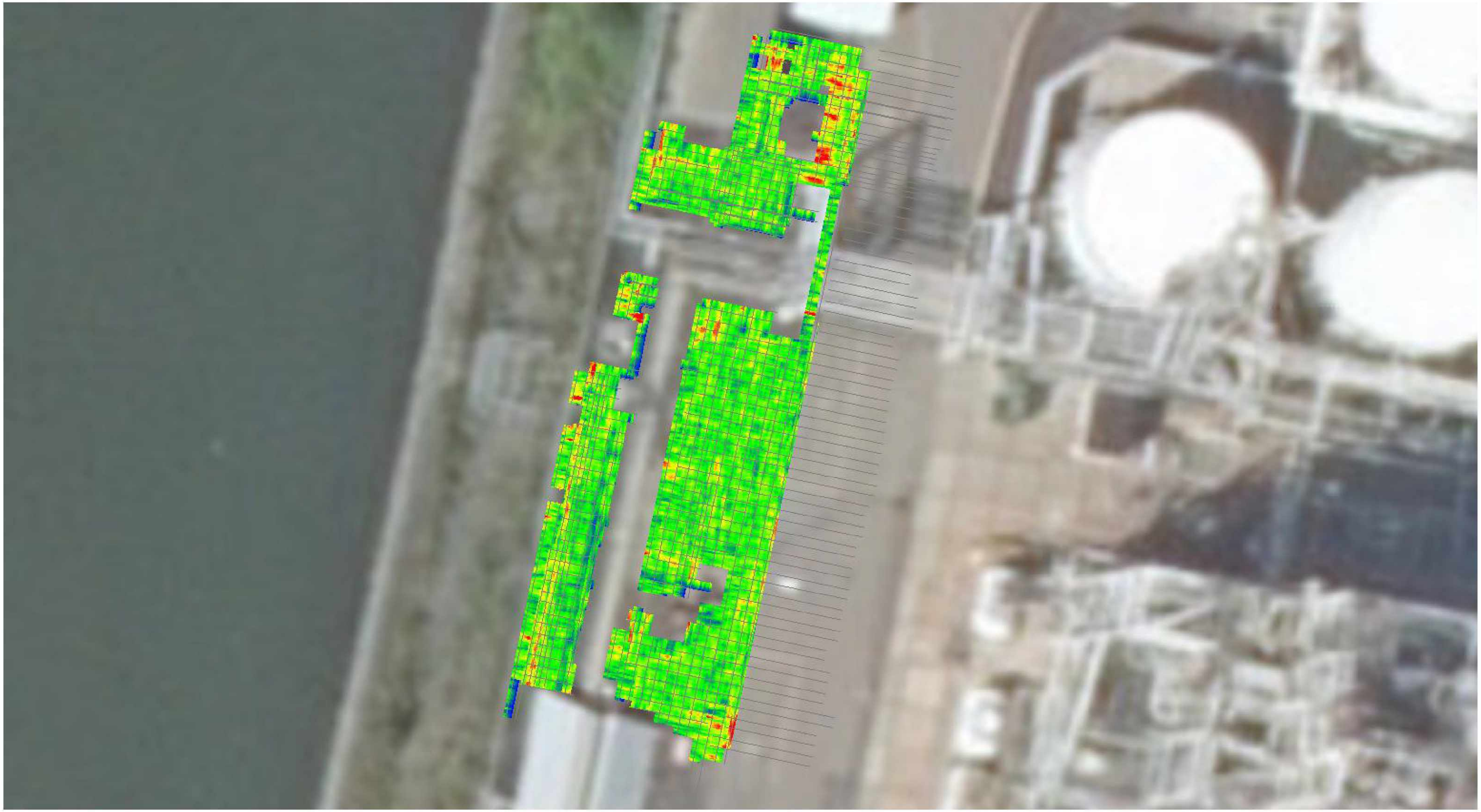
Red areas indicate areas with higher dielectric contrast

Depth Section @ 0.50m-Surface



Red areas indicate areas with higher dielectric contrast

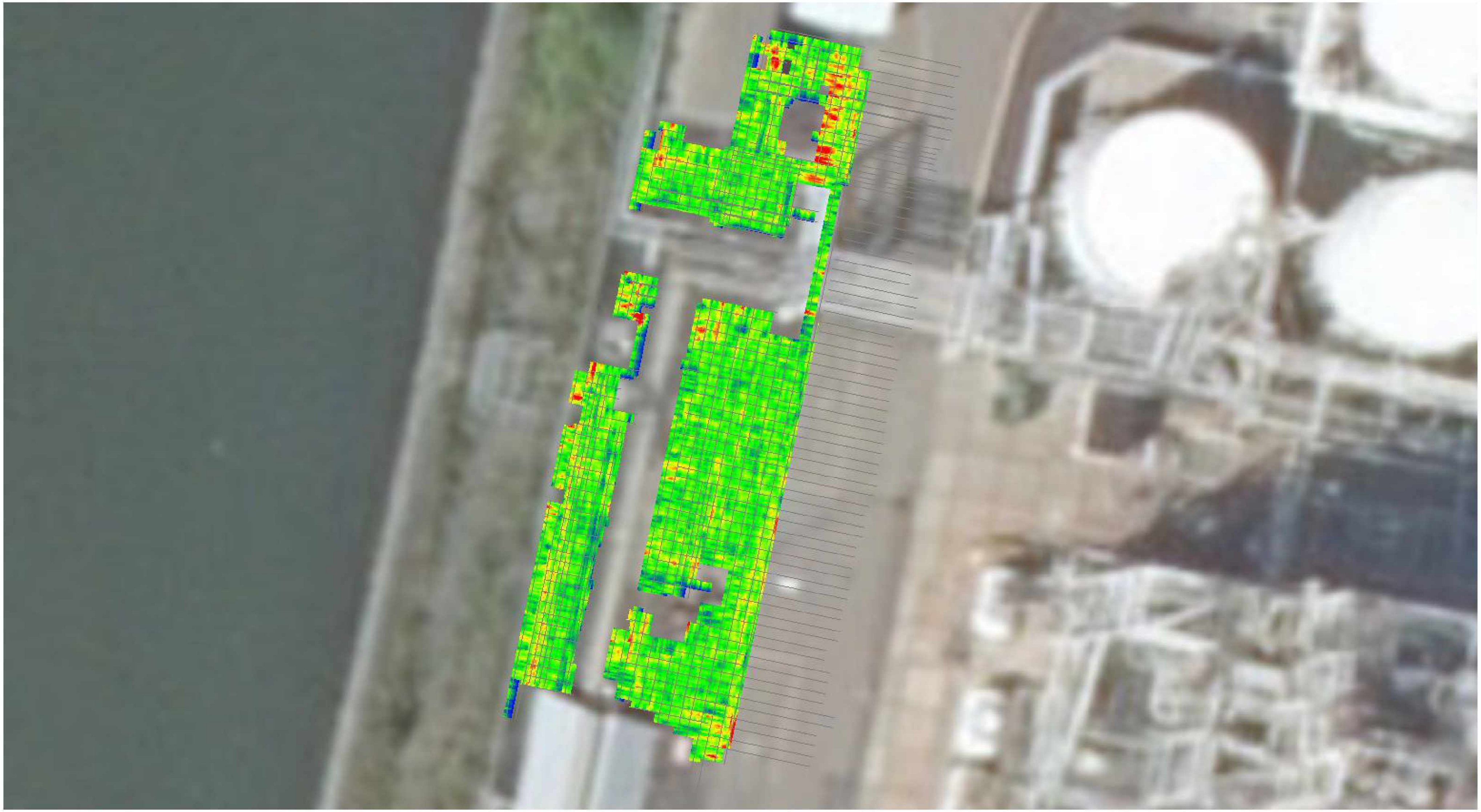
Depth Section @ 0.55m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

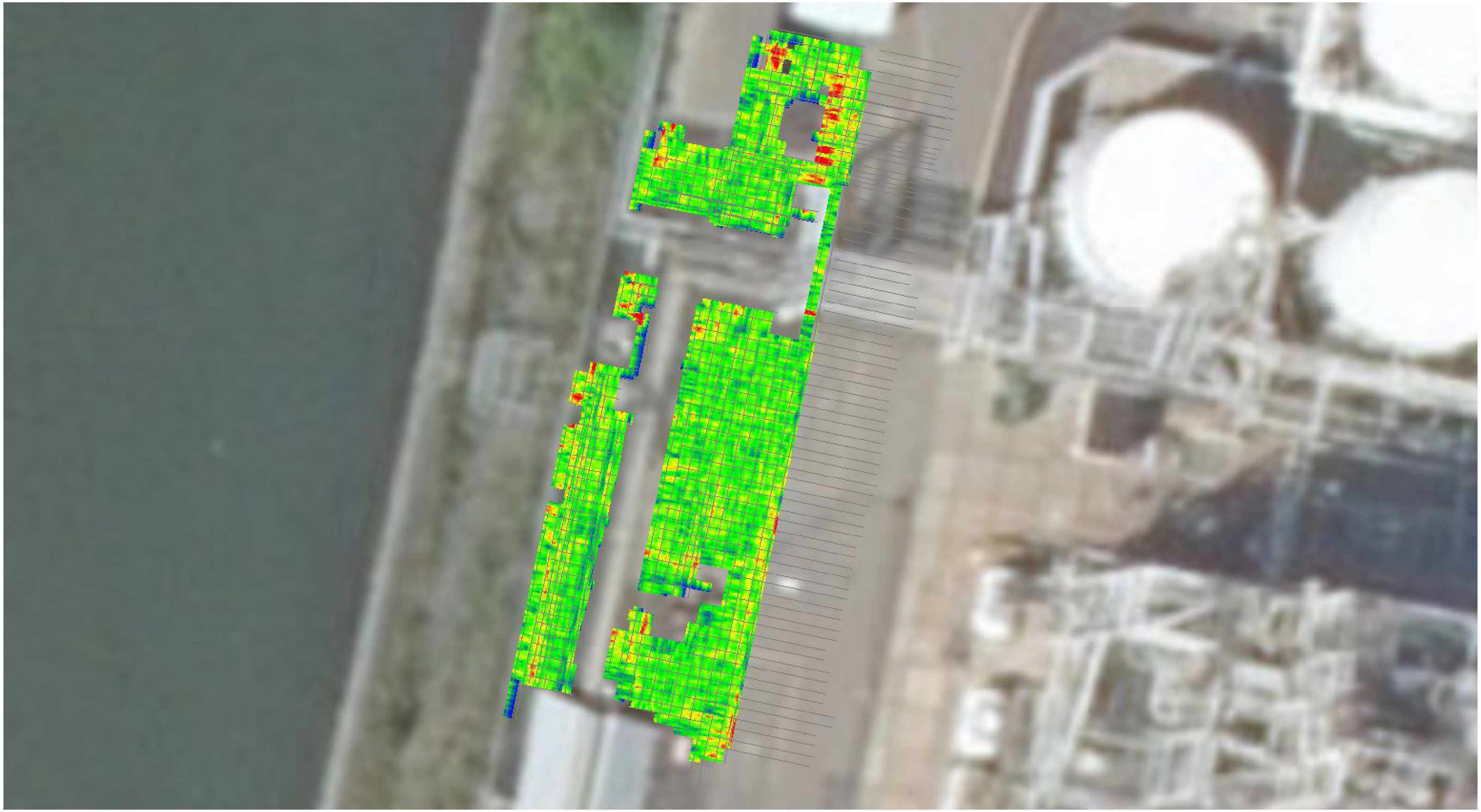
Depth Section @  0.60m-Surface



Red areas indicate areas with higher dielectric contrast

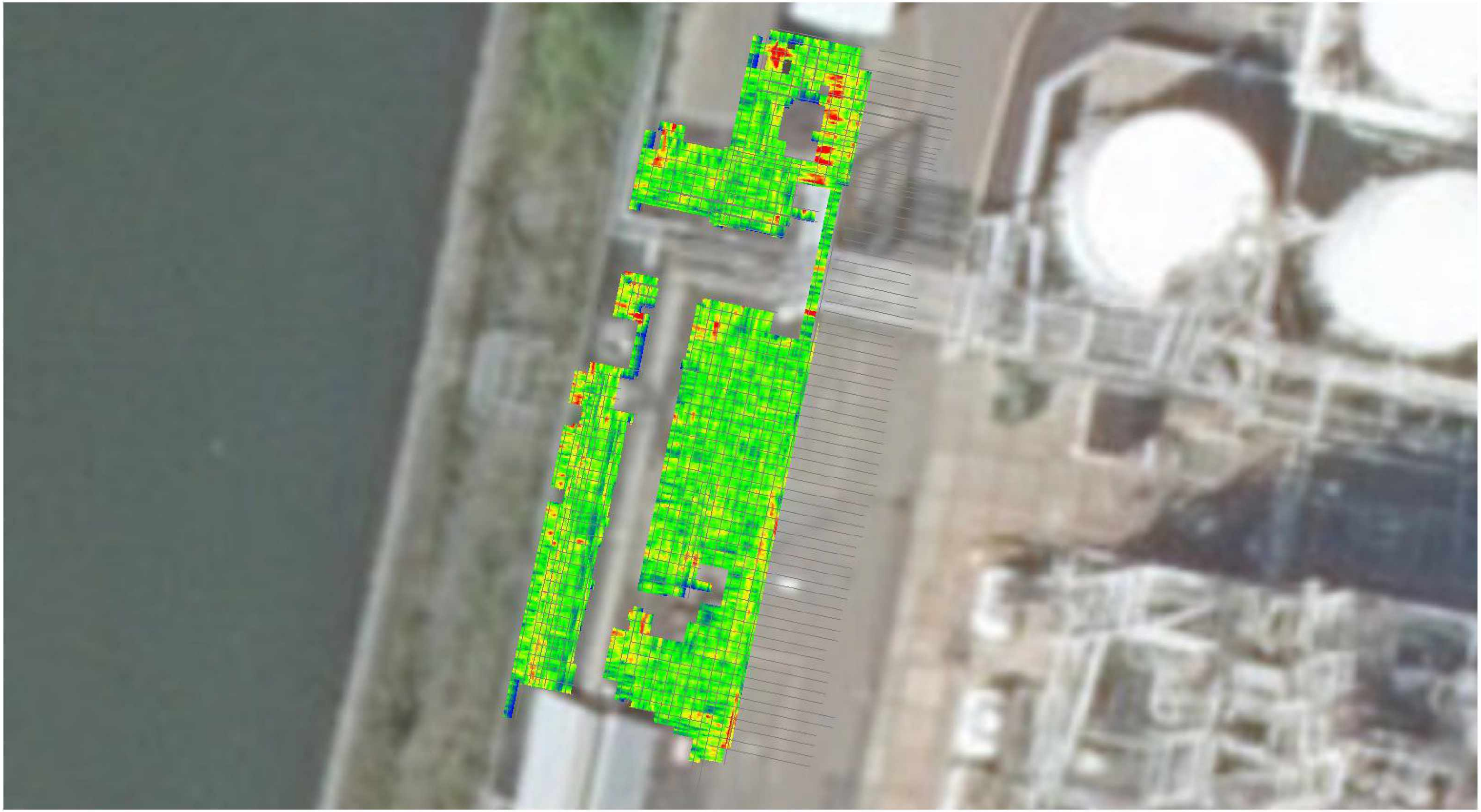
Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

Depth Section @ 0.65m-Surface



Red areas indicate areas with higher dielectric contrast

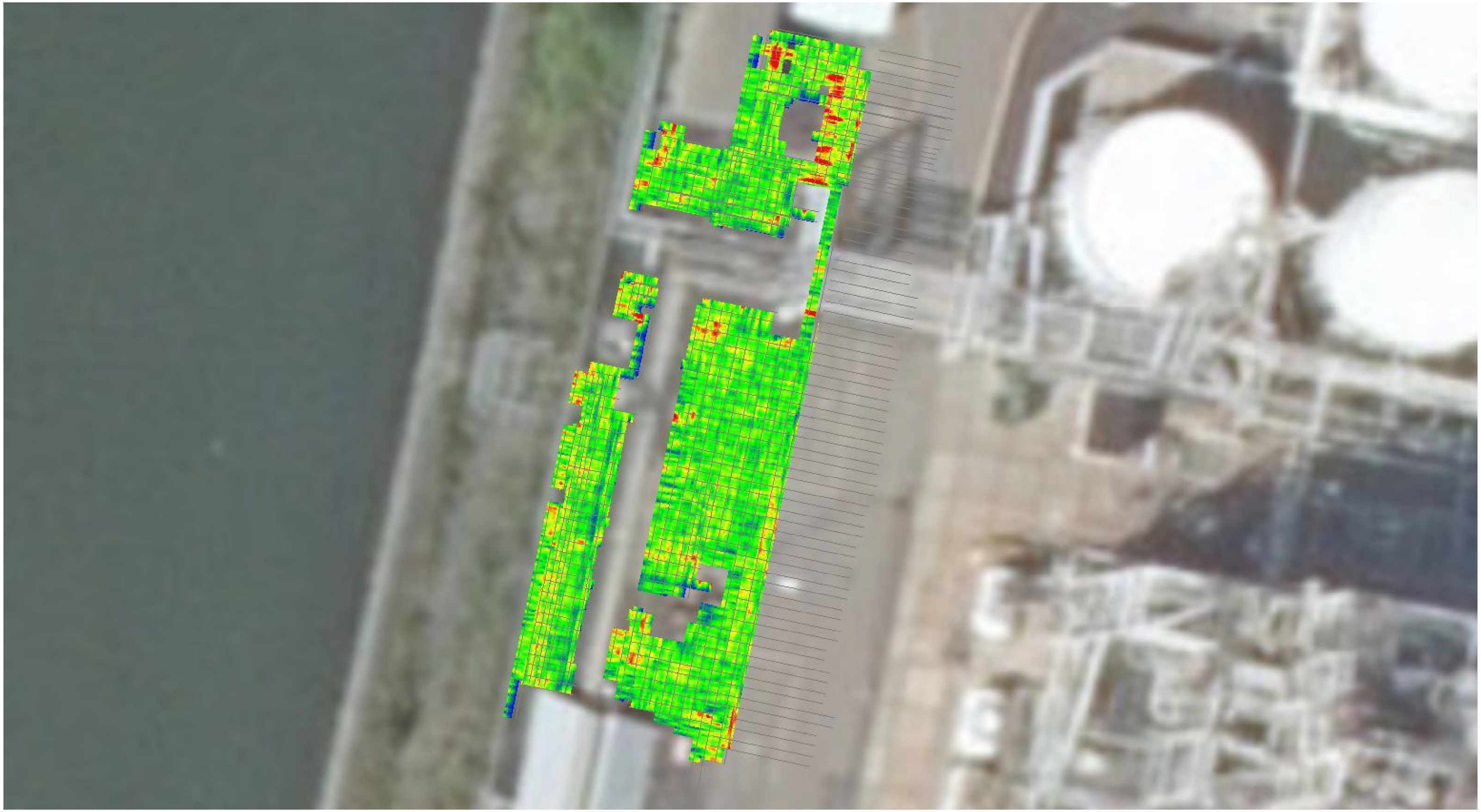
Depth Section @ 0.70m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

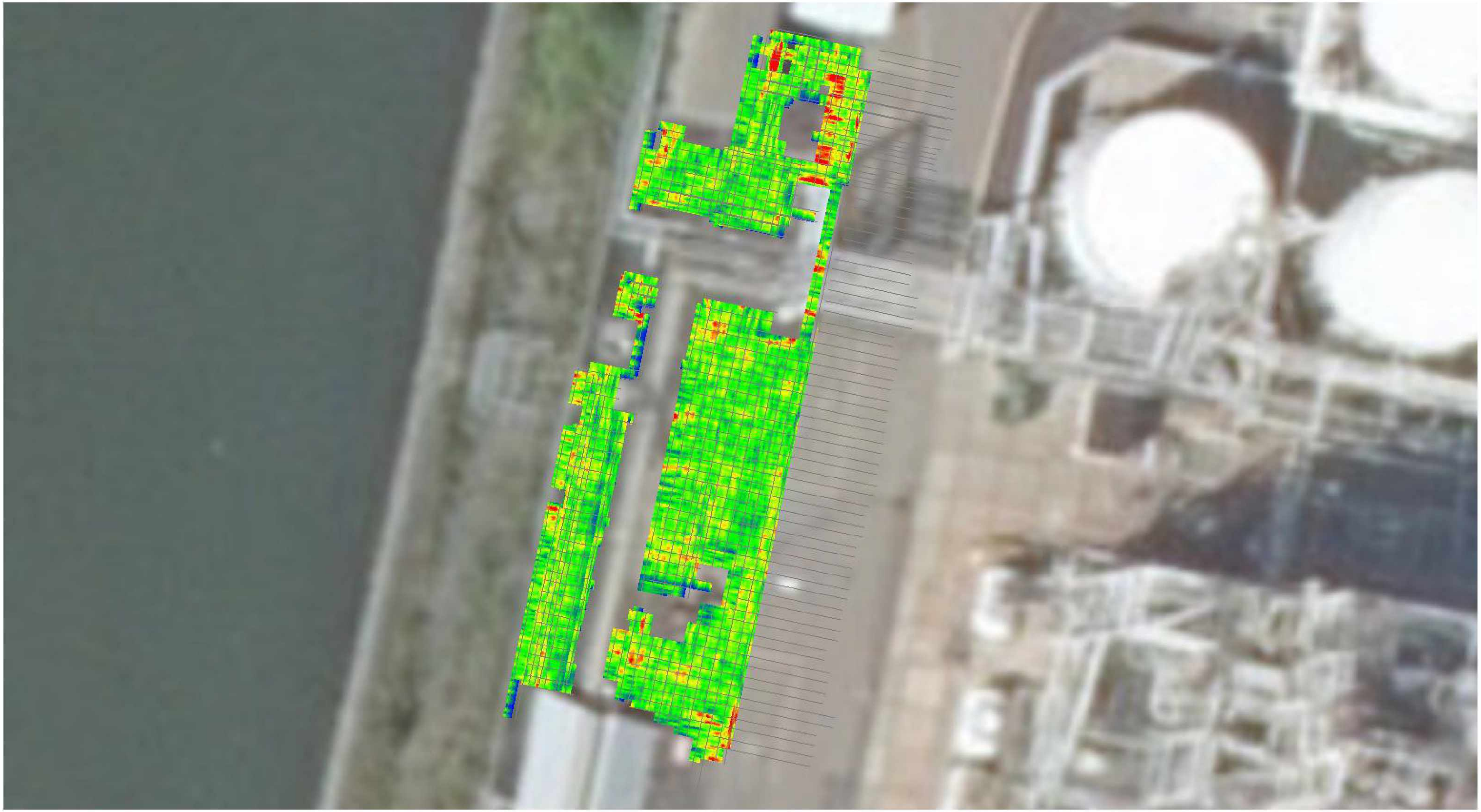
Depth Section @  0.75m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

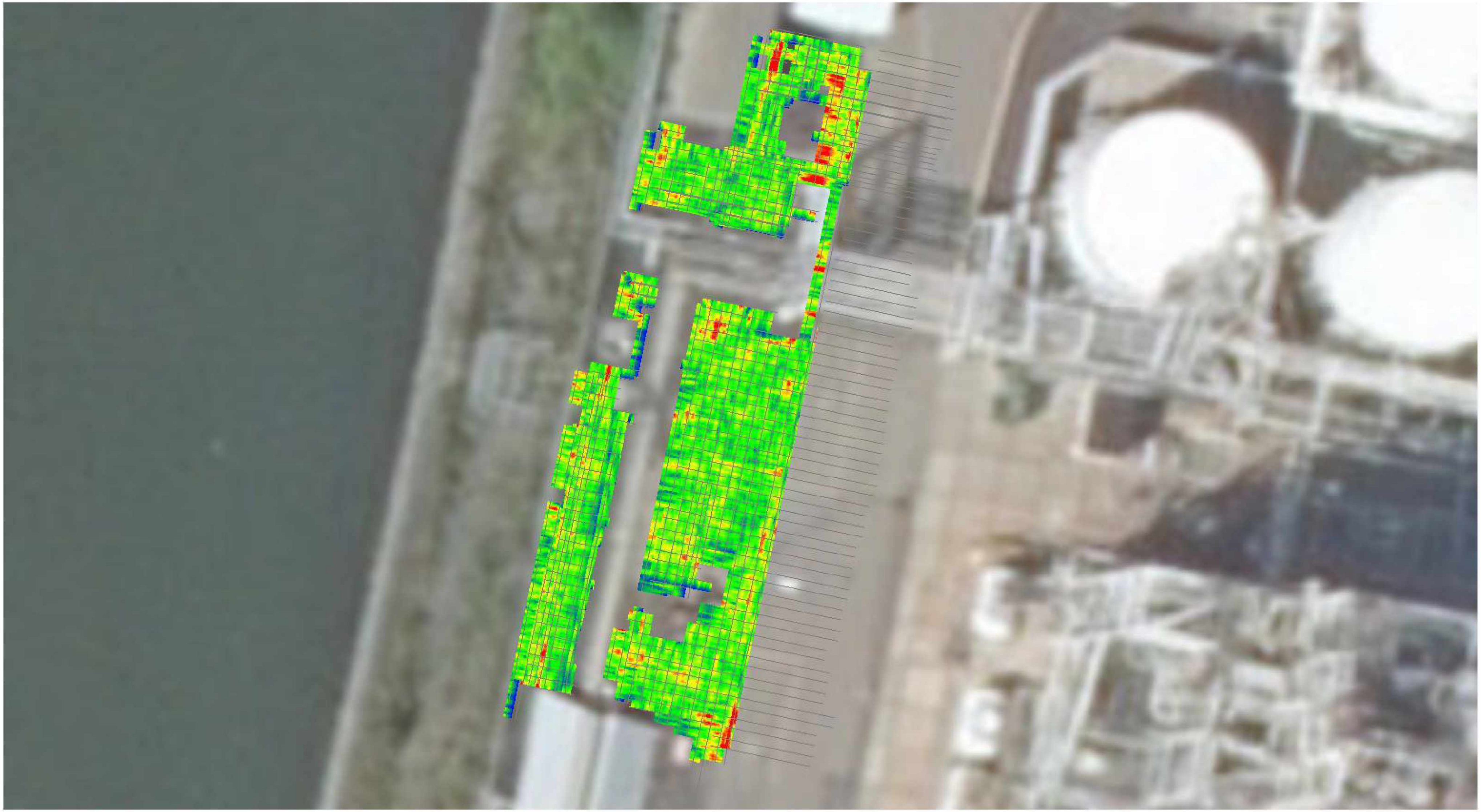
Depth Section @  0.80m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

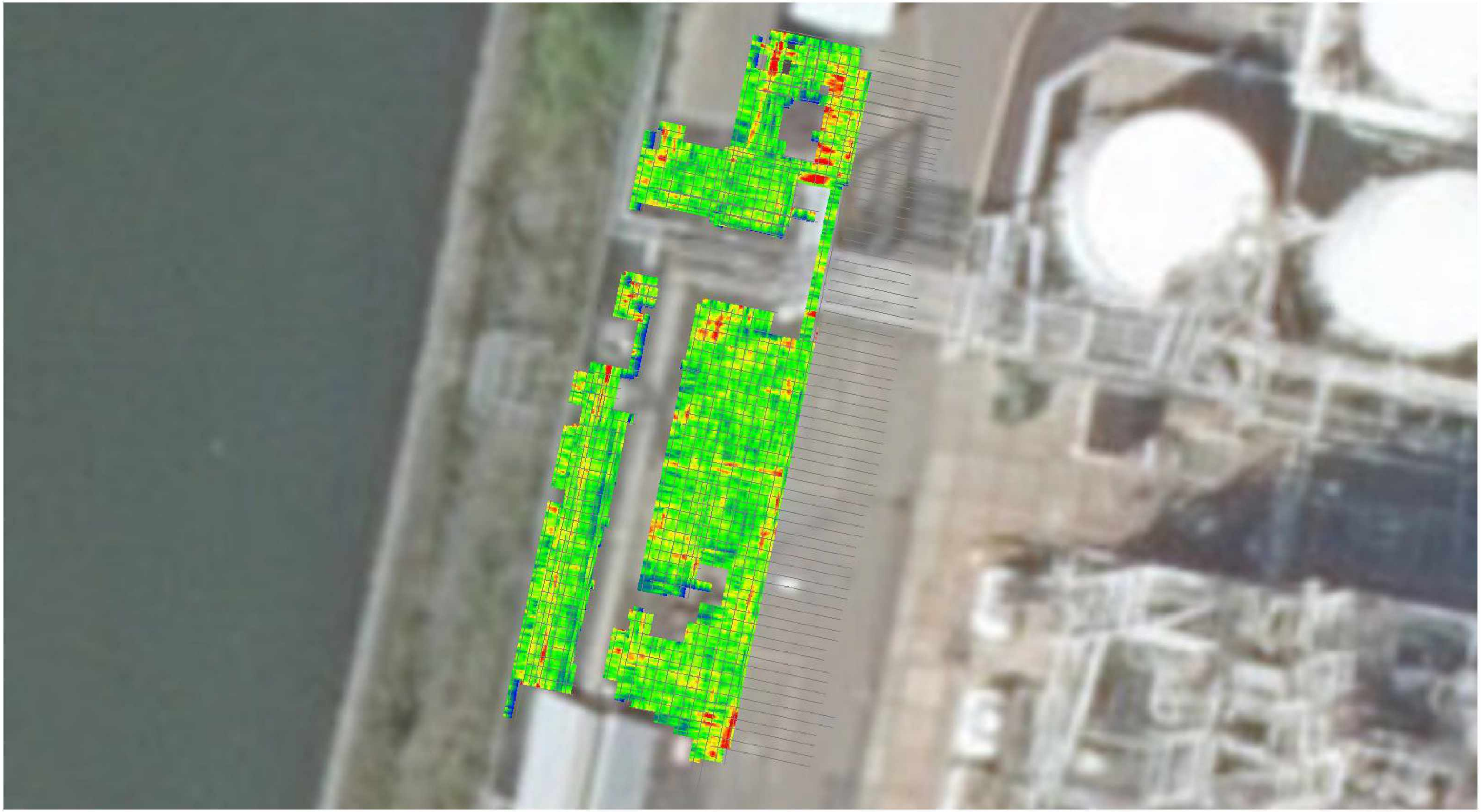
Depth Section @  0.85m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

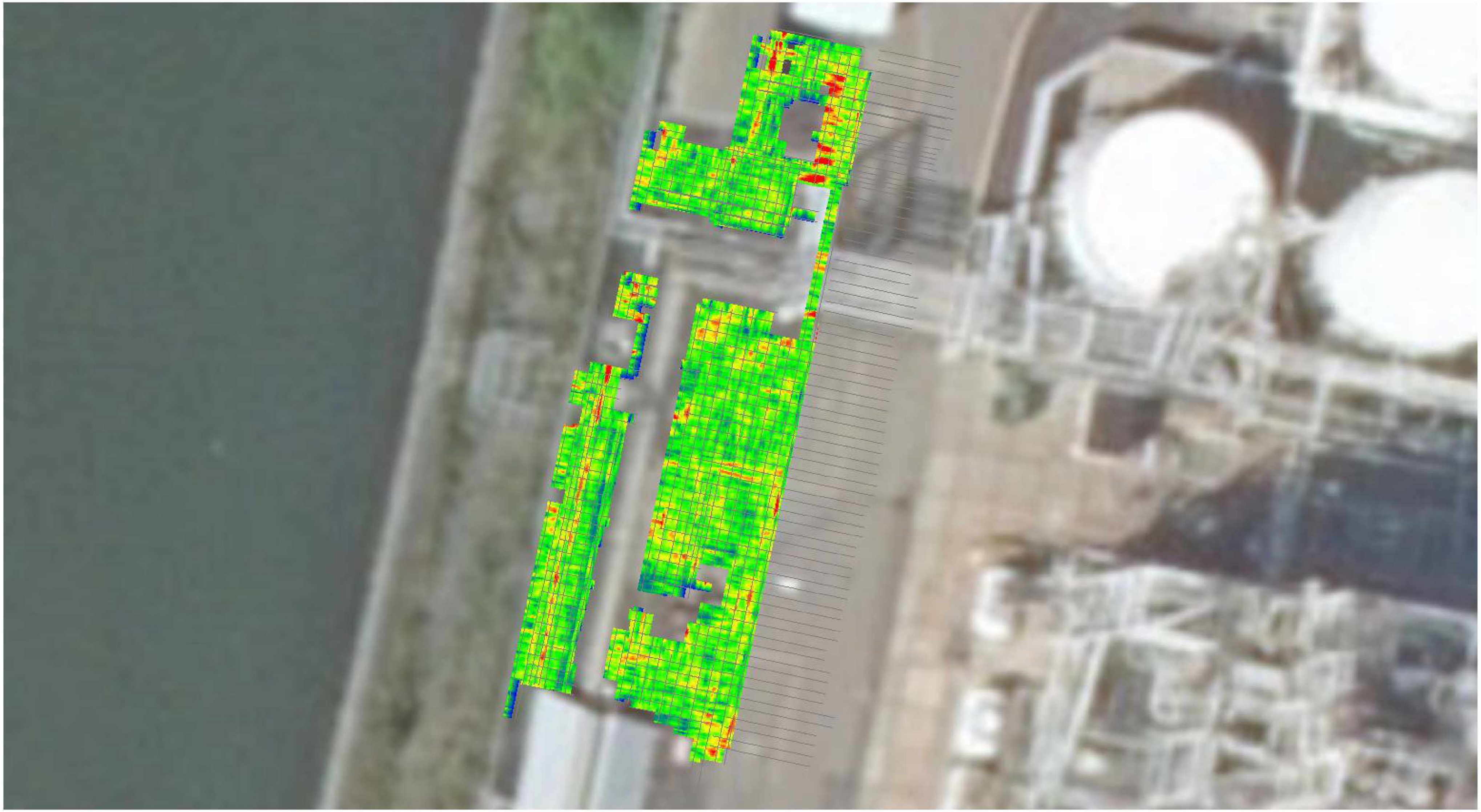
Depth Section @  0.90m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

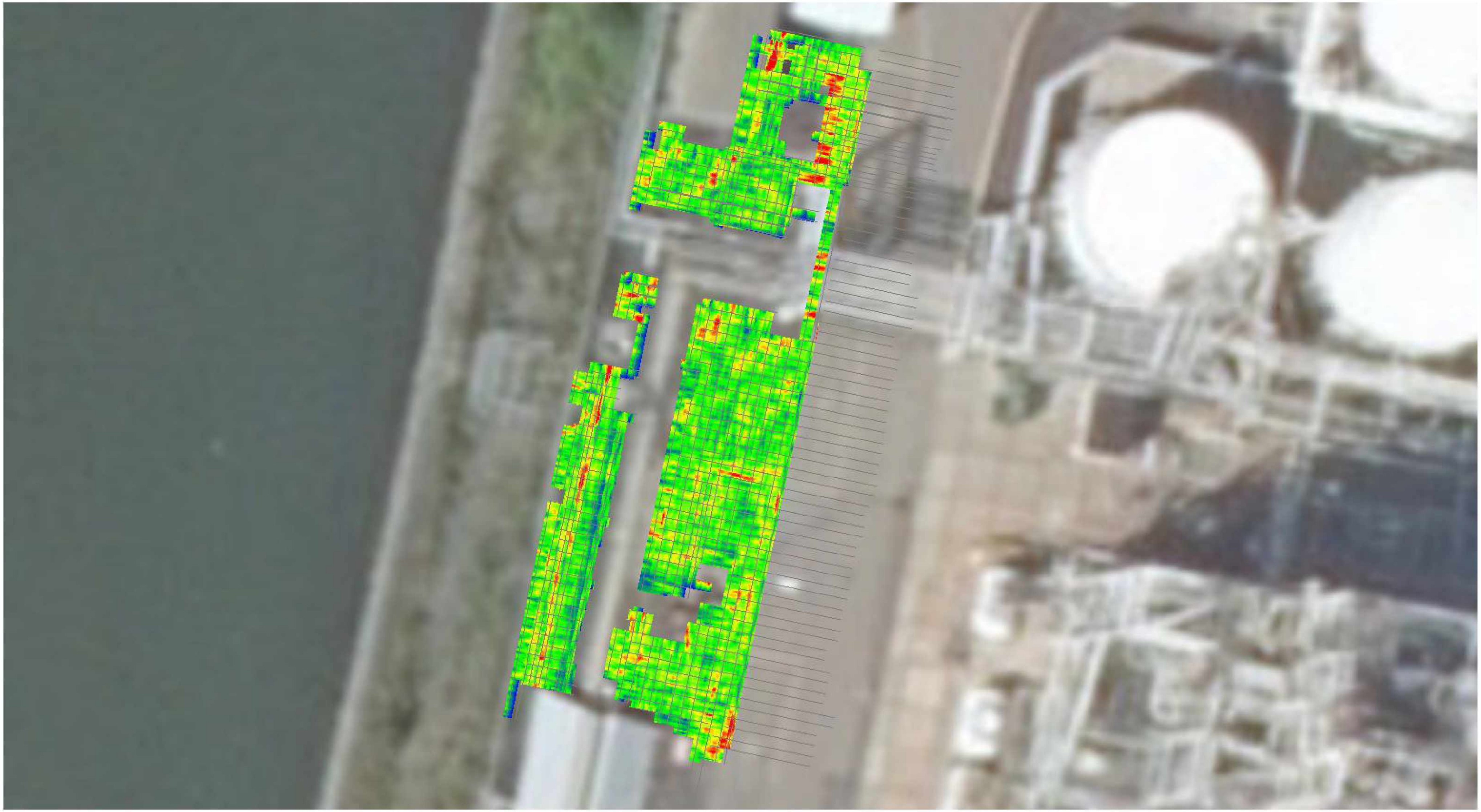
Depth Section @  0.95m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

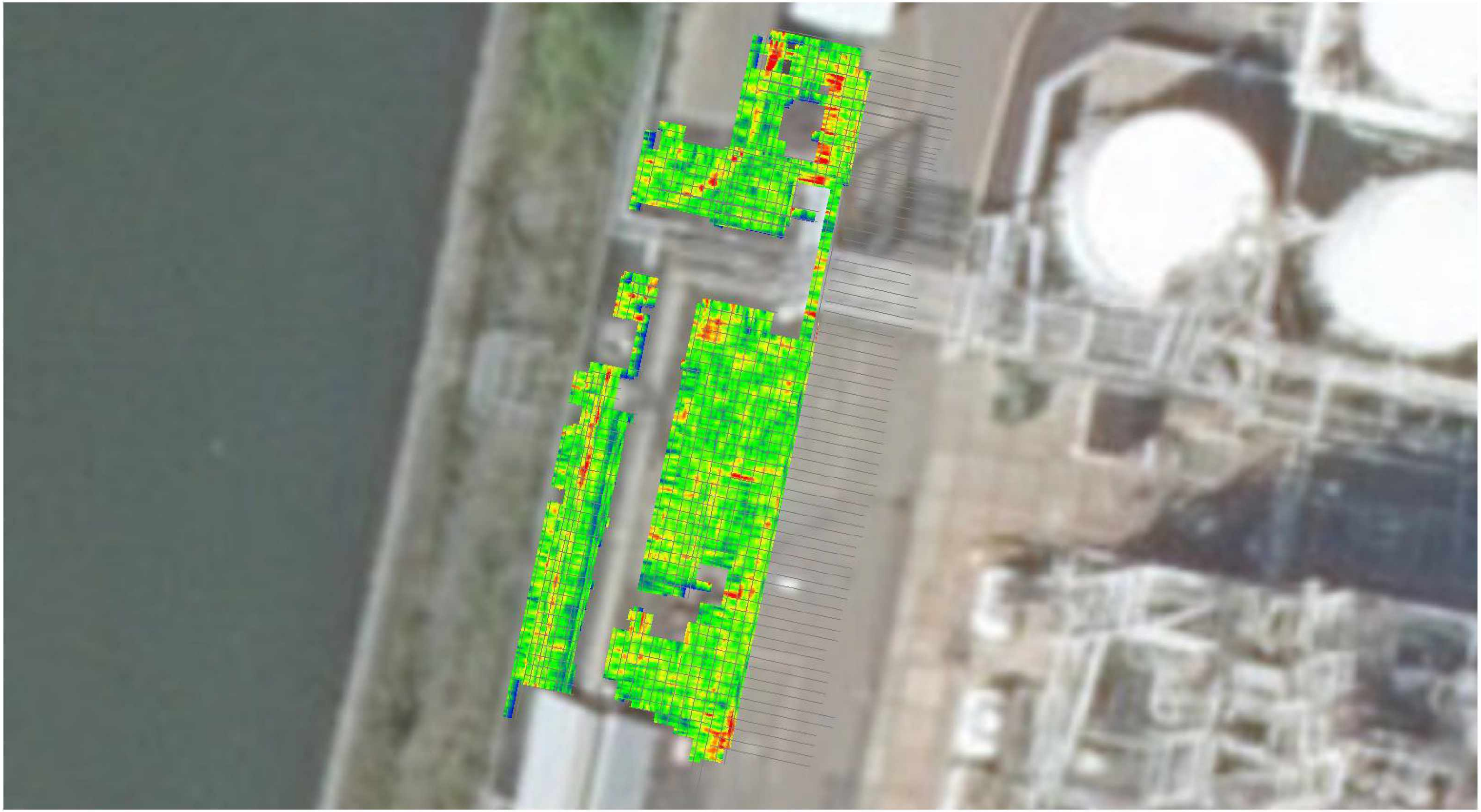
Depth Section @ 1.00m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

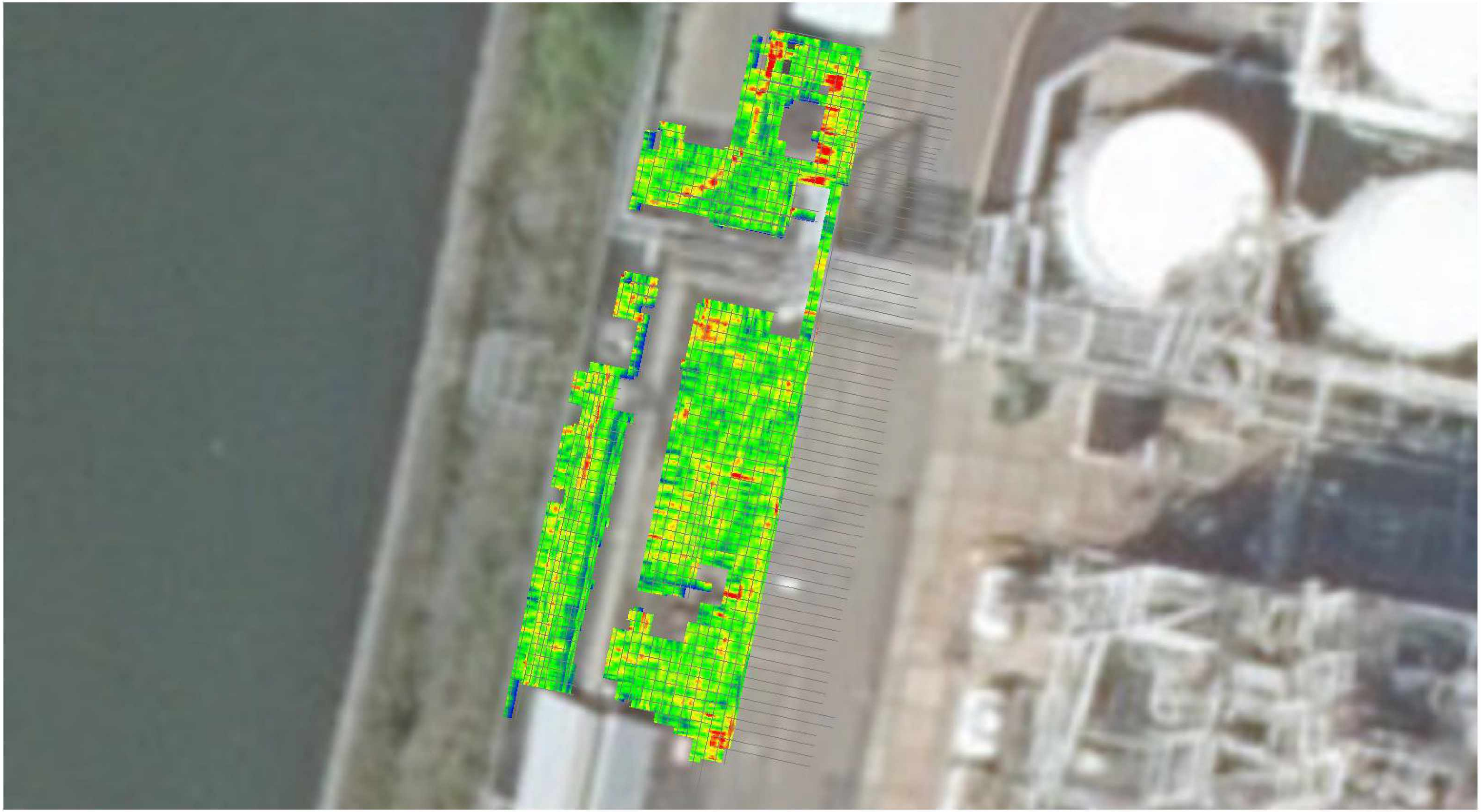
Depth Section @ 1.05m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

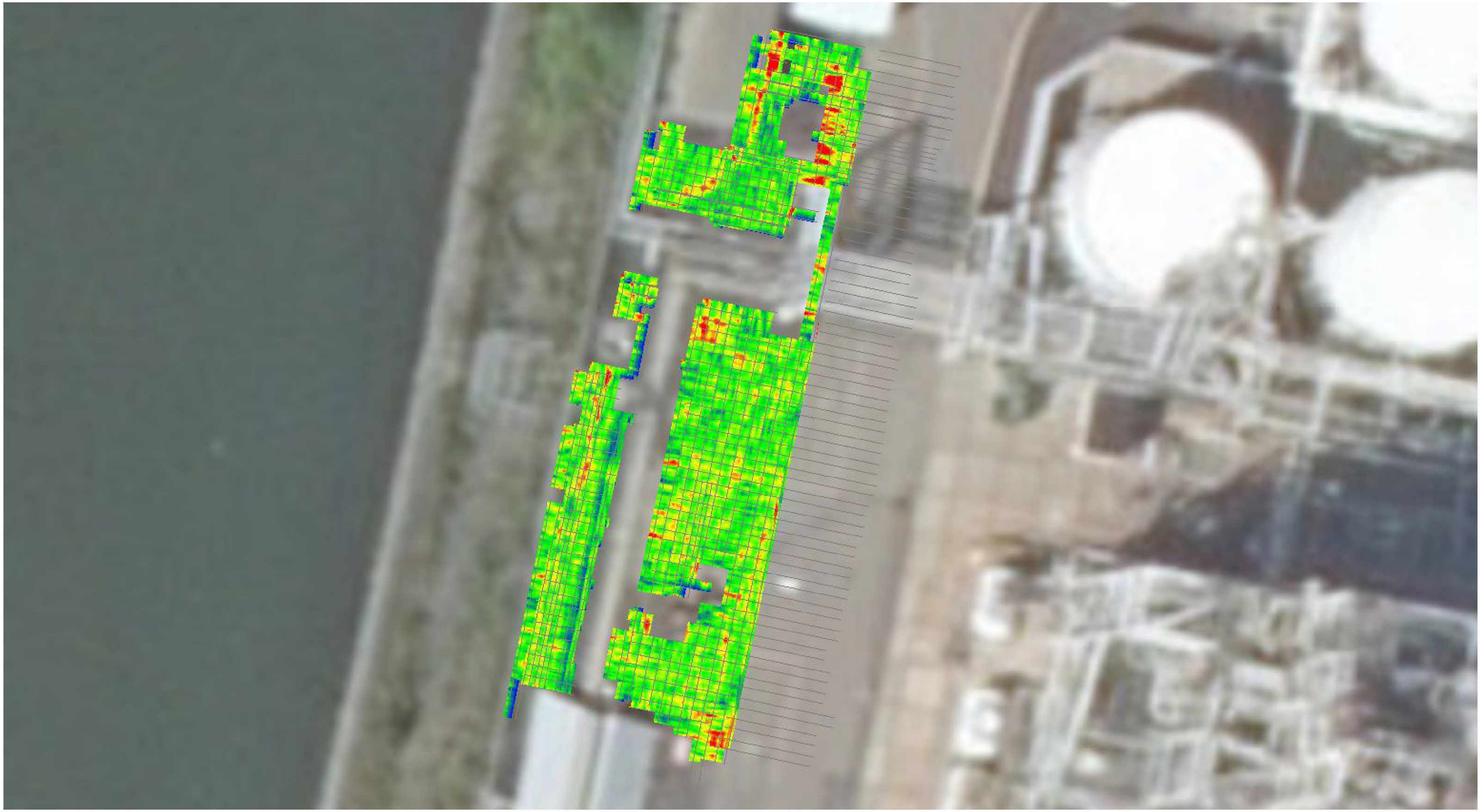
Depth Section @ 1.10m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

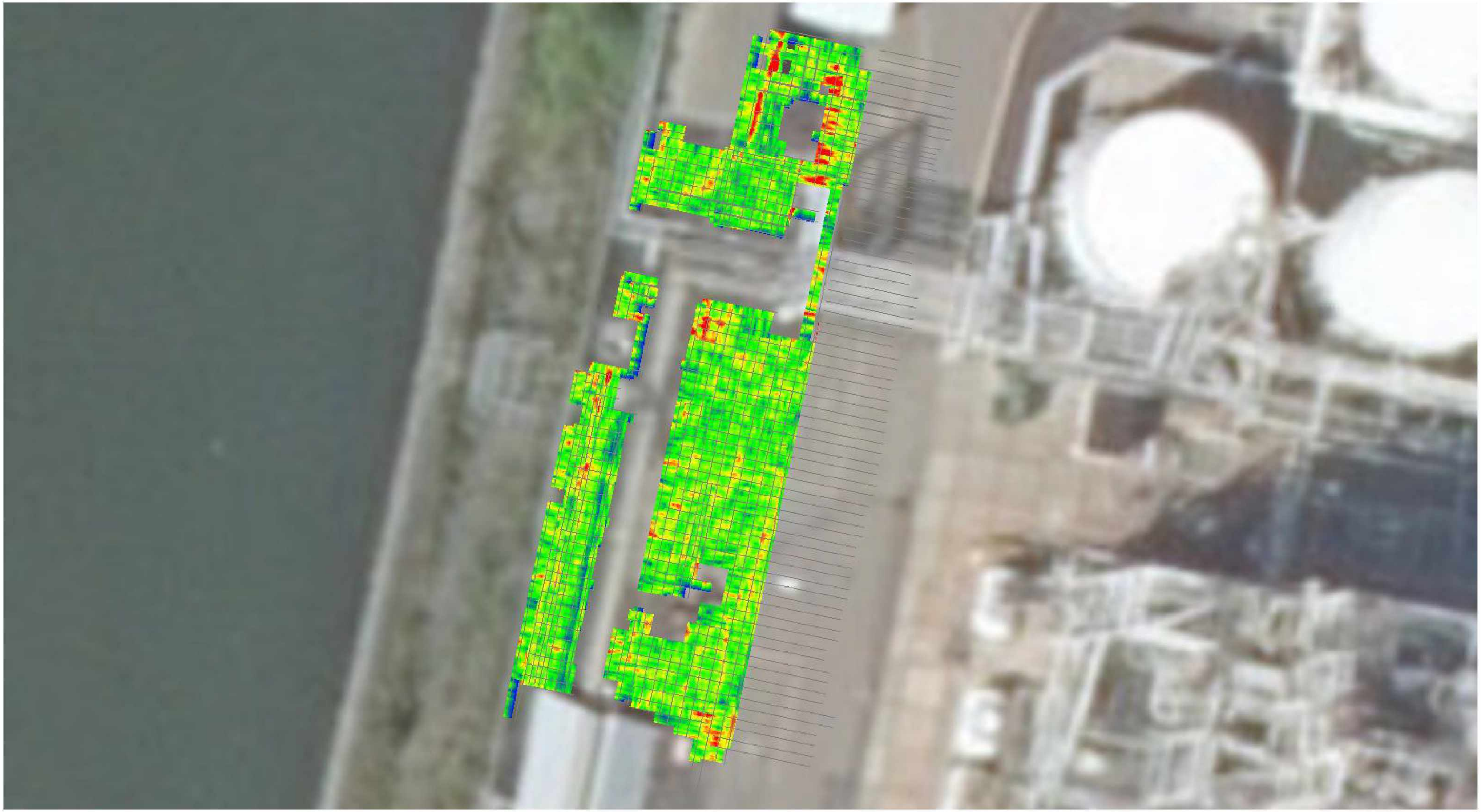
Depth Section @ 1.15m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

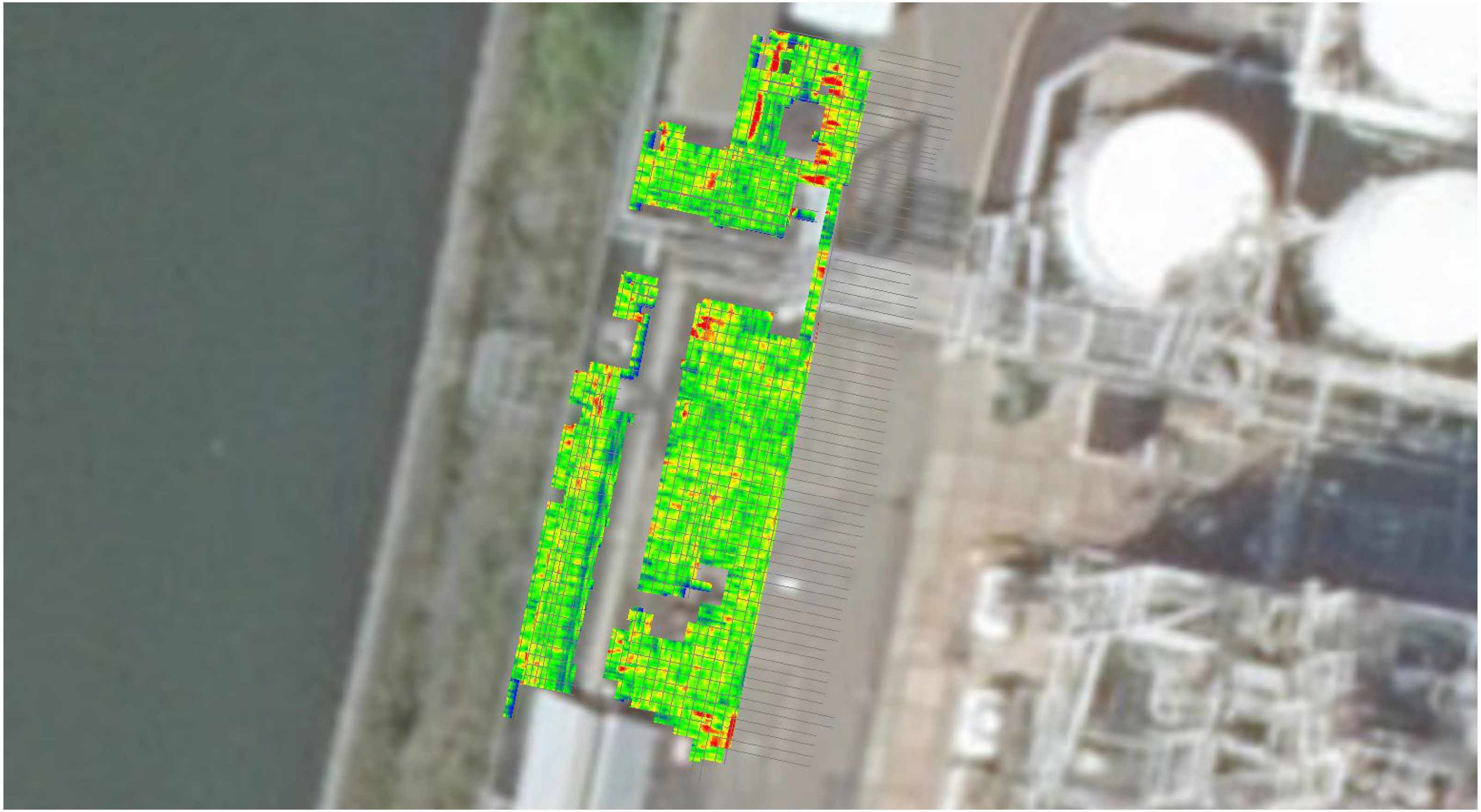
Depth Section @  1.20m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

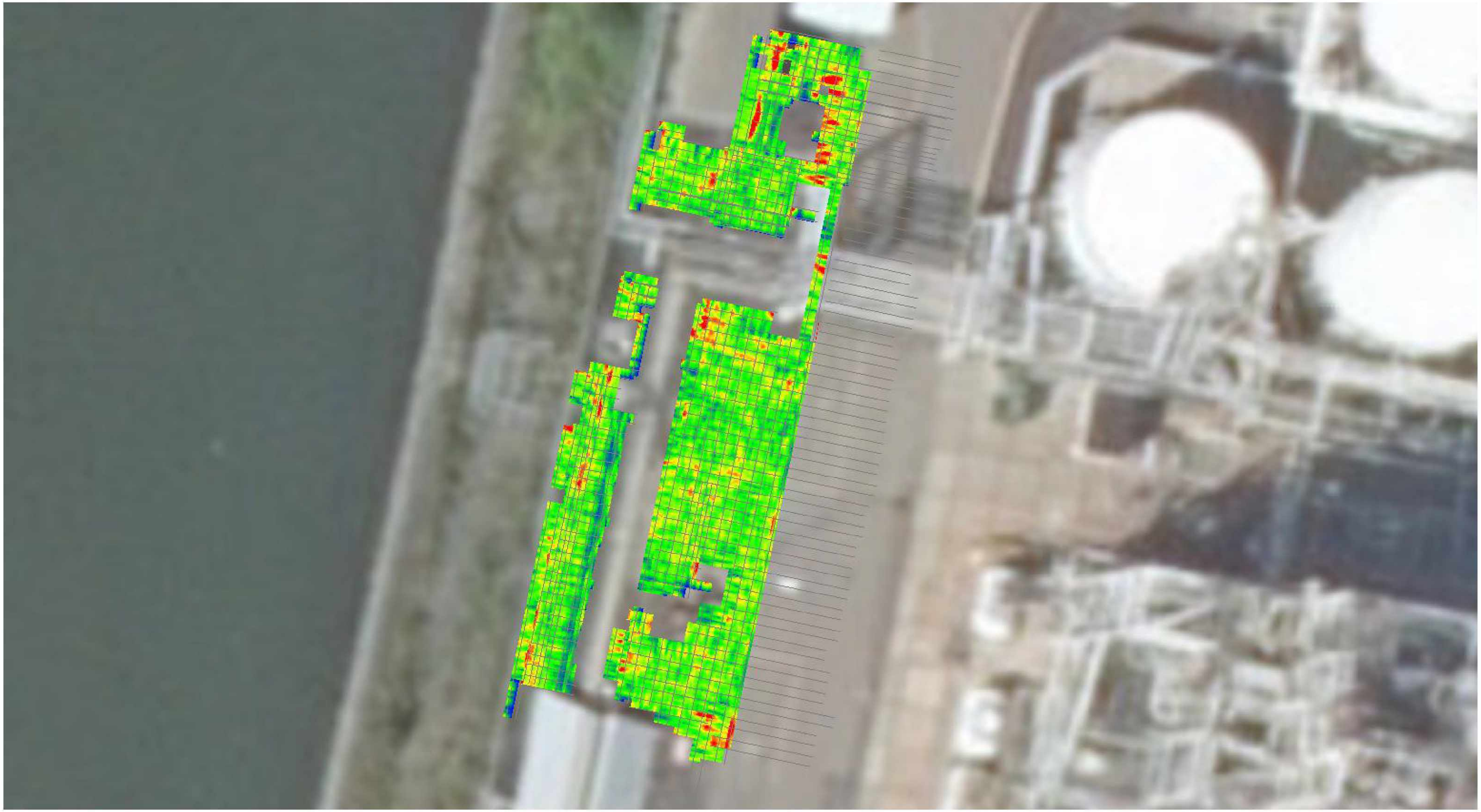
Depth Section @  1.25m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

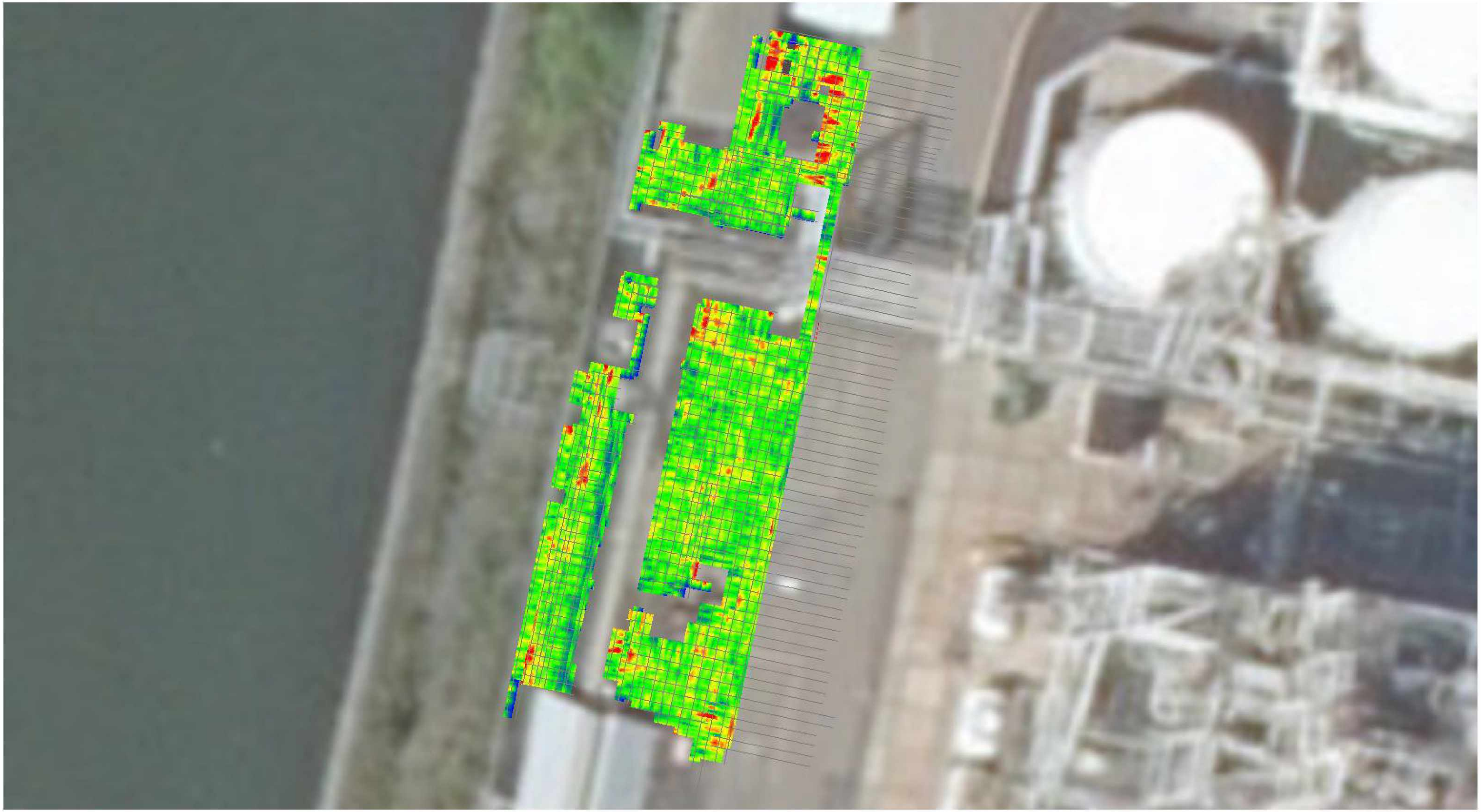
Depth Section @  1.30m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

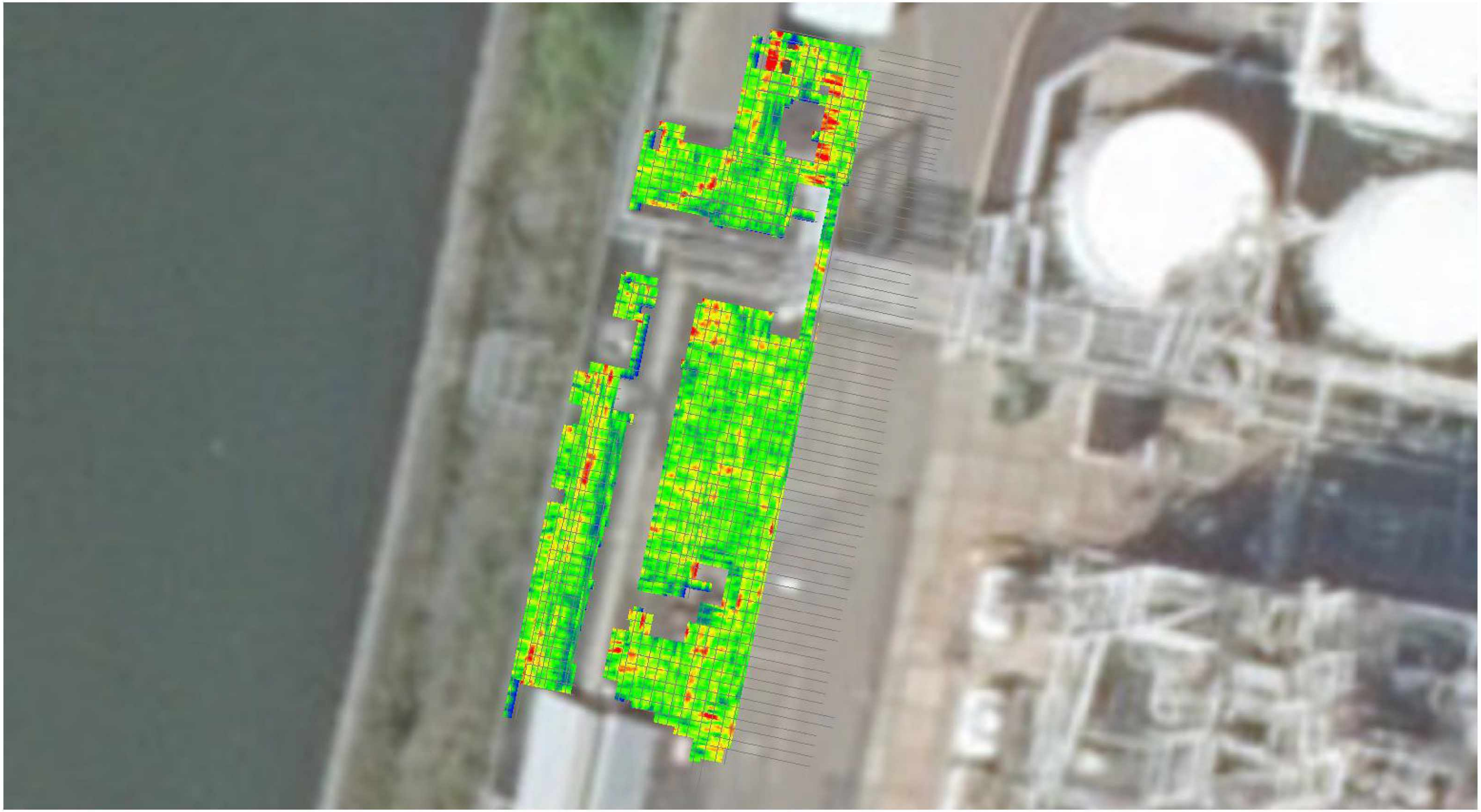
Depth Section @  1.35m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

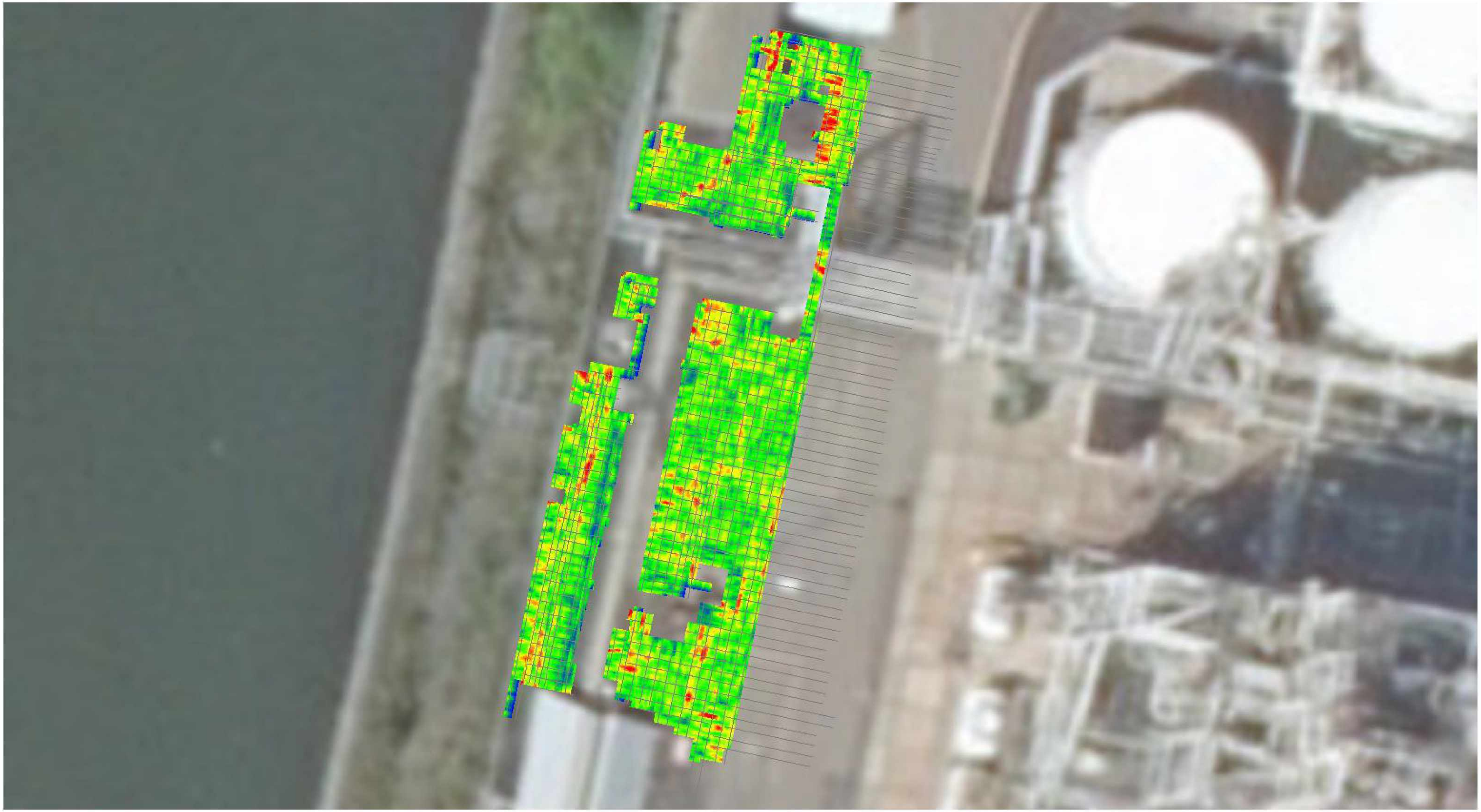
Depth Section @  1.40m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

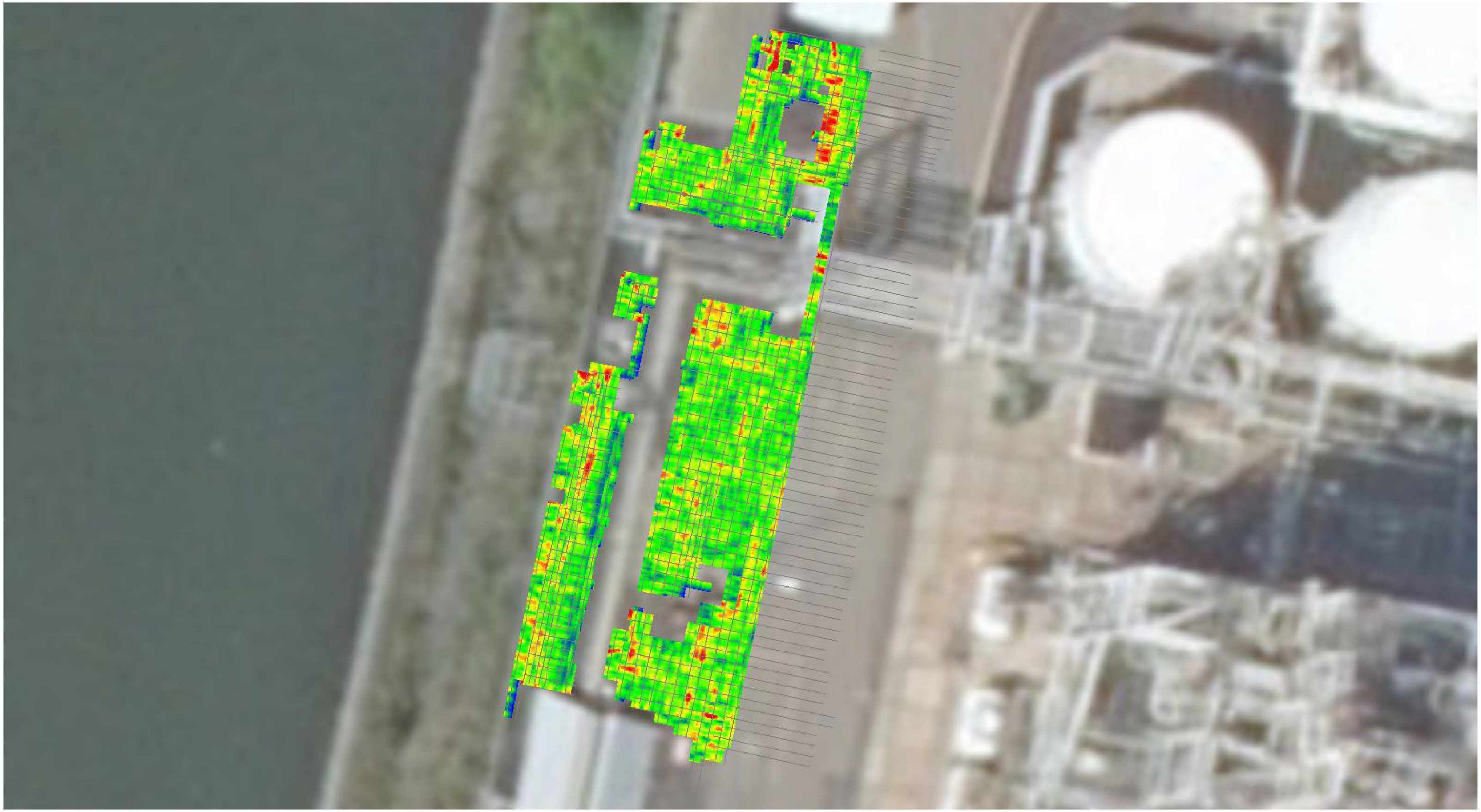
Depth Section @  1.45m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

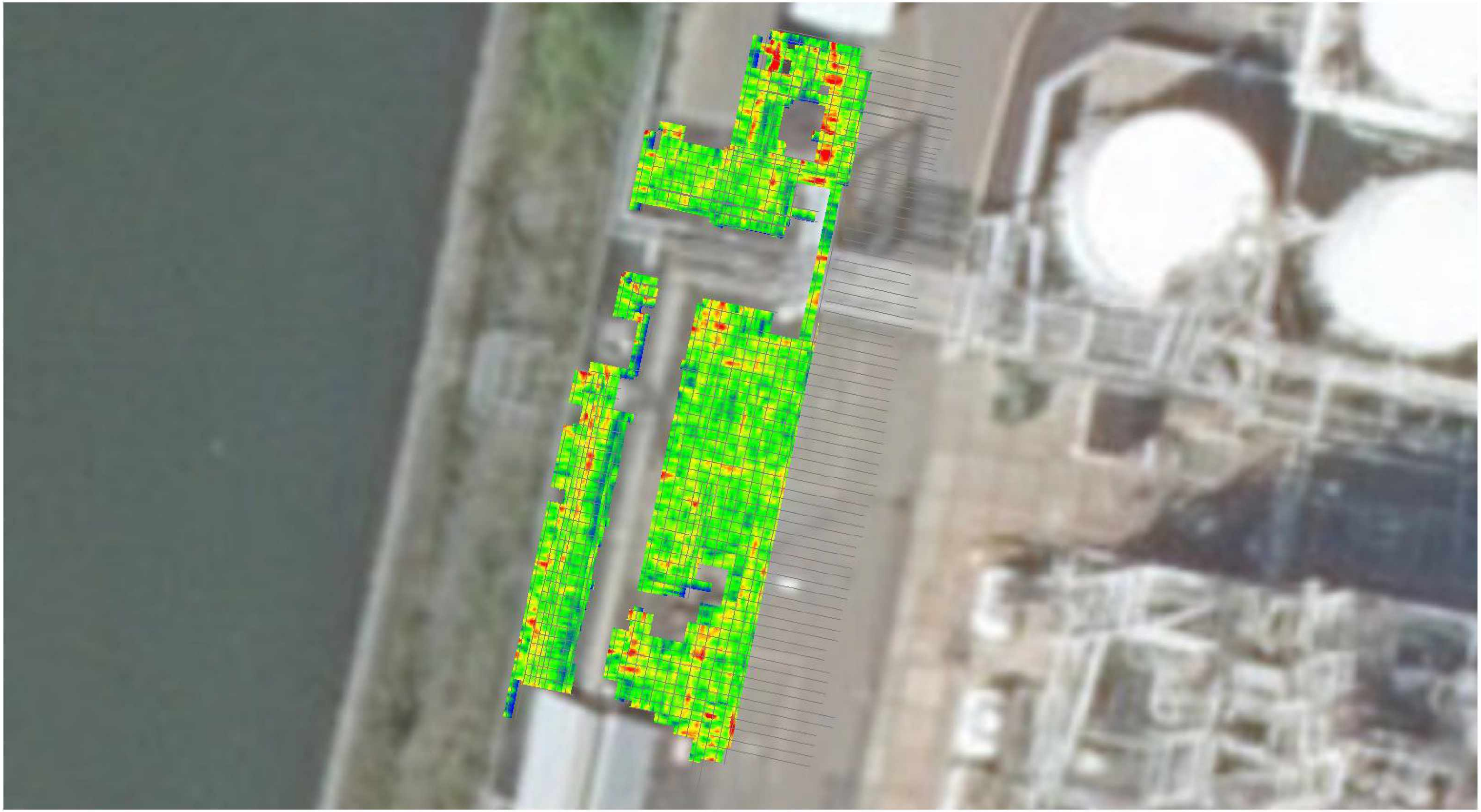
Depth Section @ 1.50m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

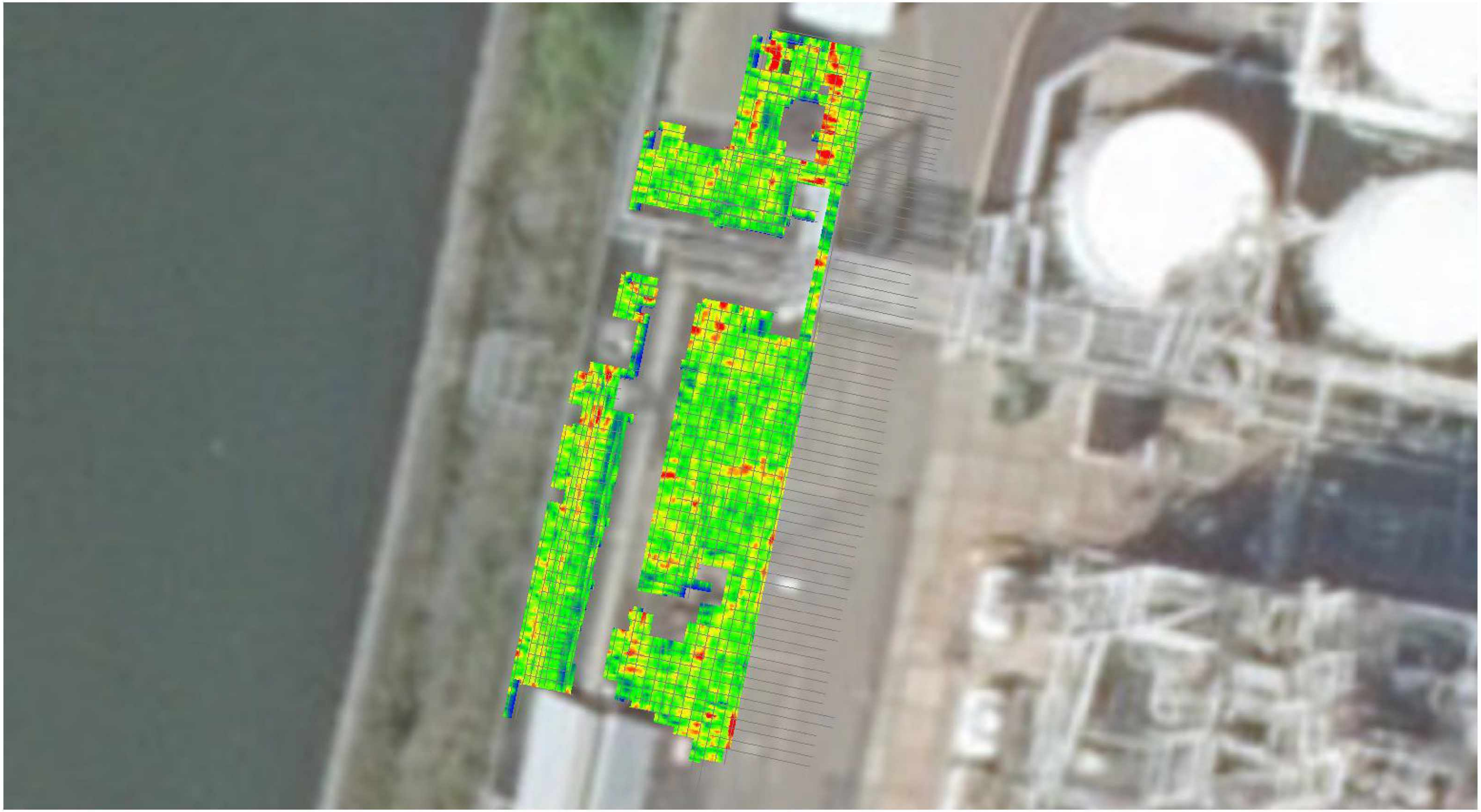
Depth Section @ 1.55m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

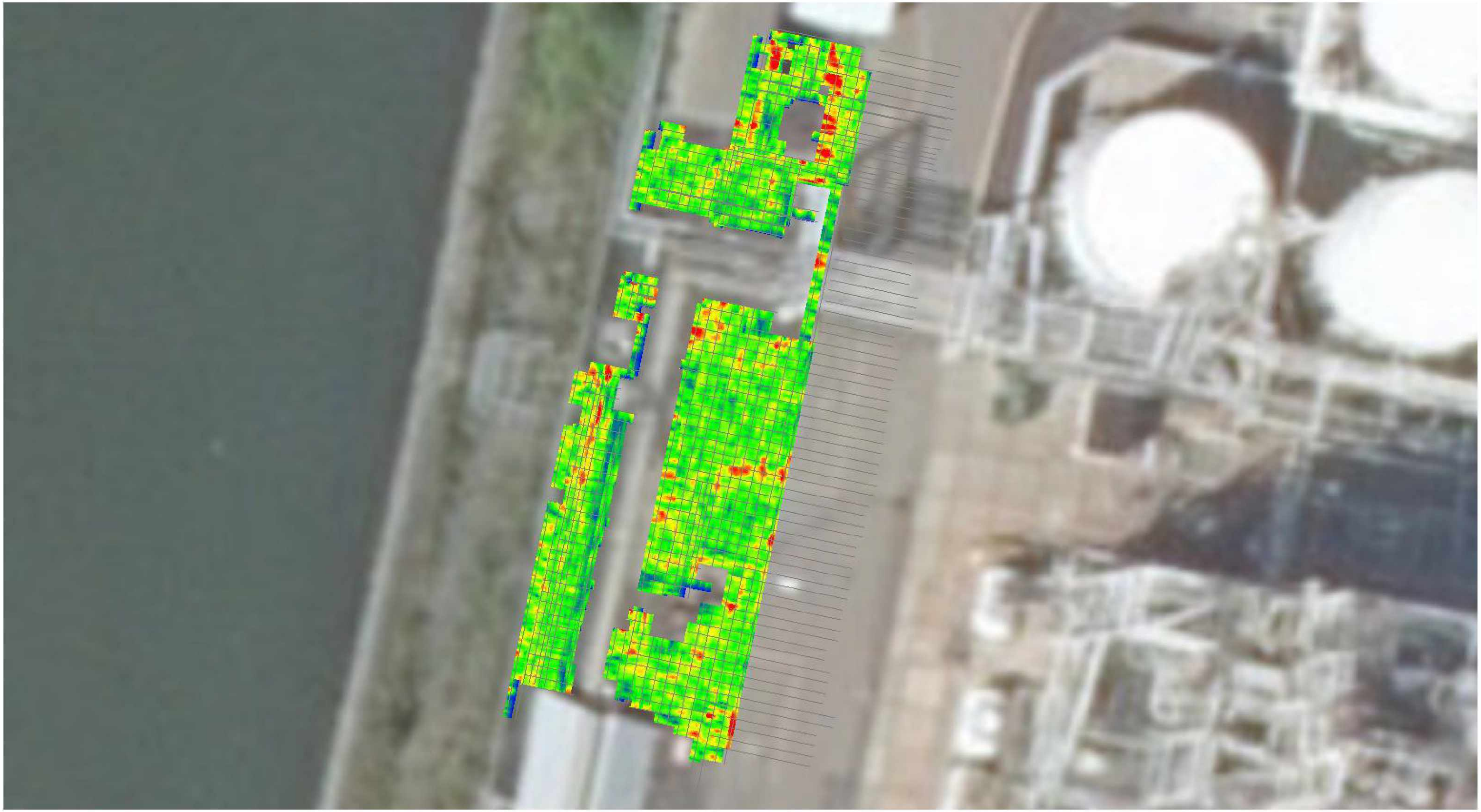
Depth Section @ 1.60m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

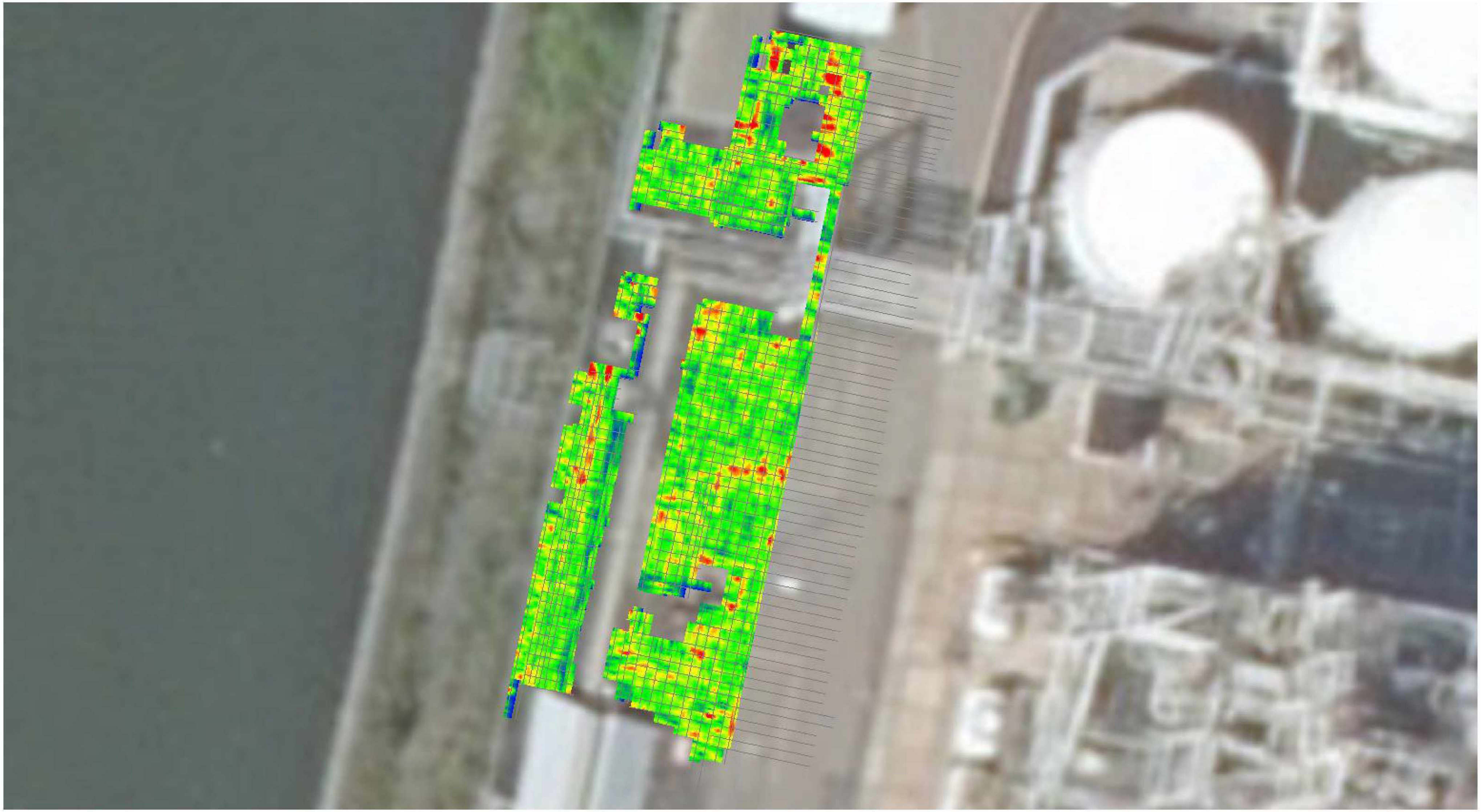
Depth Section @  1.65m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

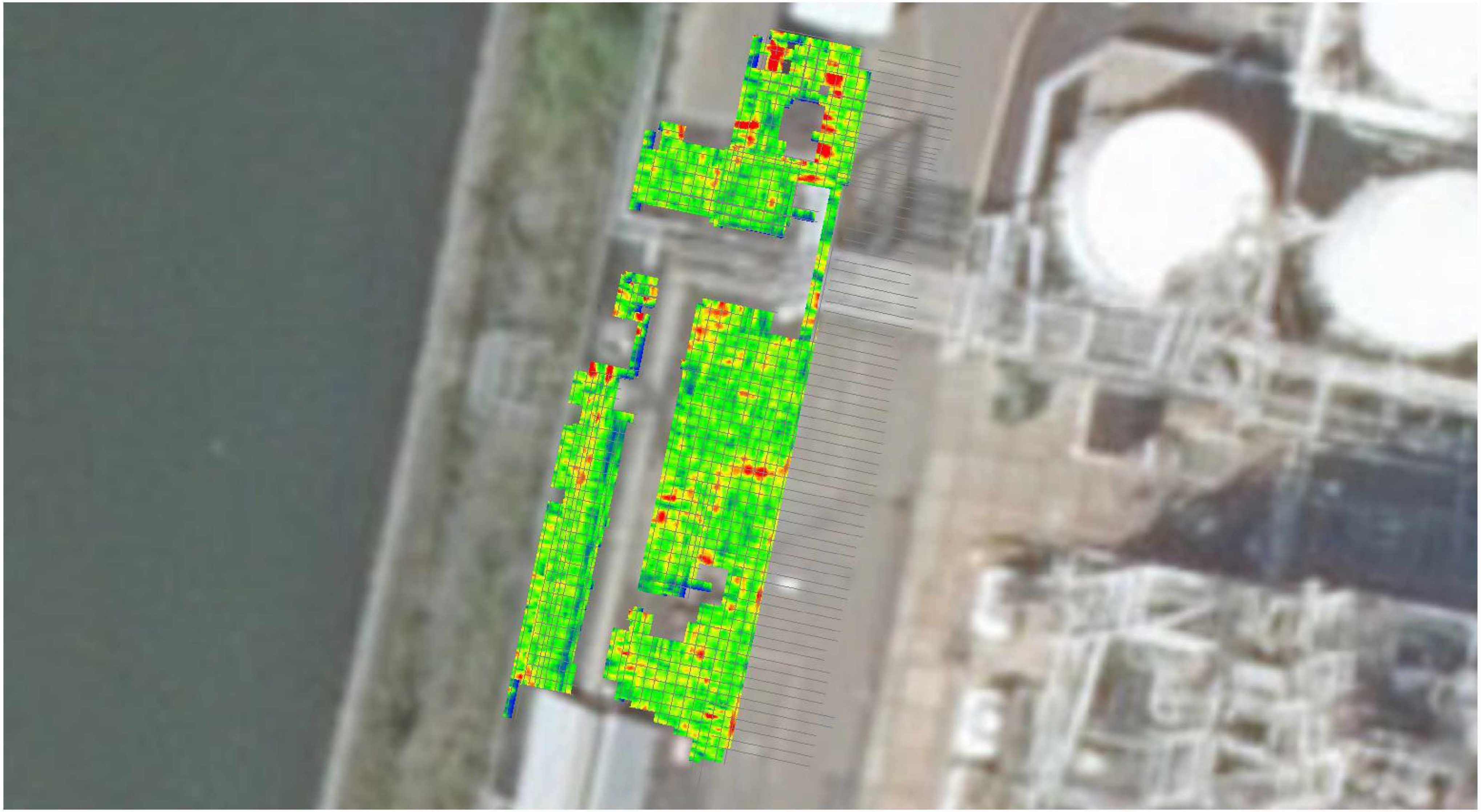
Depth Section @ 1.70m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

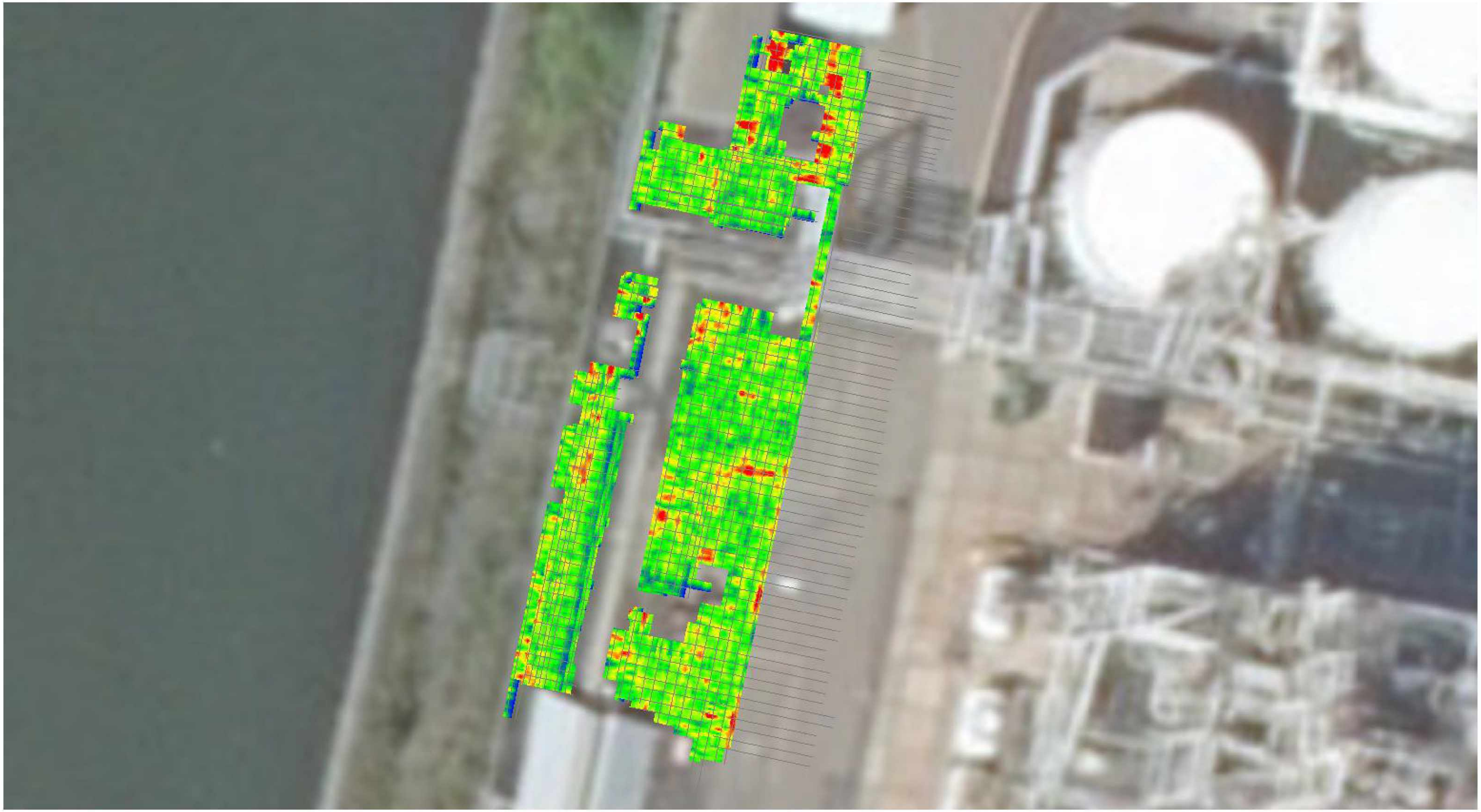
Depth Section @ 1.75m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

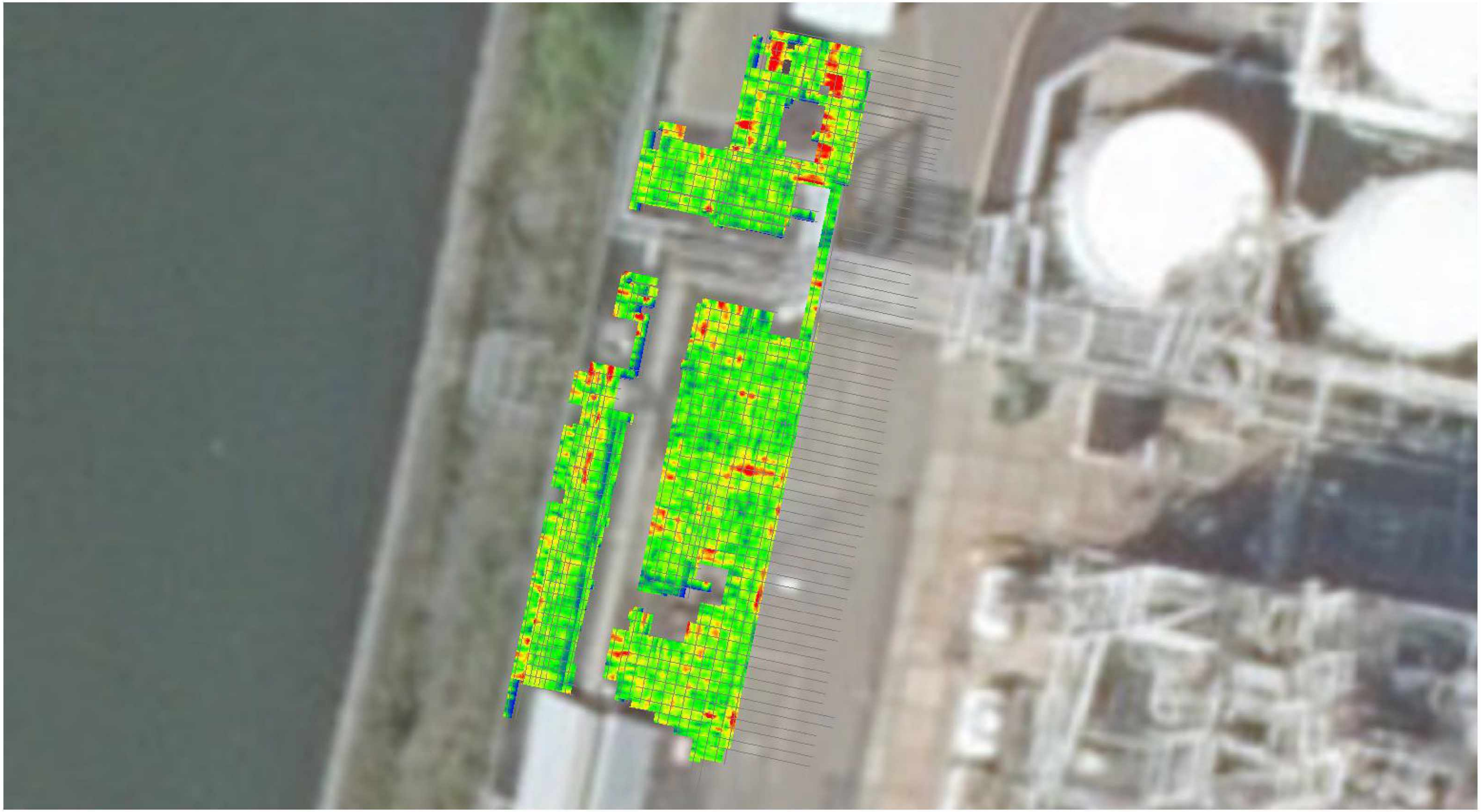
Depth Section @ 1.80m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

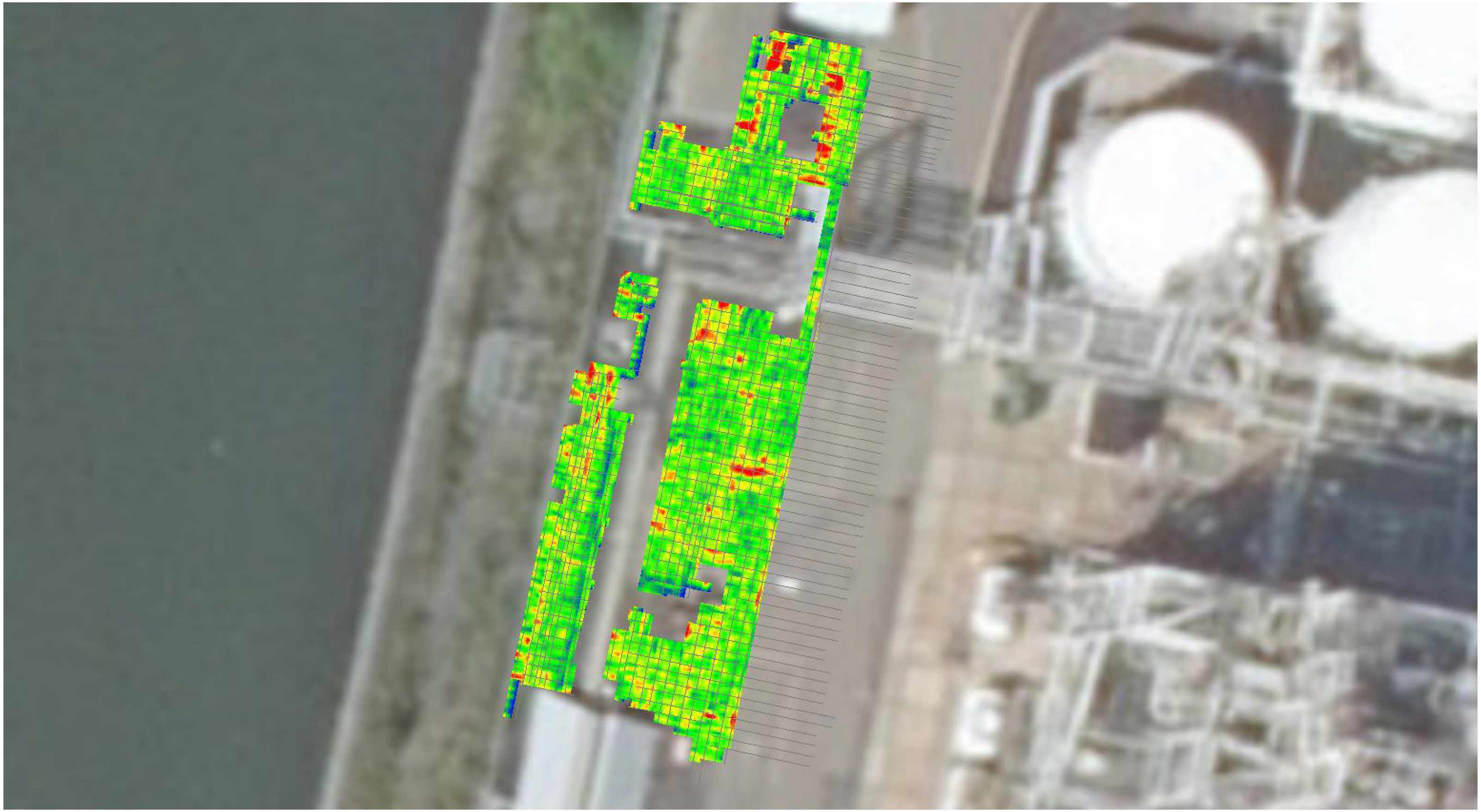
Depth Section @  1.85m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

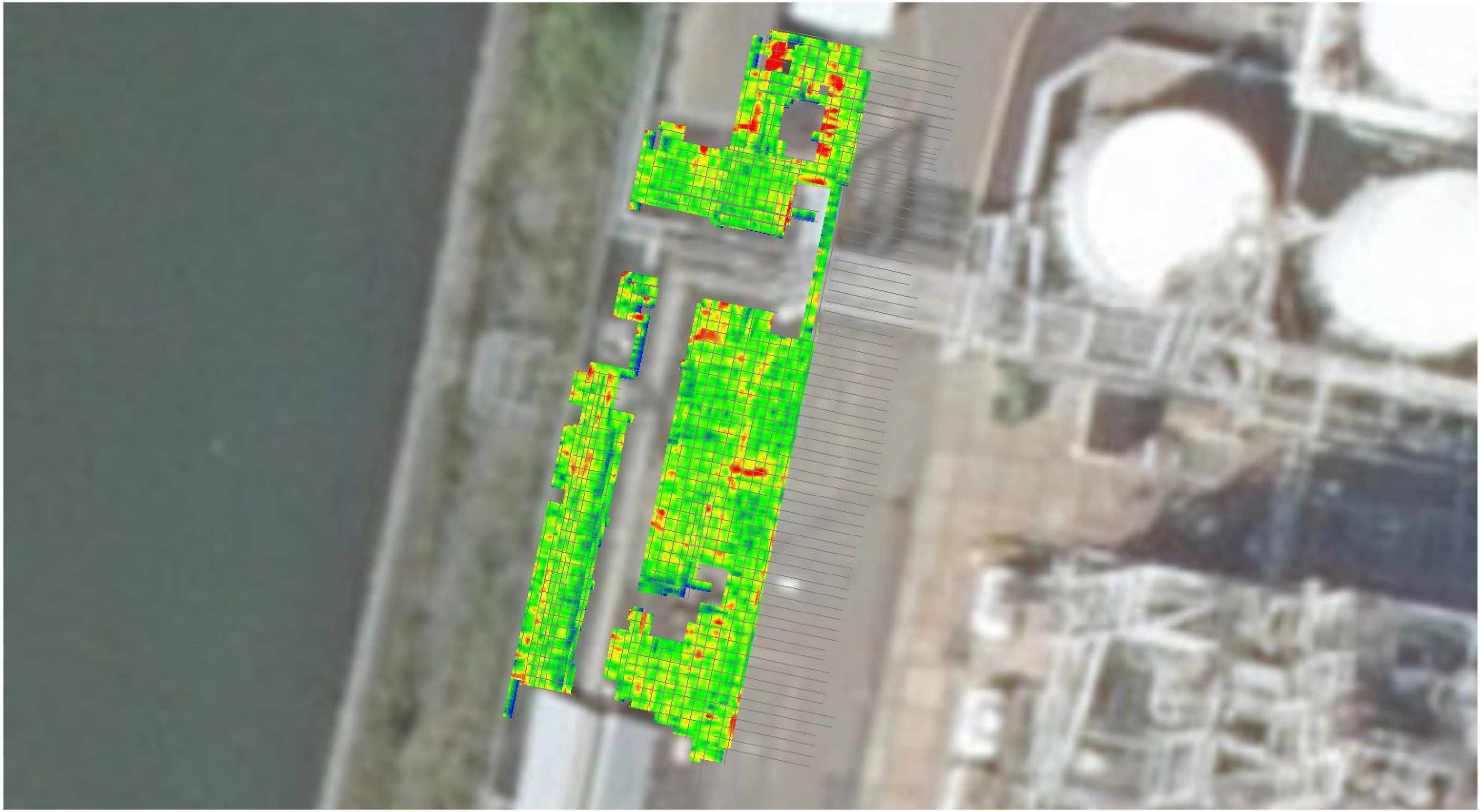
Depth Section @  1.90m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

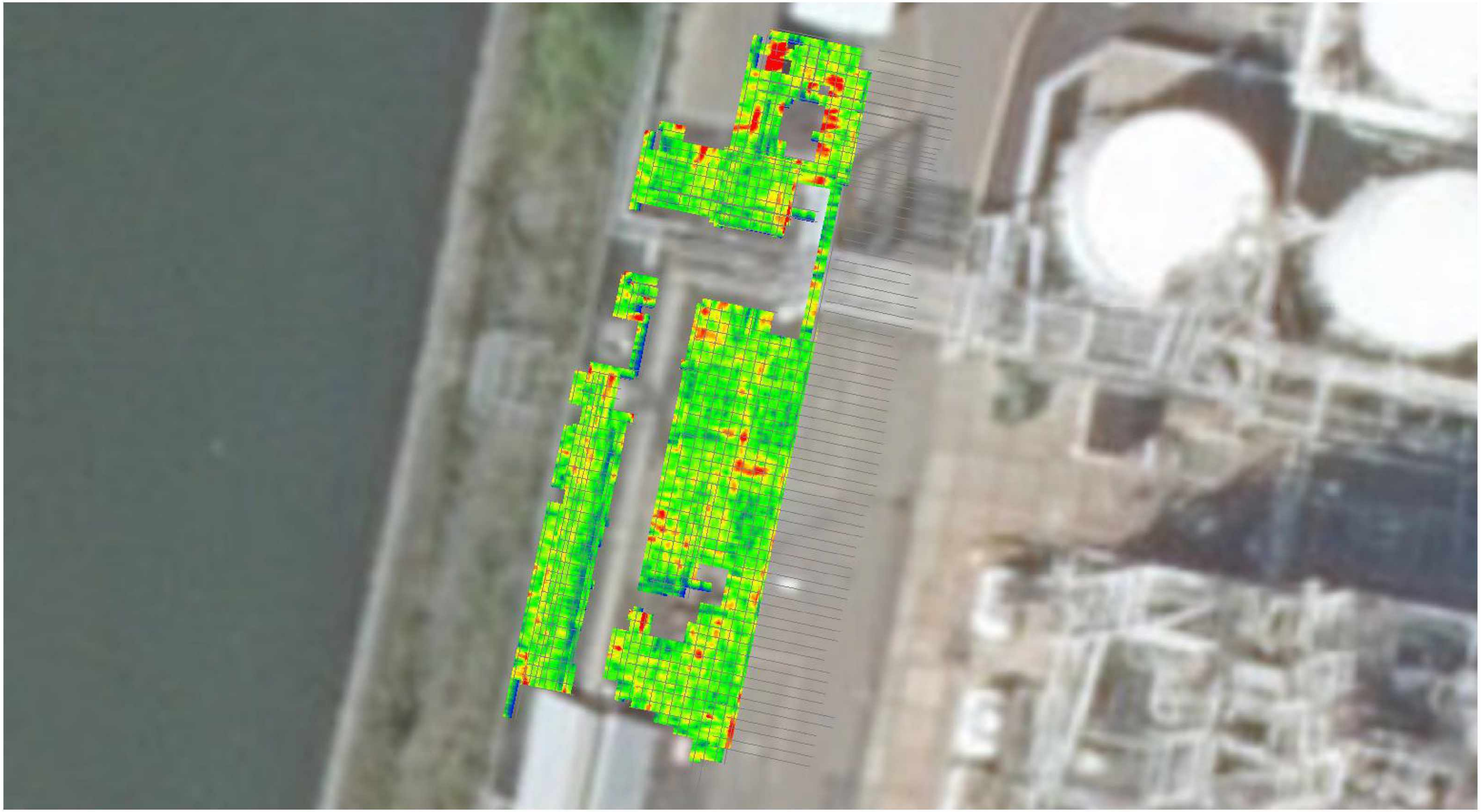
Depth Section @ 1.95m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

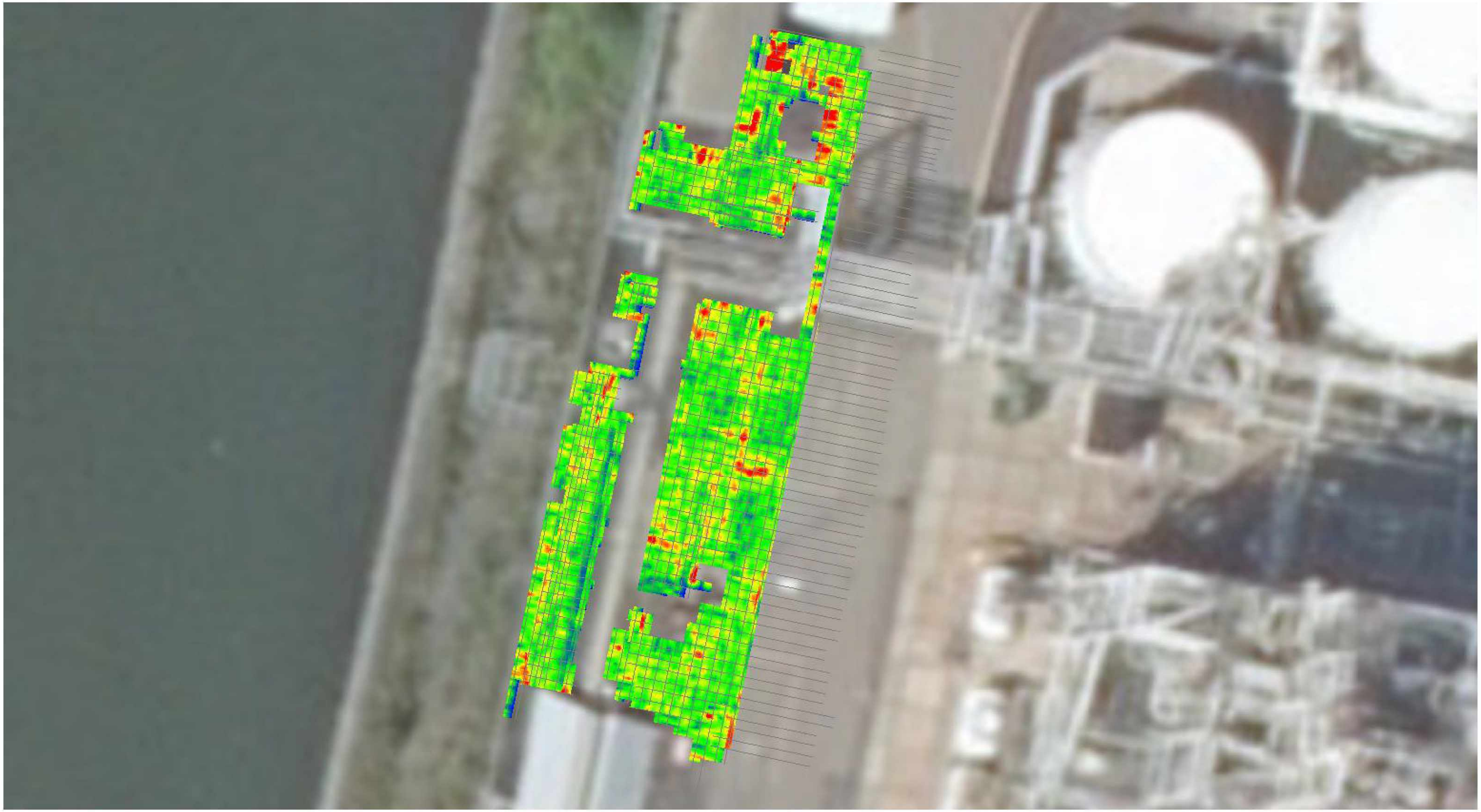
Depth Section @  2.00m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

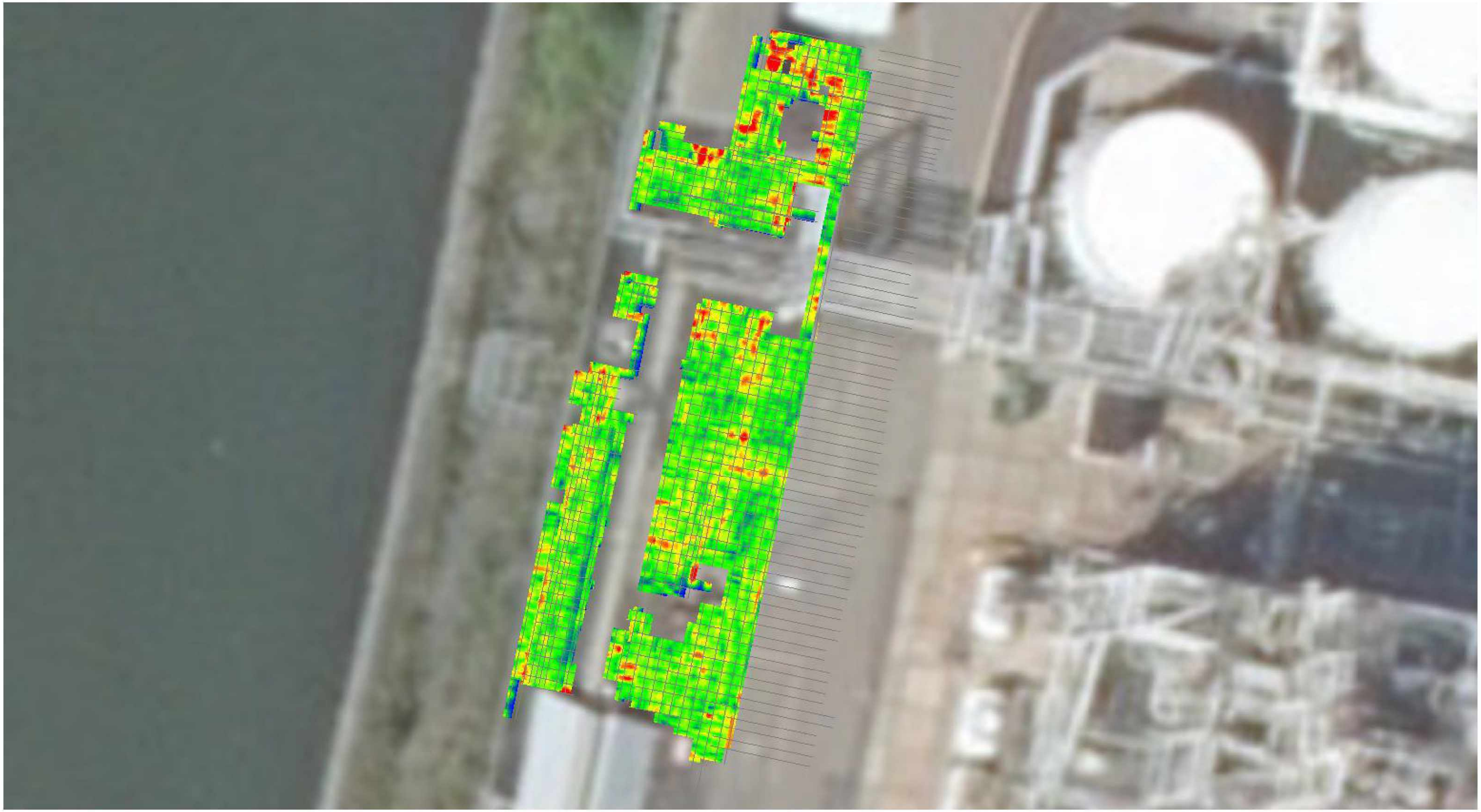
Depth Section @  2.05m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

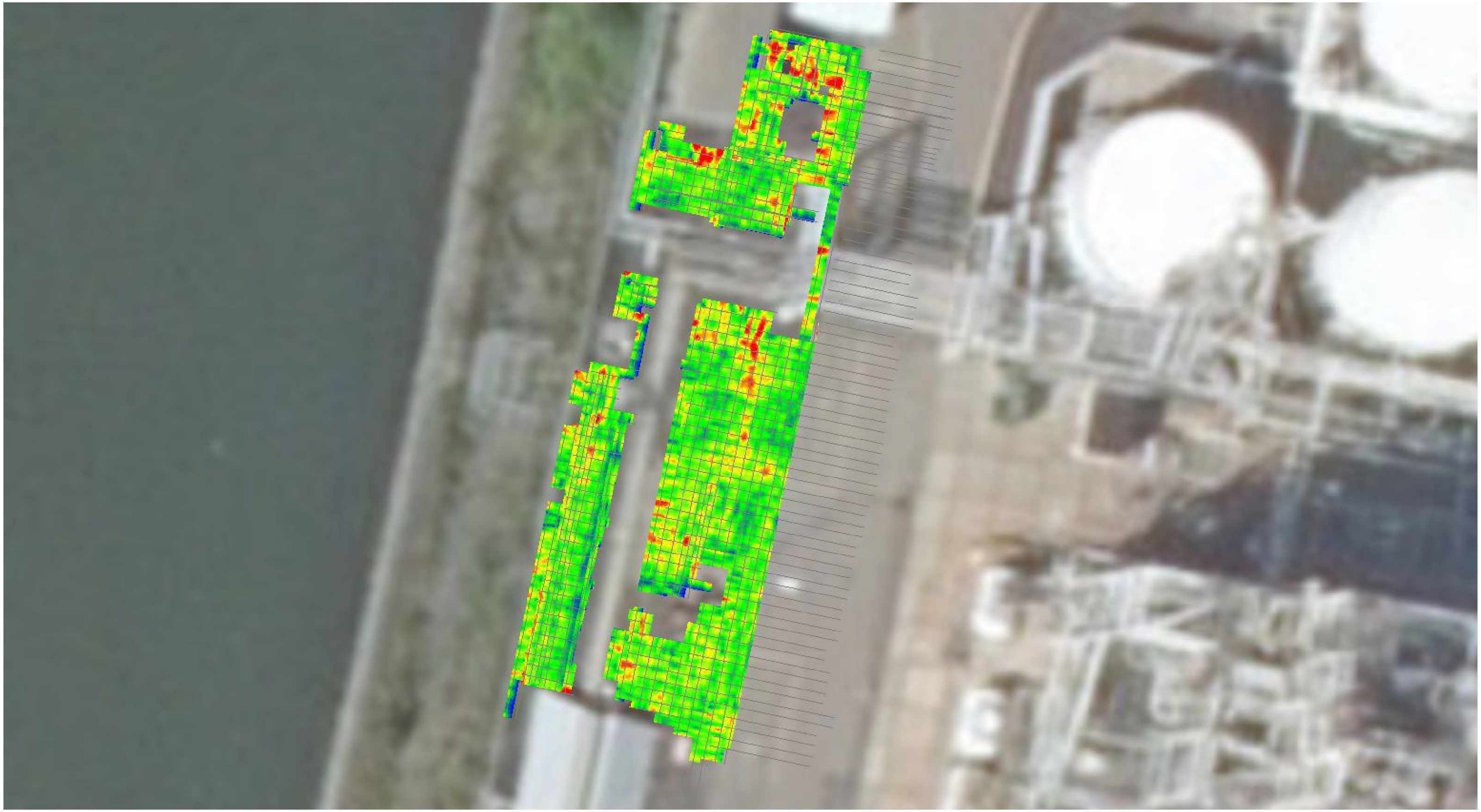
Depth Section @ 2.10m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

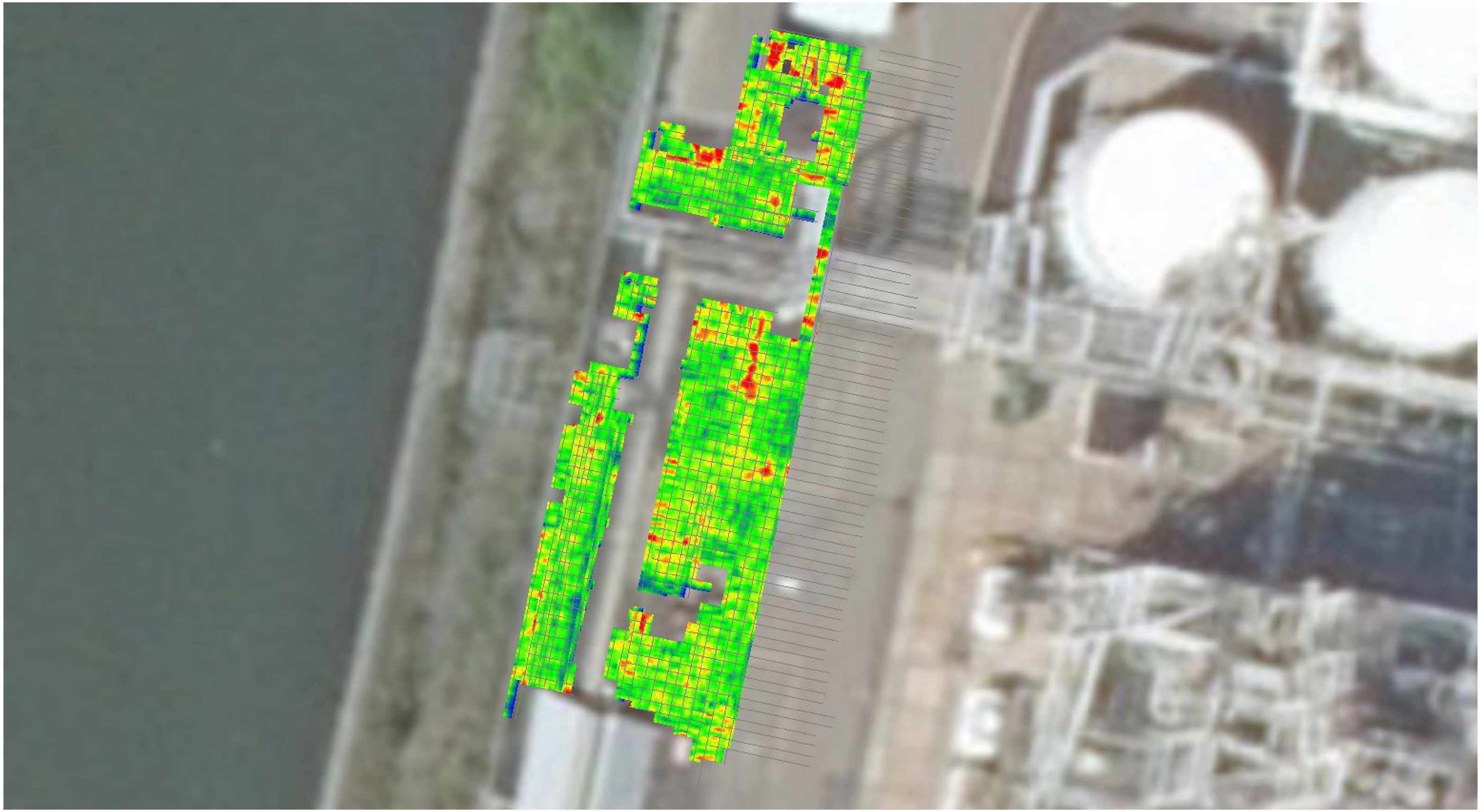
Depth Section @ 2.15m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

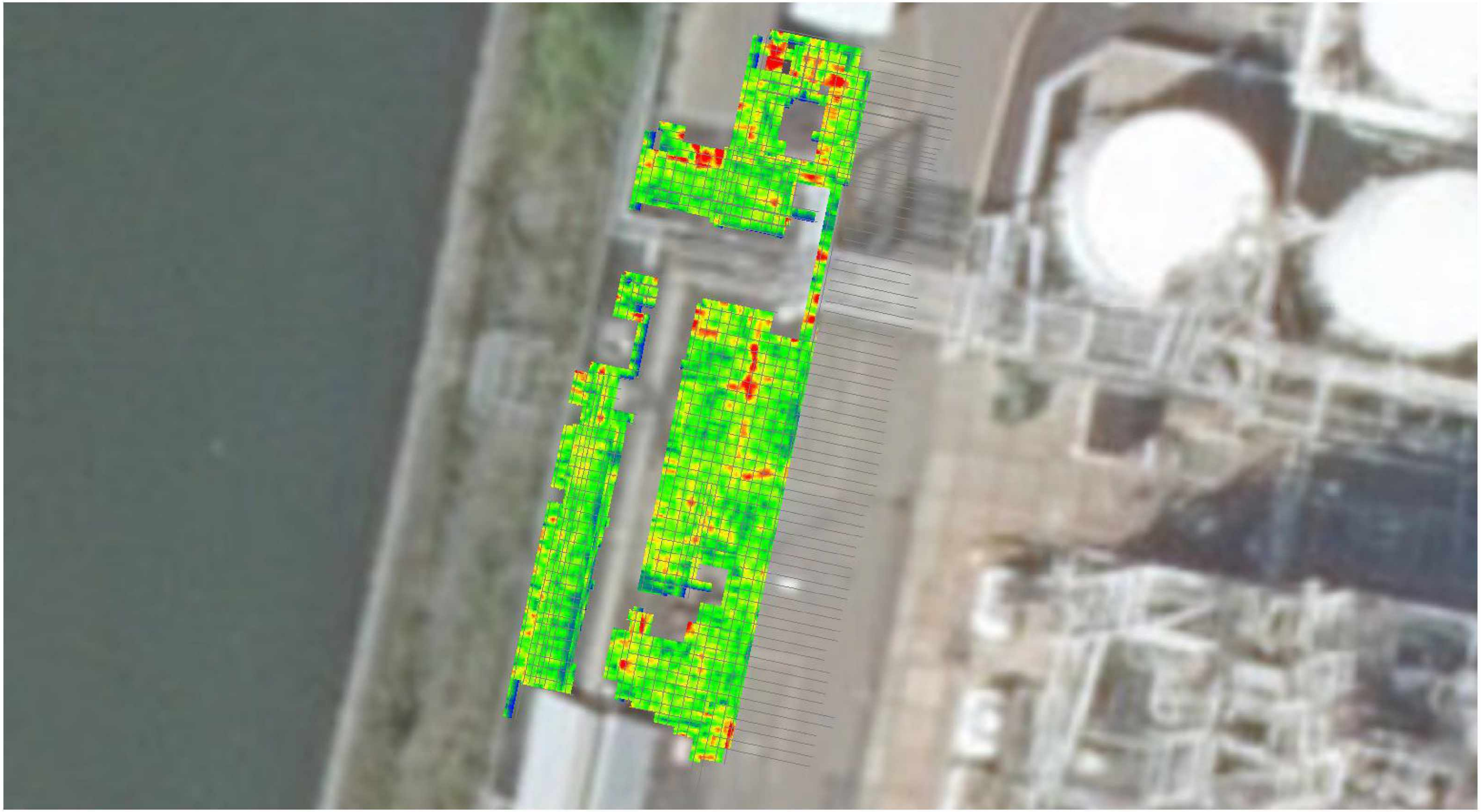
Depth Section @  2.20m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

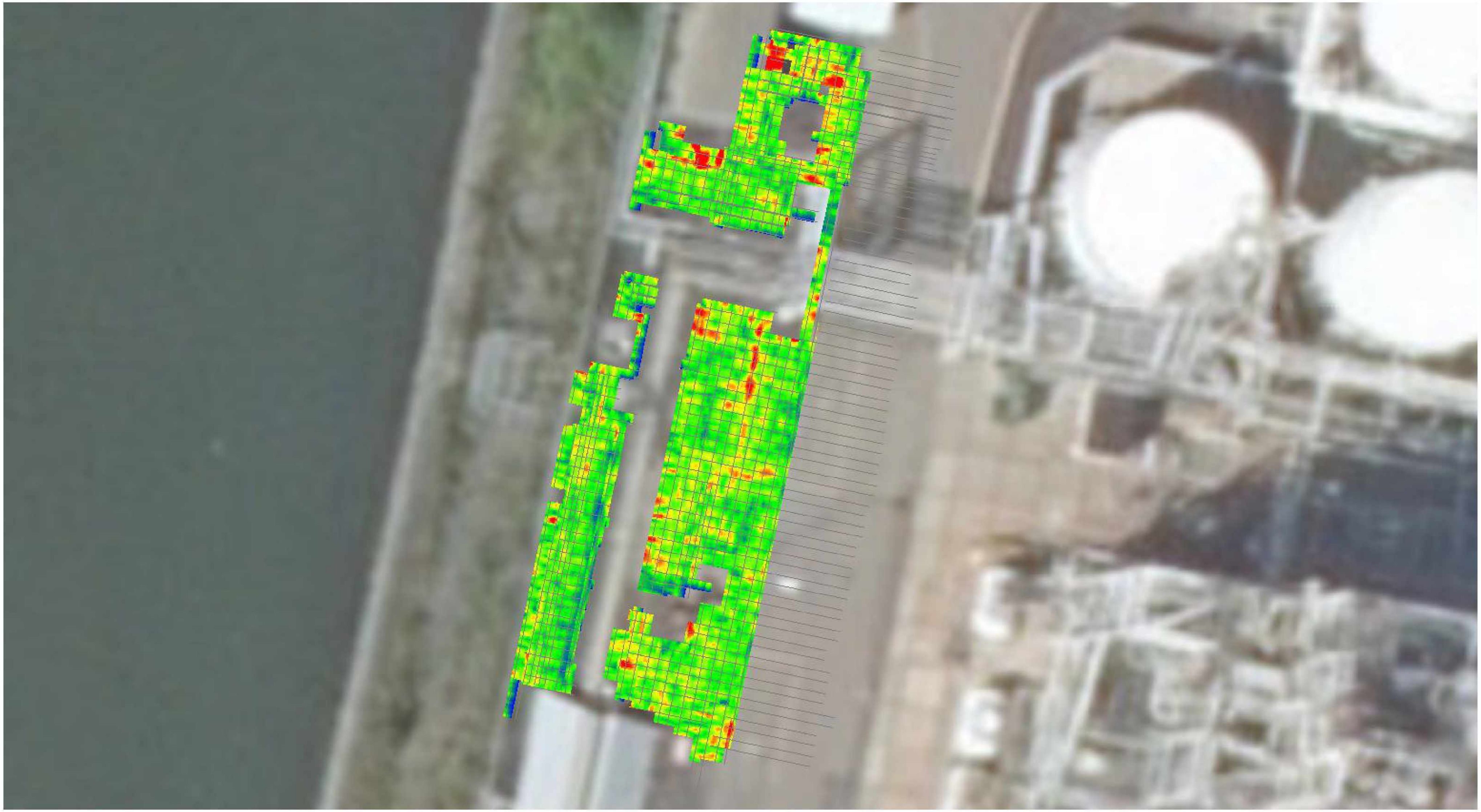
Depth Section @  2.25m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

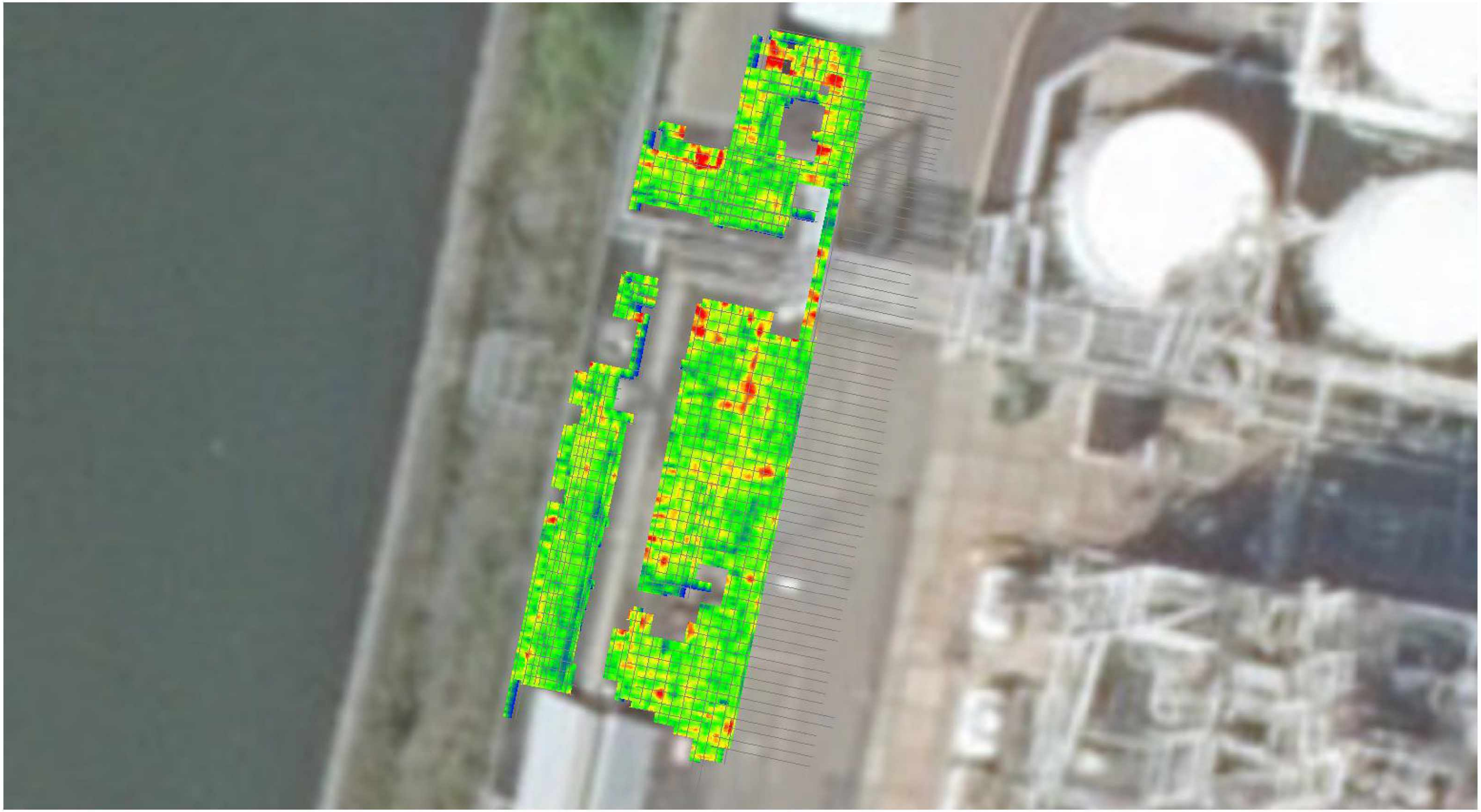
Depth Section @  2.30m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

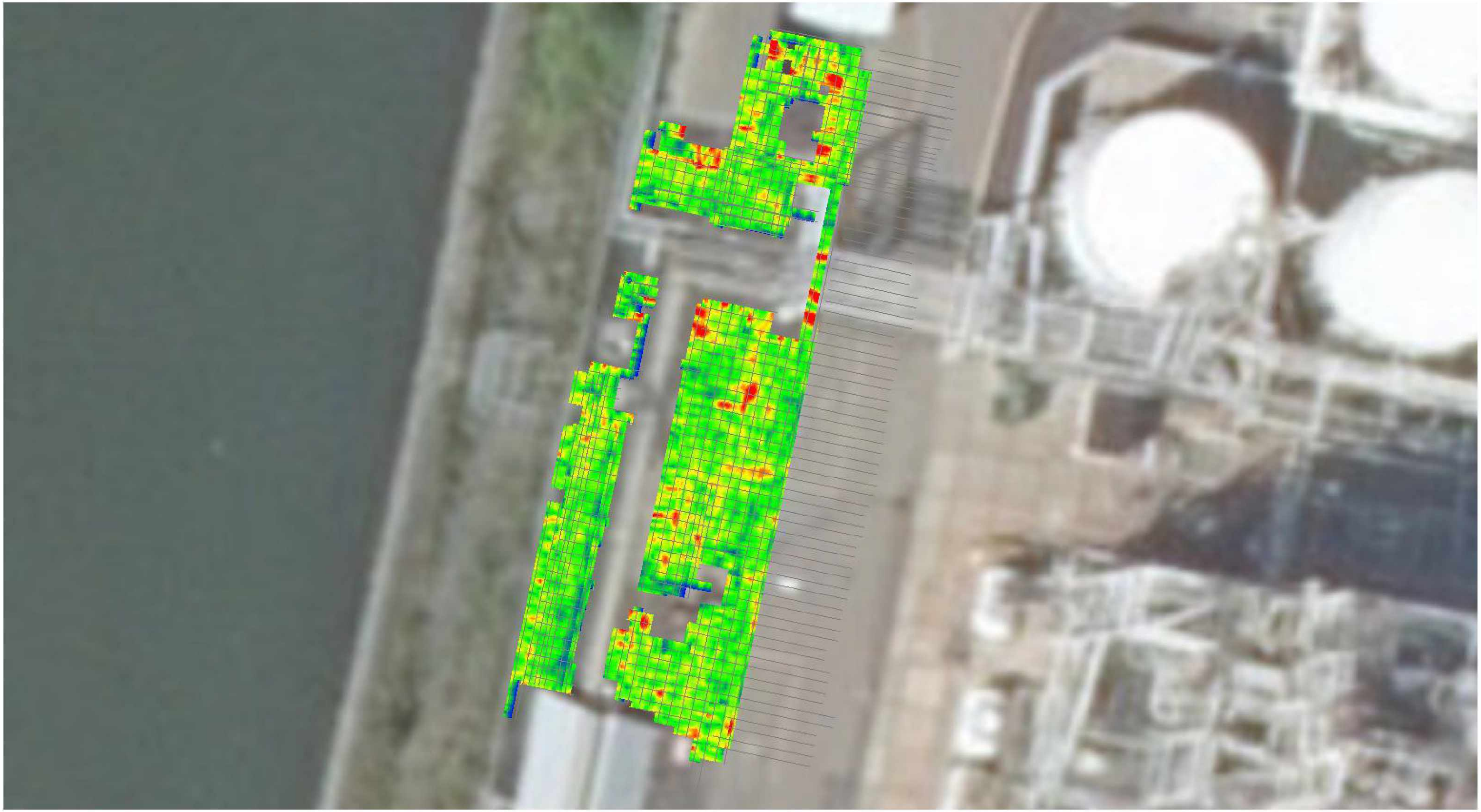
Depth Section @ 2.35m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

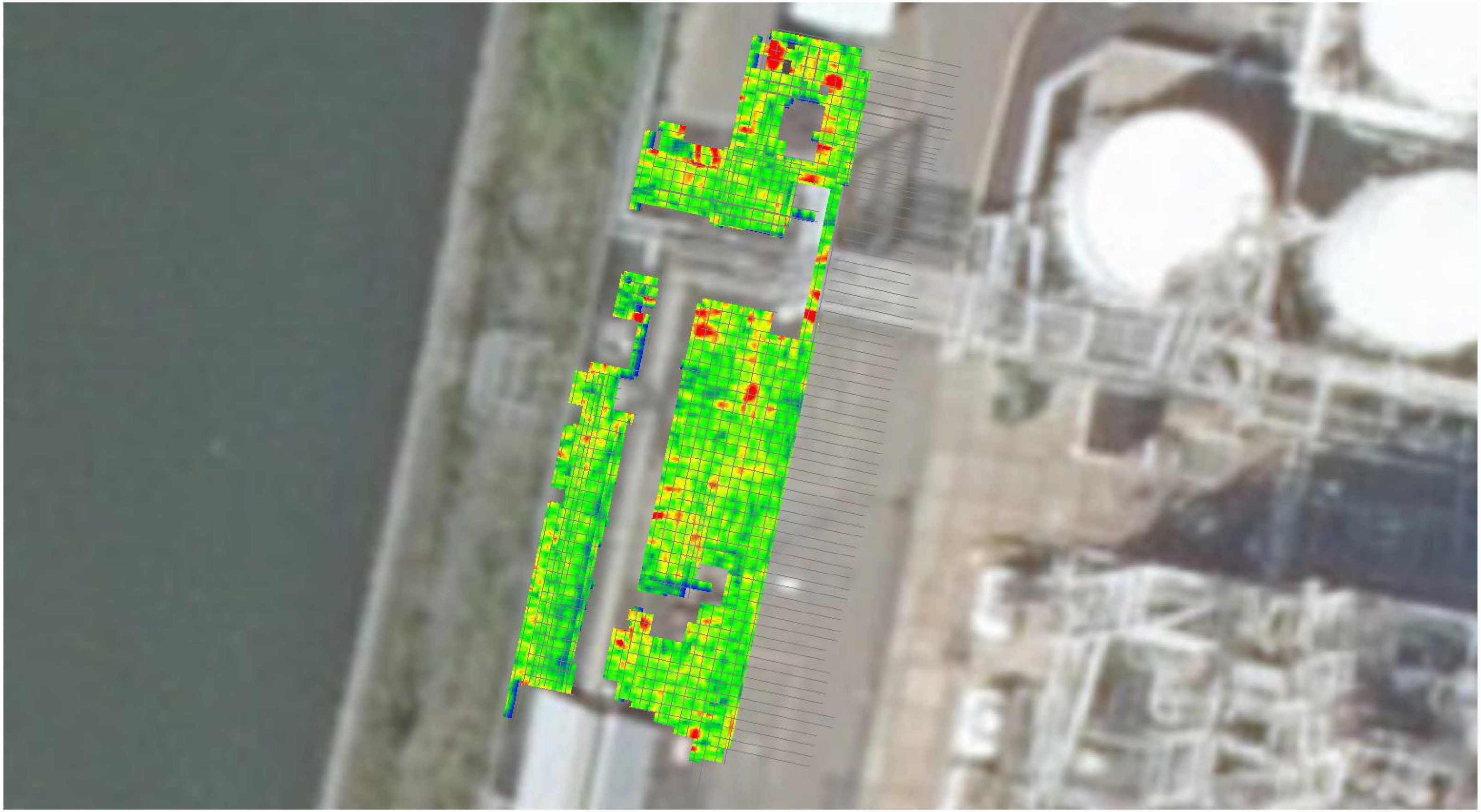
Depth Section @  2.40m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

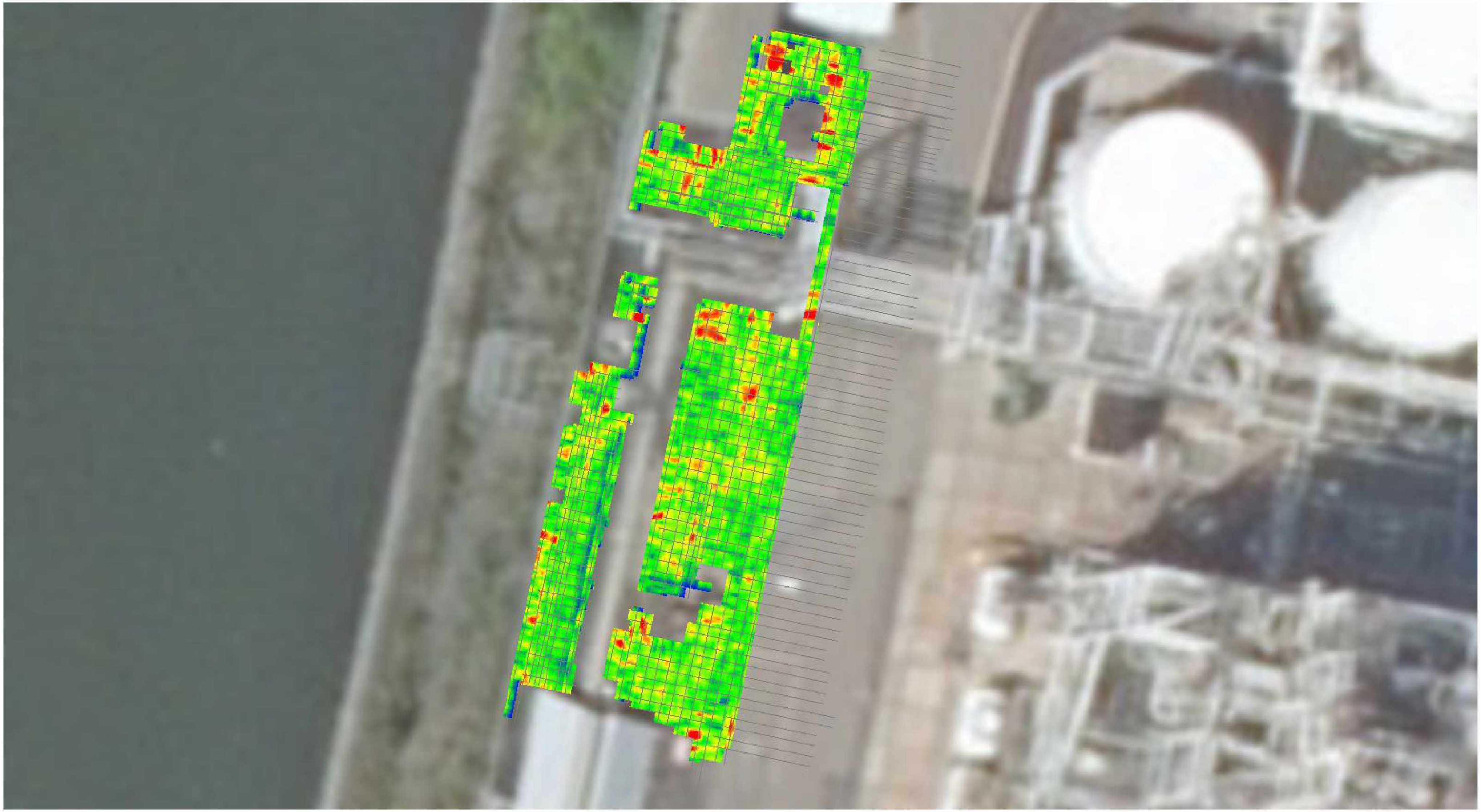
Depth Section @ 2.45m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

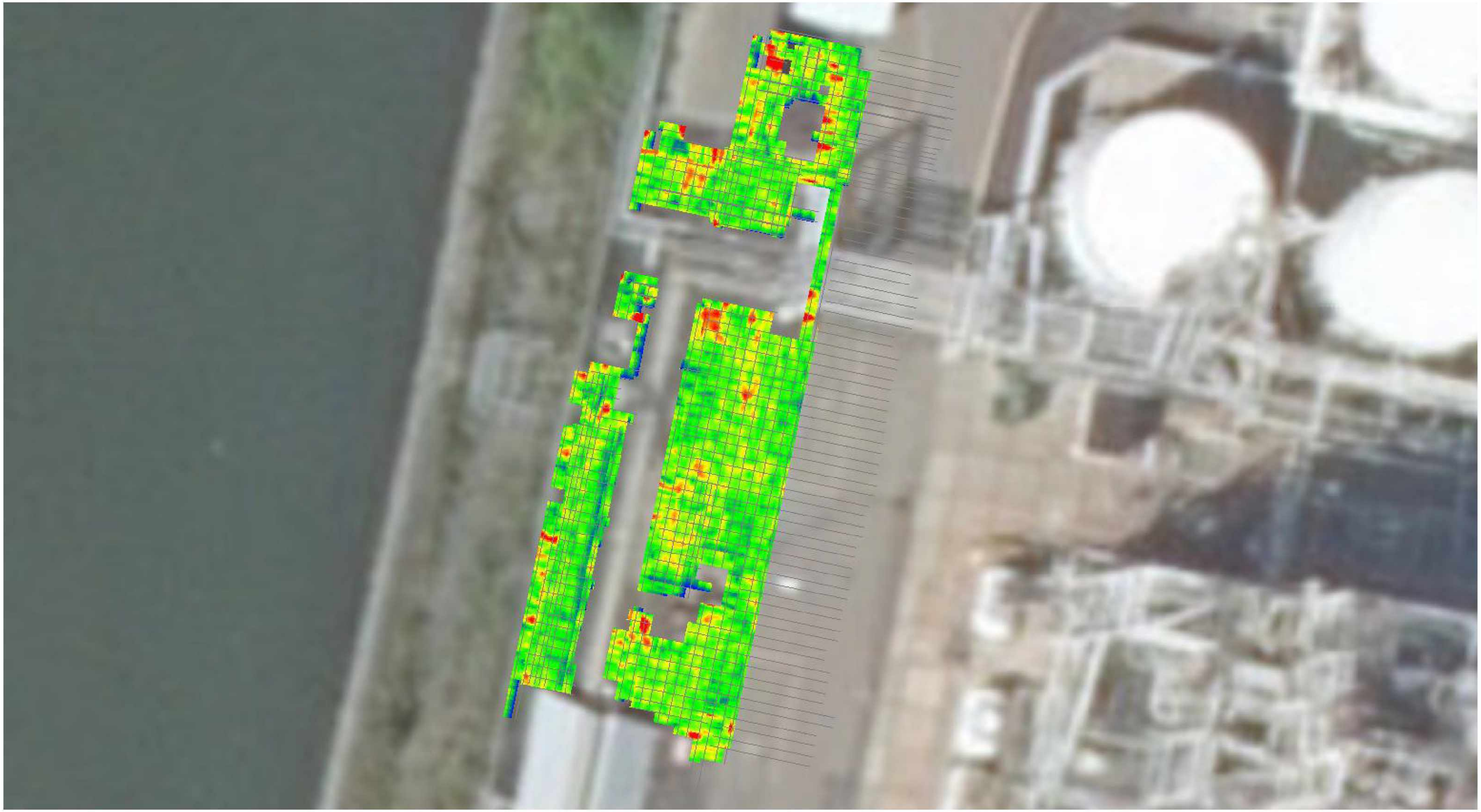
Depth Section @  2.50m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

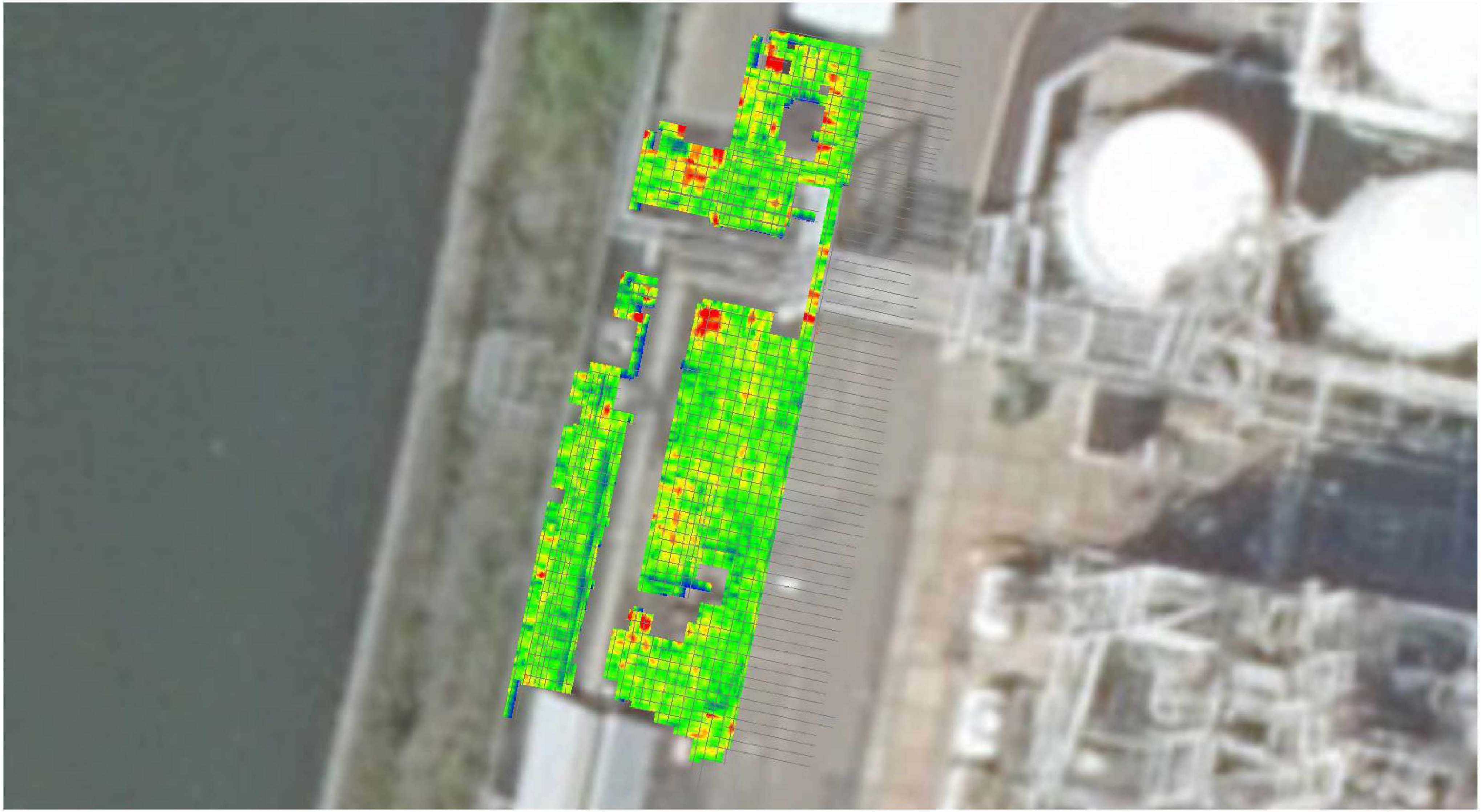
Depth Section @ 2.55m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

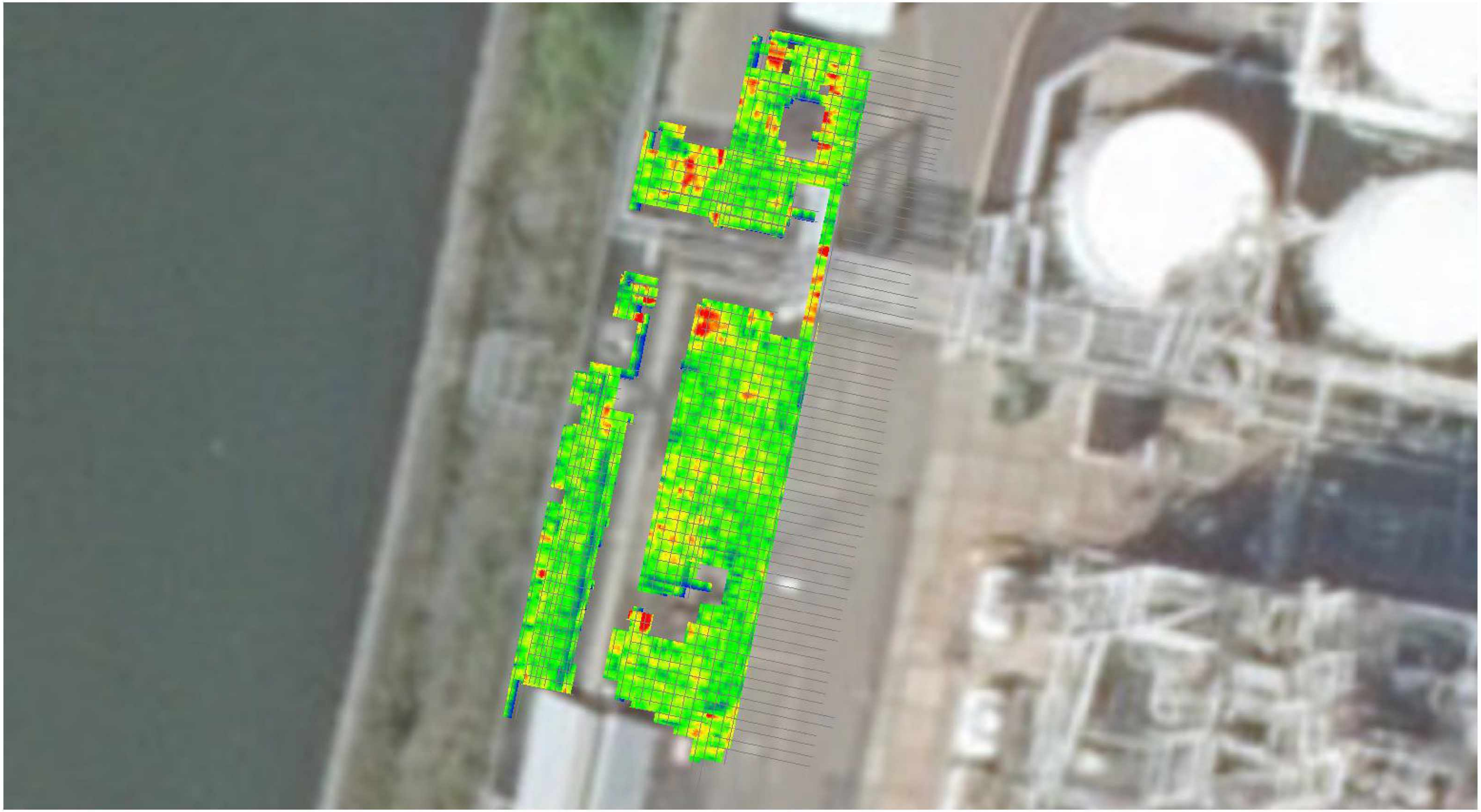
Depth Section @  2.60m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

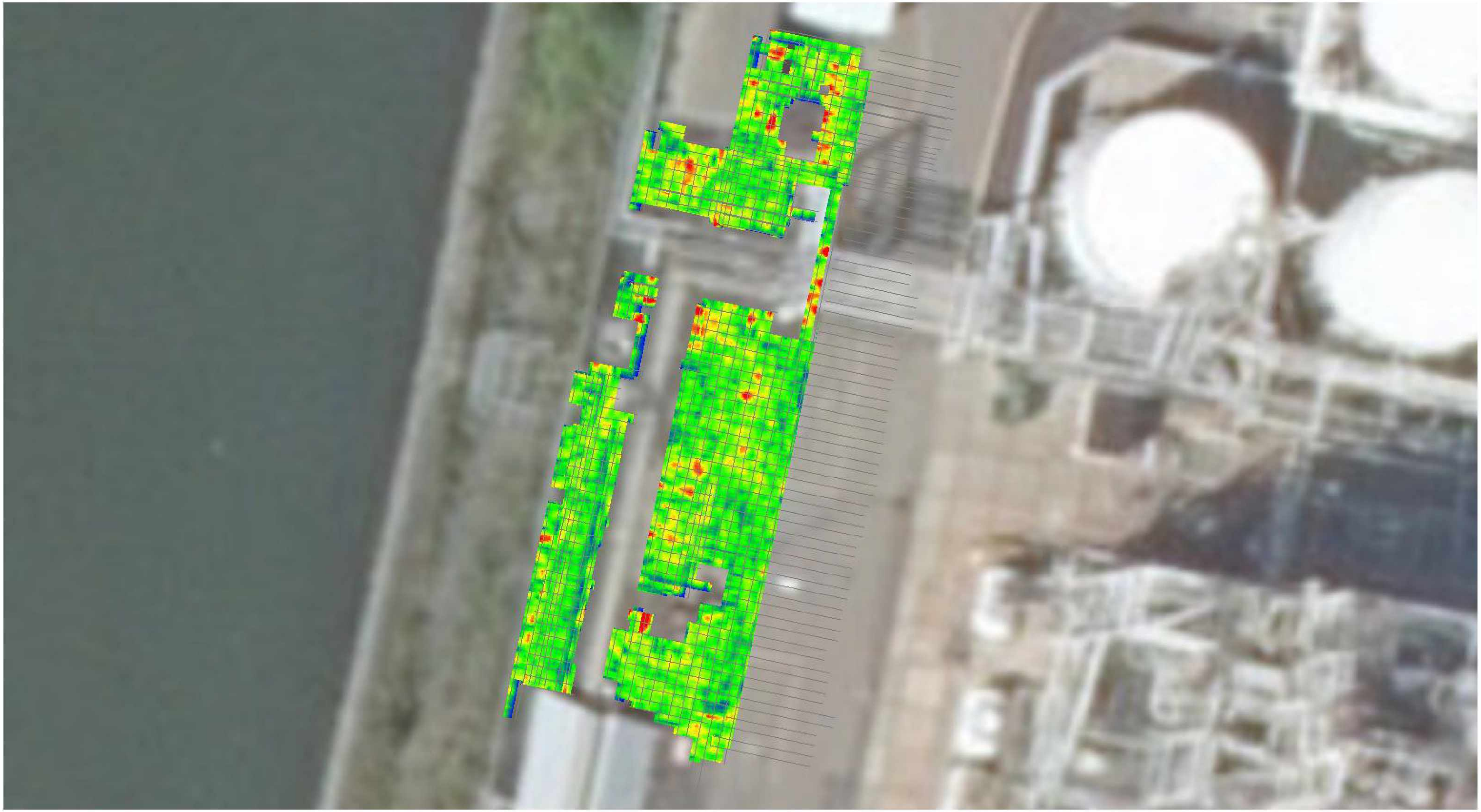
Depth Section @ 2.65m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

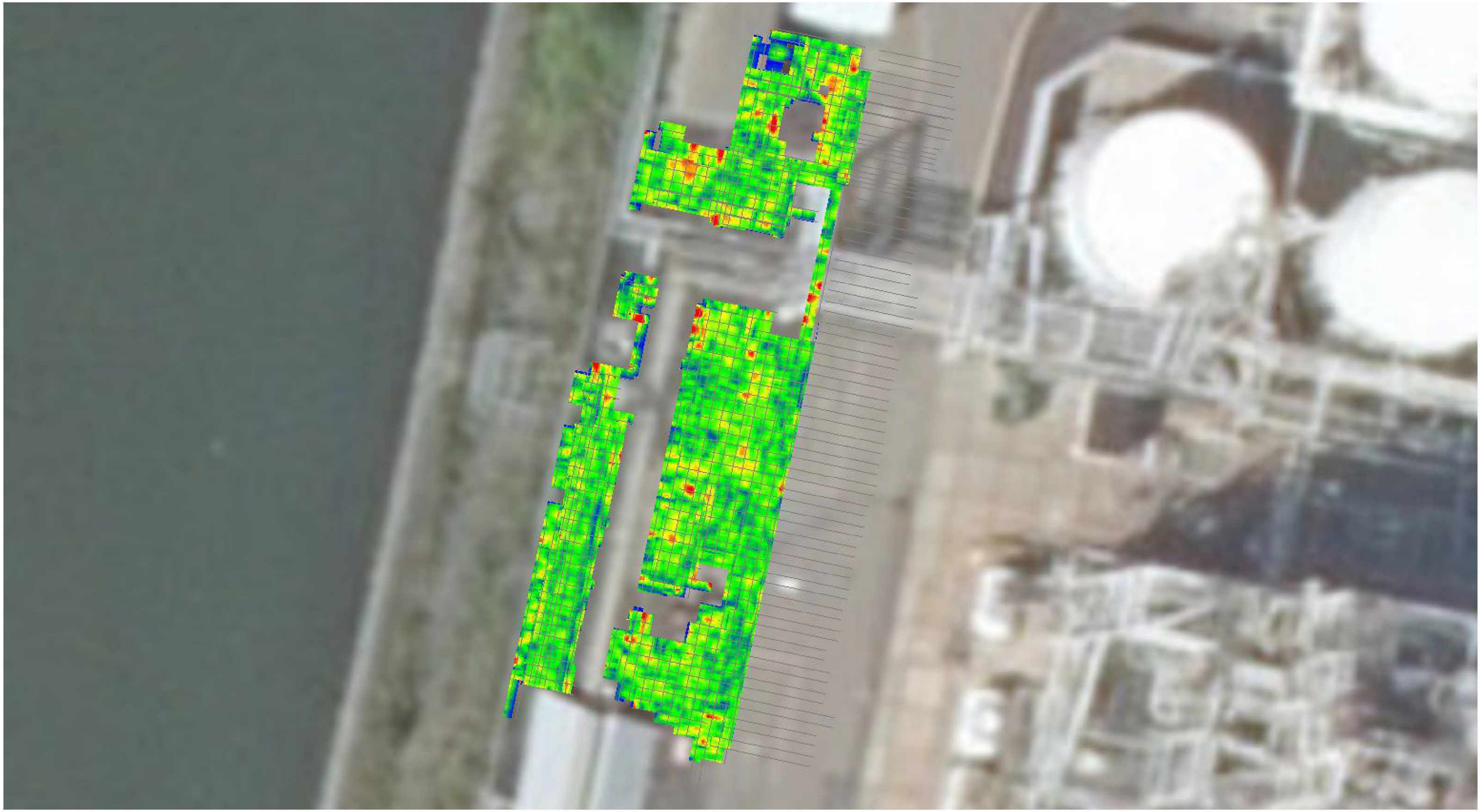
Depth Section @ 2.70m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

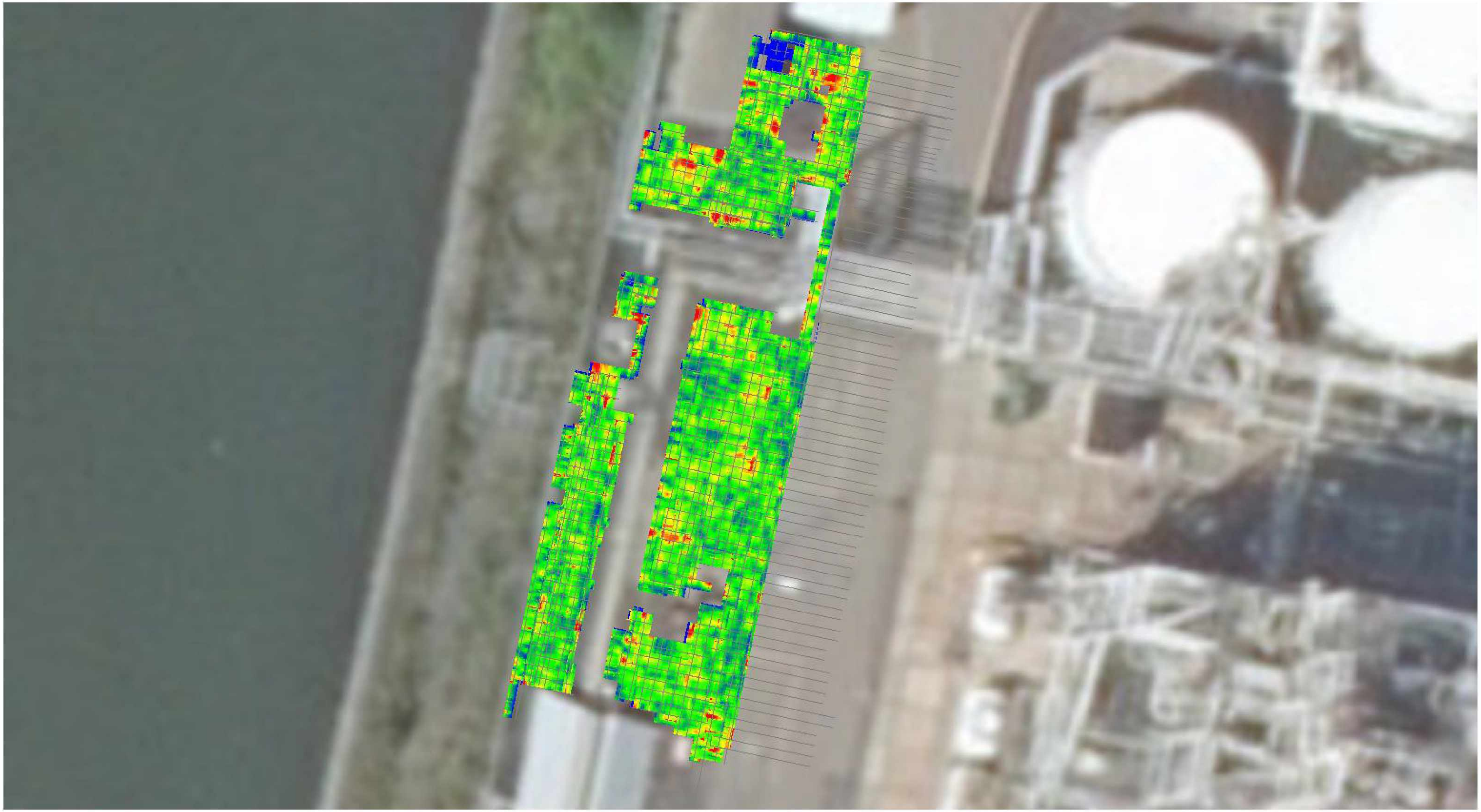
Depth Section @  2.75m-Surface



Red areas indicate areas with higher dielectric contrast

Fugro NL Land B.V. commissioned by Fluor Consultants B.V.
Ground Radar Investigation for utilities on the site of Chemours, Dordrecht

Depth Section @ 2.80m-Surface



Red areas indicate areas with higher dielectric contrast

# Appendix C: CAD Utility map

# OVERVIEW

**Legend:**

| | |
|---|---|
| Utility - Possible Underground city water | |
| Utility - Possible Fire Protection Line | |
| Utility - Unknown | |
| Local Anomaly - Possible Utility observed in longitudinal lines (NE-SW) | |
| Local Anomaly - Possible Utility observed in cross lines (NW-SE) | |
| Depth anomalies in m | 1.0 |
| GPR lines | |
| Measured Objects - Ground Level | |
| **Used Coordinate System** | PLANT coordinate system |

| | | | | |
|---|---|---|---|---|
| FUGRO | | | | Version 1.0 |
| | | | | Scale 1 : 64472 |
| **OVERVIEW DRAWING** | | | 0 644.7 1289.4 1934.1 2578.9 3223.6 m | |
| Ground radar investigation on the site of Chemours in Dordrecht, Netherlands<br>Client: Fluor Consultants B.V. | | | | Format A1 |
| Drw MB | Date 27-01-2021 | Status Draft | Project Number 1520-182933 | App 1 |

# OVERVIEW

**Legend:**

| | |
|---|---|
| Utility - Possible Underground city water | |
| Utility - Possible Fire Protection Line | |
| Utility - Unknown | |
| Local Anomaly - Possible Utility observed in longitudinal lines (NE-SW) | |
| Local Anomaly - Possible Utility observed in cross lines (NW-SE) | |
| Depth anomalies in m | 1.0 |
| GPR lines | |
| Measured Objects - Ground Level | |
| **Used Coordinate System** | RD coordinate system |

FUGRO

| | | | | |
|---|---|---|---|---|
| | | | | Version 1.0 |
| | | | | Scale 1 : 64 |
| **OVERVIEW DRAWING** | | | 0 0.6 1.3 1.9 2.6 3.2 m | |
| Ground radar investigation on the site of Chemours in Dordrecht, Netherlands<br>Client: Fluor Consultants B.V. | | | | Format A1 |
| Drw MB | Date 27-01-2021 | Status Draft | Project Number 1520-182933 | App 1 |