INTEGRATION OF SURFACE AND UNDERGROUND UTILITY NETWORK SURVEYING TECHNOLOGIES

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Abstract: *This article aims to present the main technologies used today in collecting data related to utilities networks. The paper summarizes both classical and modern surveying techniques in urban infrastructure mapping, techniques that can be used separately or in some cases integrated. Gathering above surface or underground details of utility network a complete geographic information system (GIS) can be developed. GIS enables the sharing of all available information about assets and operations throughout the utility line from a single comprehensive and authoritative source and supports the needs of multiple departments through a common set of applications.*

Keywords: *Utility infrastructure, GPR, above and underground utilities.*

1. Introduction

The client had a requirement to accurately map the existing underground utility network within a site boundary in Alkermes, Athlone. The survey was largely due to developers and contractors not carrying out accurate as built surveys on underground service utilities during the construction period. Our company was contacted by client and asked to provide a non-intrusive and accurate solution to their requirement. Therefore in obtaining a solution, we combined a number of survey methods together to achieve the required result. These methods included a ground penetrating radar survey incorporating a multi frequency array radar system, radio detection surveys and finally manhole surveys.

The main objective for this project was to detect, record and map all the utilities above and below ground as outlined in red on survey map. That was achieved utilising various techniques such as sonde surveys, radio detection surveys, ground penetrating radar surveys, pulse wave generators and any existing records that maybe available, all methods beeing non-intrusive.

As the main investigative techniques used were largely non-destructive, the findings given in this paper are based on indirect measurements and the interpretation of acoustic, electrical and electromagnetic signals. The findings represent the best professional opinions of the authors, based on our experience and the results of non-intrusive pipe location carried out elsewhere on similar materials and projects.

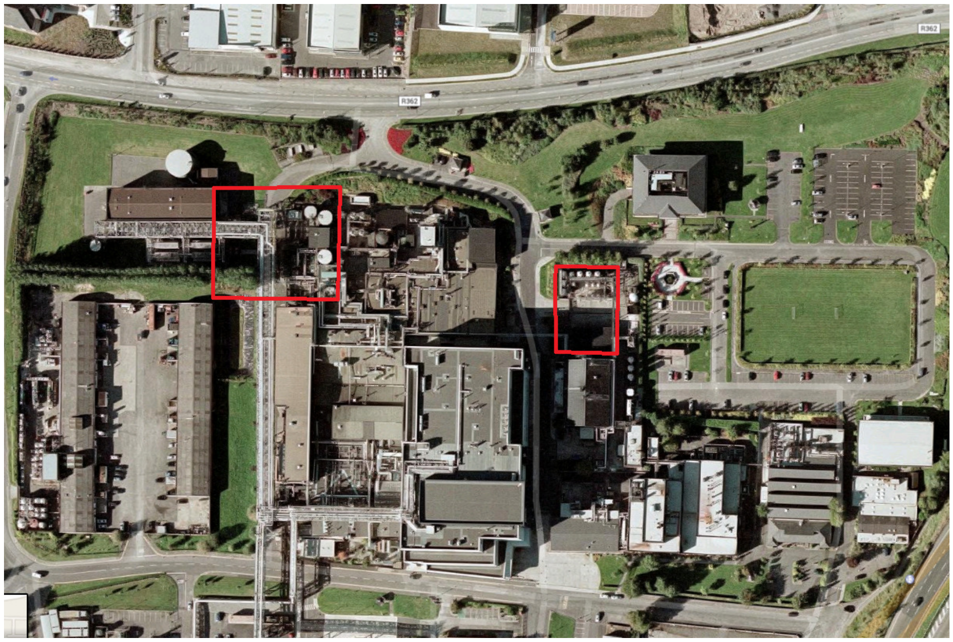


Fig. 1. Survey area highlighted in red

2. Sequence of works

1. Entering site sign in at security desk, all staff had Hi- Vis vest and ID badge. To ensure the safety, the company:
   - Kept all gates closed.
   - 3 point barrier around manhole, supervised by surveyor
   - All survey equipments were attended at all times
2. Liaise with site representative each morning regarding work for complete day.
3. Manholes inspection and record of invert and cover level with type of services, material, diameter, top of pipe level, flow direction. No confined space entry is required to tanks or access to top of tanks.
4. Live marking with crayon/paint radio detection survey with RD4000 and in-pipe emitter.
5. GPR Grid setup for Scan at 2 meter intervals (transaxial), and a longitudinal survey scan of entire area (blanket survey) using a IDS Detector Duo ground penetrating radar system to cover survey area to produce a tomographic map for post processing & interpretation & creation of 2D plan drawing.

As per document " The Survey Association – Guidance Note to Utility Surveys" 'In good ground conditions and within the depth range of two meters the ability to detect an underground utility (applies to all material types) will reduce in diameter by 1mm for each 10mm of depth. I.e. a 200mm pipe can be detected at 2m and a 50mm pipe at 0.5m but a 25mm plastic water service pipe to a house cannot be detected at 1.2m with radar. Furthermore small diameter plastic gas and water pipes laid at a depth of one meter or more maybe undetectable.

6. Survey of grid points and utility lines using GPS/Total Station.
7. Leaving site each day all personnel will sign out with security.
8. Download, process and interpretation of survey field data.
9. Compile all results in 2D AutoCad format.

Access wasn't required to chambers and manholes. Access was only be required to obtain invert levels within the manholes. Where any cover lifting was necessary the work area was made safe using barriers, cones and signs. At no time the surveyor entered the manhole. Measurements were taken from the cover lid using a level staff.
All survey works were carried out in safe manner and the survey site maintained so that it functions safely and efficiently. A Risk Assessment was carried out by the Safety Advisor and the precautions and actions recommended were adhered to bearing in mind that we were surveying in an active workplace with moving pedestrian and vehicular traffic.

3. Survey

The survey investigation works were carried out in April 2015.
The successful detection and mapping of buried utilities involves the combination of several techniques, the results of which are synthesized down to a single interpreted plot. The techniques and methodologies used will primarily depend upon the required outcome for the survey, the site conditions and the type of pipes or cables being targeted.
There were some areas were GPR radar scan couldn't be carried out due to the rough ground conditions and area being obstructed so in those areas there were used existing plans supplied by the utilities providers as are shown below:

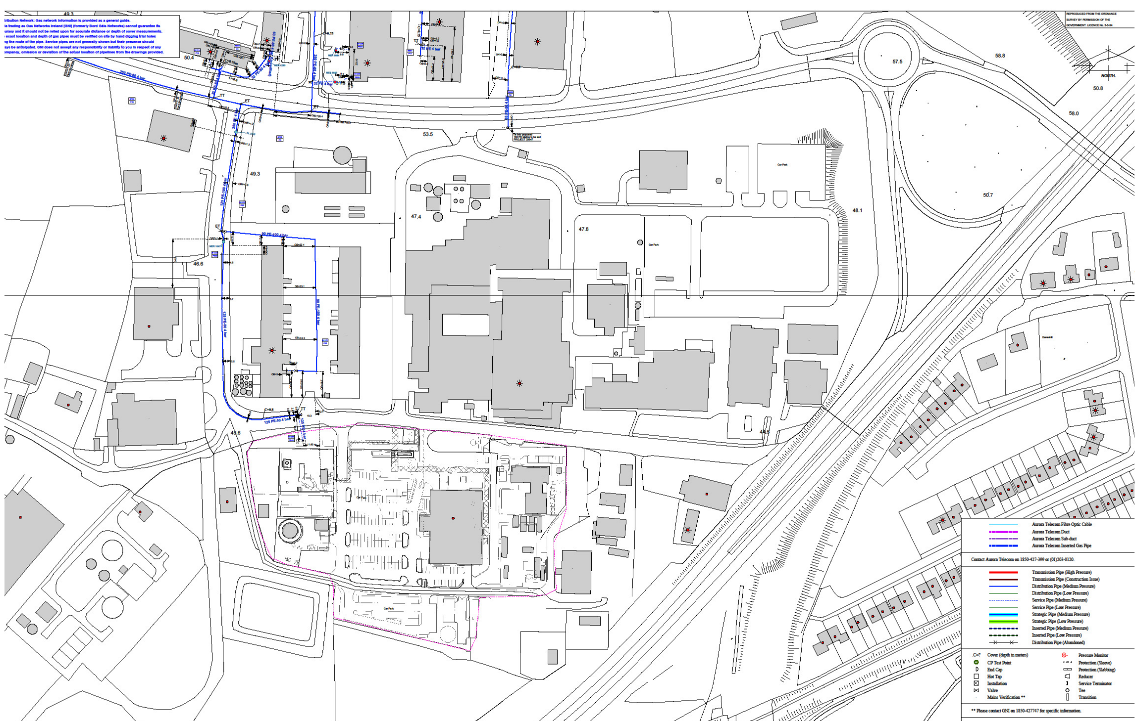


Fig. 2. Provited plan of gas ducts

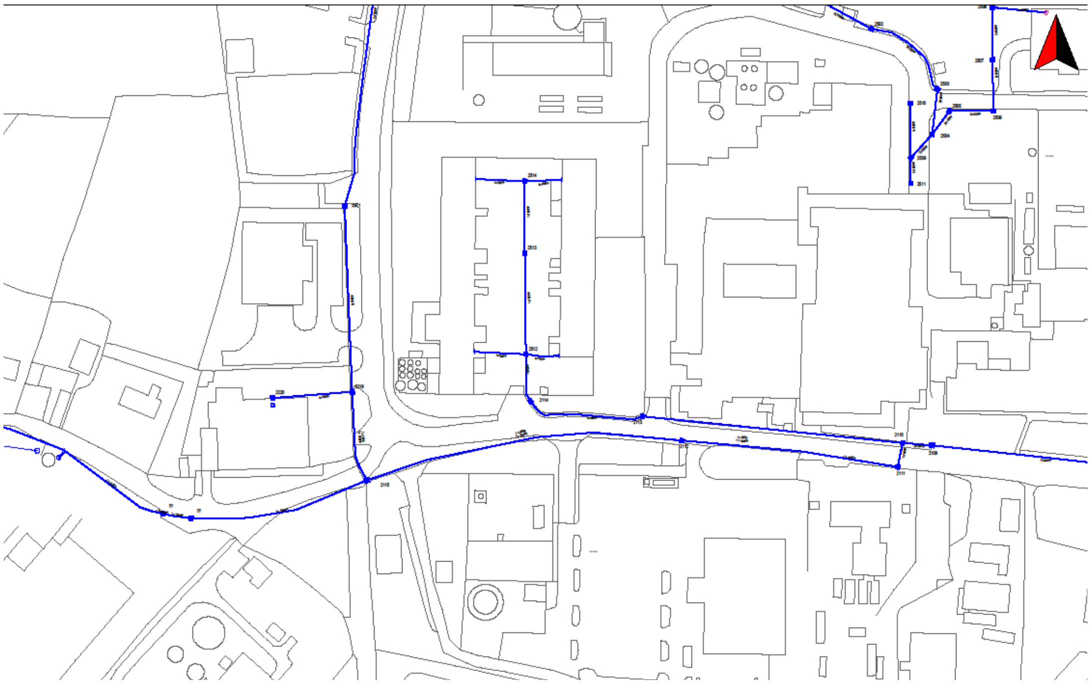


Fig. 3. Provited plan of telecom network

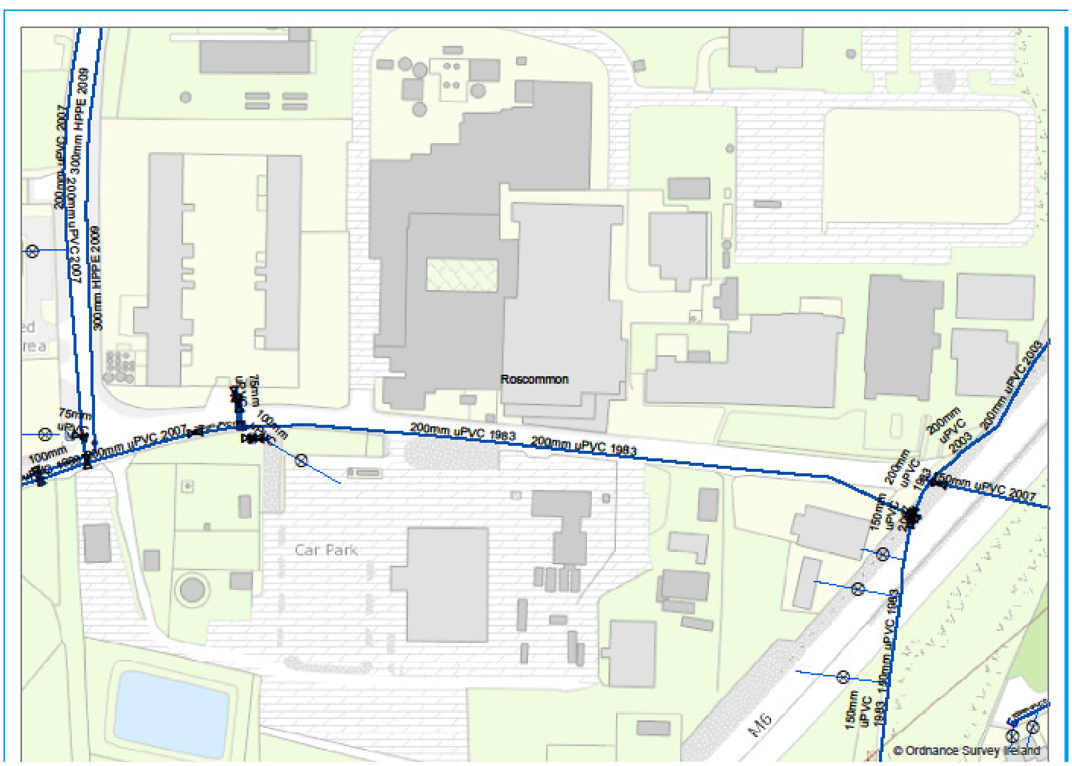


Fig. 4. Provited plan of water network

4. Surface utility network survey

Survey crew surveyed all visible utilities using Leica 1203 Total station (General accuracy=1mm+1.5ppm/typ 2.4s, Angular accuracy=3") and Trimble R6dGPS (220 channel system with Trimble R-track satellite tracking technology). The surveyors opened manholes and record and photograph all details found in site.
All data collected was post process in Autodesk Civil 3D and analyzed and all survey information is reference onto a topographical survey drawing.

Fig. 5. Site photos

In some of the site areas it the crew couldn't survey all details using modern technologies (such as GPR or TPS) so form were completed in the field. All that collected data was added manually at the office on the utily plan as it is shown below:

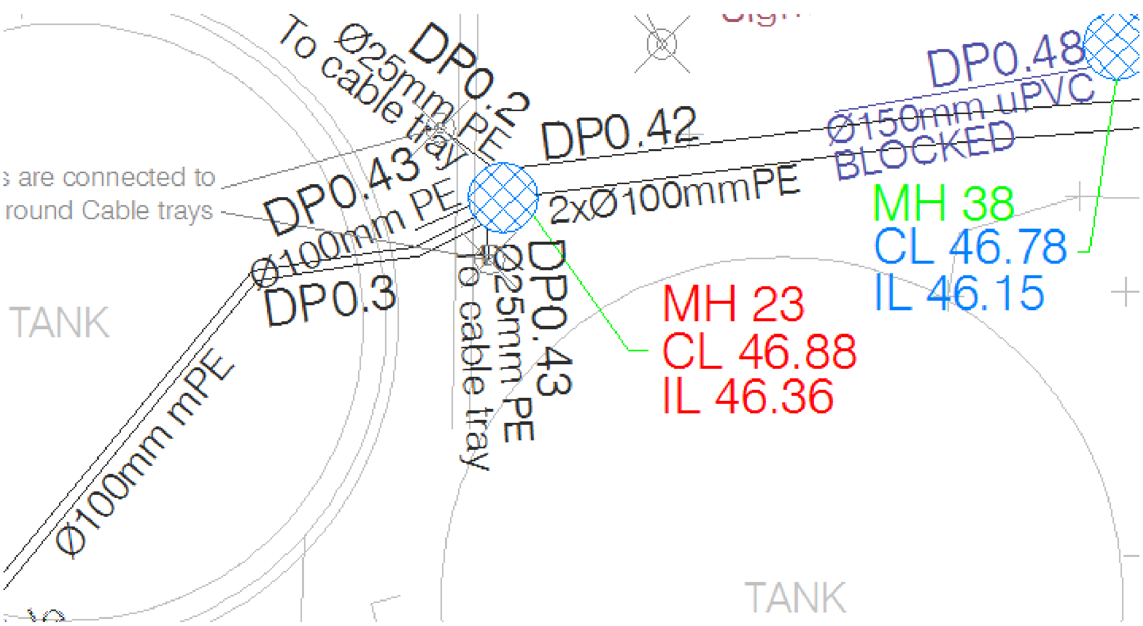
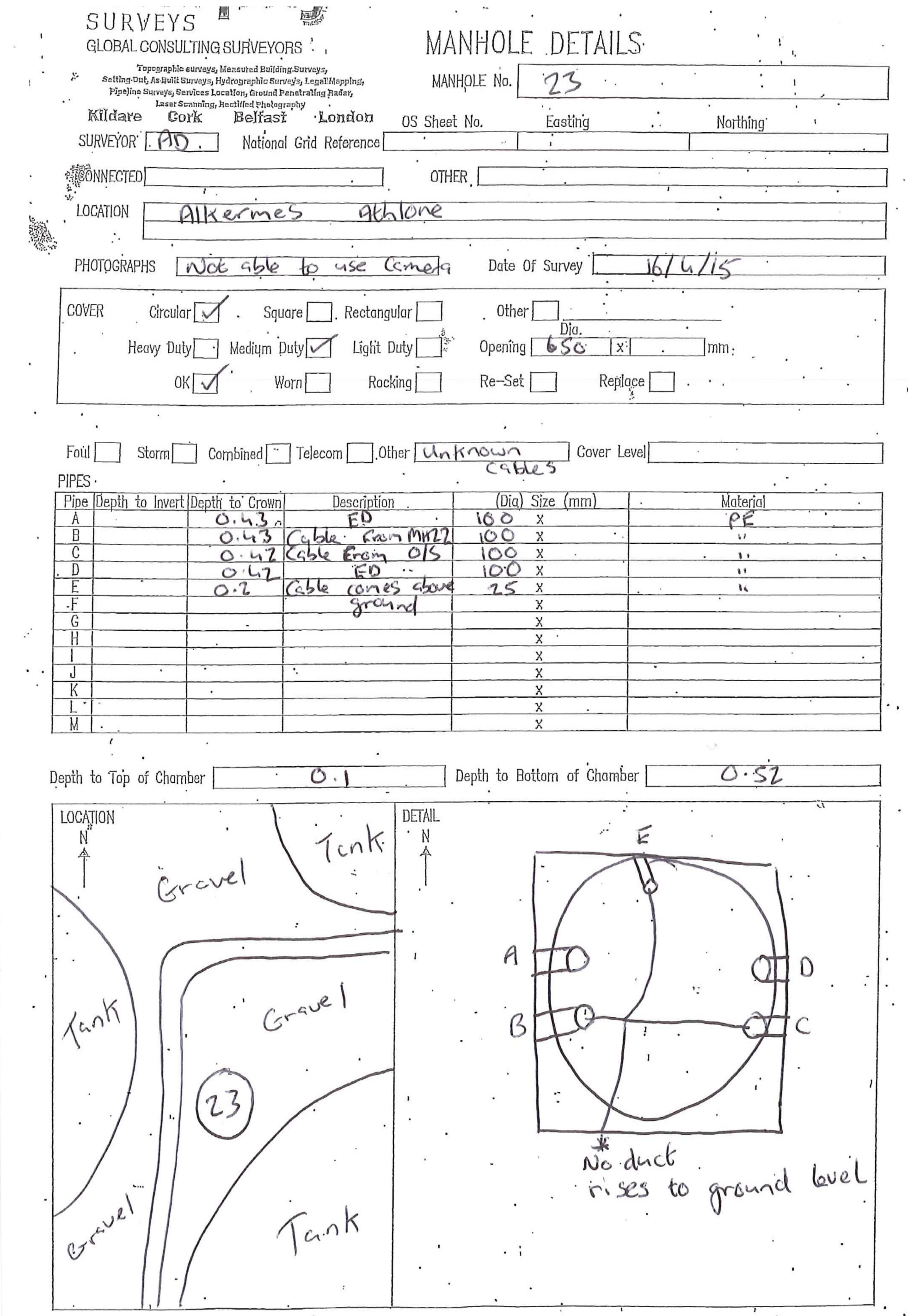


Fig. 6. Manhole details added manualy using the form



SURVEYS
GLOBAL CONSULTING SURVEYORS

Topographic surveys, Measured Building Surveys, Setting-Out, As-Built Surveys, Hydrographic Surveys, Legal Mapping, Pipeline Surveys, Services Location, Ground Penetrating Radar, Laser Scanning, Rectified Photography

Kildare Cork Belfast London

MANHOLE DETAILS

MANHOLE No. 23

OS Sheet No. Easting Northing

SURVEYOR AD National Grid Reference

CONNECTED OTHER

LOCATION Alkermes athlone

PHOTOGRAPHS Not able to use Camera Date Of Survey 16/4/15

COVER Circular ✓ Square Rectangular Other

Heavy Duty Medium Duty ✓ Light Duty Opening Dia. 650 x mm

OK ✓ Worn Rocking Re-Set Replace

Foul Storm Combined Telecom Other Unknown Cables Cover Level

PIPES

Pipe	Depth to Invert	Depth to Crown	Description	(Dia) Size (mm)	Material
A		0.43	ED	100 x	PE
B		0.43	Cable from MH22	100 x	"
C		0.42	Cable from O/S	100 x	"
D		0.42	ED	100 x	"
E		0.2	Cable comes above ground	25 x	"
F				x	
G				x	
H				x	
I				x	
J				x	
K				x	
L				x	
M				x	

Depth to Top of Chamber 0.1 Depth to Bottom of Chamber 0.52

LOCATION N

Gravel Tank Tank Gravel 23 Gravel Tank

DETAIL N

E A D B C

No duct rises to ground level

Fig. 7. Manhole description sheet completed on field

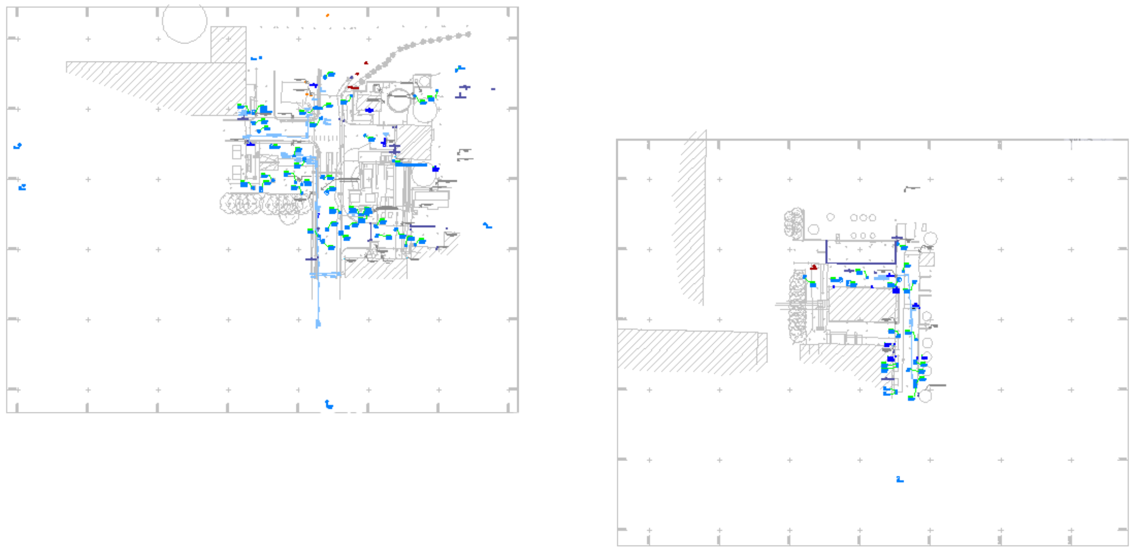


Fig. 8. Surface utility details reduced on topographical plan

5. Underground utilities survey

A number of different GPR grids were set out over the site. Data field files were collected with a multi frequency array antenna system to give maximum depth penetration whilst maintaining a high resolution at both shallow and deep depths. Full calibration was carried out at the start scan with constant quality monitoring during acquisition and frequent recalibration checks were carried out where necessary.

Depth readings from GPR rely on multiplying the measured two-way travel time by the velocity of the radio signals passing through the materials under investigation. As the surface and subsurface of the site changes, frequent recalibration of the subsurface velocities results in an accurate calculation of depths and thicknesses of located features relative to the surface.

Where possible, the whole site was covered by a tight GPR grid, using Multi Frequency Array systems, in order to detect any sub surface utilities not located by other methods and to ascertain depths of all targets.

Post site processing then took place at the office, using specialized software, Gred/In/Road. A number of processing stages were involved, including start time correction, amplitude gain adjustments, Gaussian filtering, dynamic correction and noise removal. Once the raw data was processed individual targets were identified on each survey line and linear features mapped out over the survey areas. These GPR results are then incorporated into Autocad for final processing.

The radio frequency location equipment that used on site is the RD4000 cable locator. This has 4modes or methods of operation. These methods have been developed to fit particular circumstances of locating known and unknown utilities on site. The radio frequency locator is used at the same time as the GPR system to determine the line and depth of metallic pipes and cable services i.e. Gas, Electricity, Water, Telecoms, CATV and Sewers with the aid of Sonde equipment. The way in which the operators use this equipment is to start from a known point on a service and trace it using one or more of the four methods.

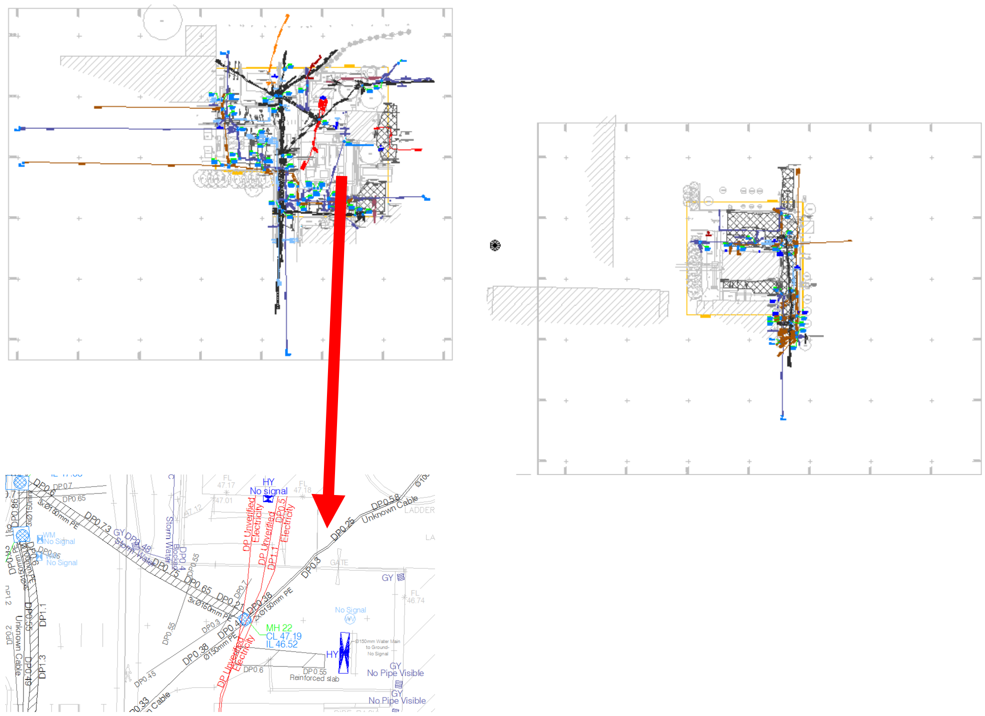


Fig. 9. All utility details reduced on topographical plan

6. Conclusions

The data collected from the utility survey has ranged from reasonable to a high quality from the various methods used across the site.
Although 100% detection of all utilities was not achieved using ground penetrating radar, the correlation using the combined methods of the radio detection survey, TPS survey, and the GPR survey yielded a very accurate set of results as opposed to carrying out each method independently or carrying out a desktop study only. However, due to the limitations based on site conditions, a 100% guarantee cannot be offered.
This paper represents the best professional opinion of the authors. Every effort has been made to ensure that all results are accurate and reliable. Ground Penetrating Radar is a well established technique to determine subsurface utilities, voids and anomalies.

7. References

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