

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 215

Onshore geophysical site survey - Radar Geophysical Survey

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1. Scope

The content of this General Technical Specification indicates the minimum standards required by Company for Ground Penetrating Radar (GPR) geophysical survey. However, should Company consider that any aspect of the work requires more detailed investigation, Company reserves the right to apply further Particular Technical Specifications.

All Equipment and Materials necessary to complete the survey in accordance with this Contract shall be supplied by Contractor. Such Equipment and Materials shall include all spare parts and spare Equipment units as may be necessary to provide normal and continuous operations, and shall be in good operating condition prior to start of mobilization.

Such Equipment shall be properly maintained in such a way as to assure accuracy within the tolerances set by the manufacturer for such Equipment. Contractor undertakes to provide a statement of the surveying accuracy of this Equipment.

The Work defined in these Specifications shall be performed in accordance with the Agreement.

The Work shall include the following phases:

- **Data acquisition phase**
- **Data processing phase:** This phase is to be carried out in conjunction with data acquisition in order to be sure that survey objectives have been reached
- **Interpretation phase.**

Reports shall include measured and computed data and interpreted maps as per objectives of the Particular Technical Specifications.

The final product shall be an Expert Report.

The scope of the Work is included in the Particular Technical Specifications.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
ASTM D 6432 -11	Standard Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation
ISO 80000-1	Quantities and units – Part 1 General

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Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP GEO 210	Onshore Geophysical Site Survey - Cross hole geophysical survey
GS EP GEO 211	Onshore Geophysical Site Survey - Seismic refraction geophysical survey
GS EP GEO 212	Onshore Geophysical Site Survey - Multichannel surface waves geophysical survey
GS EP GEO 213	Onshore geophysical site survey - Micro-Gravity Geophysical Survey
GS EP GEO 214	Onshore geophysical site survey - Electric Geophysical Survey
GS EP GEO 216	Onshore geophysical site survey – Electro-Magnetic Geophysical Survey
GS EP GEO 401	GIS requirements for engineering site surveys and studies
GS EP GPA 202	Seismic HSE for Land Activities
GS EP POS 003	Onshore land surveying and positioning works
GS EP POS 004	The use of Differential Global Navigation Satellite System

3. Ground Penetrating Radar survey objectives and methodology

3.1 GPR survey objectives

Ground Penetrating Radar is an electromagnetic geophysical method for high-resolution detection, imaging and mapping of subsurface soils and rock conditions, from the near-surface to a depth of few tens of meters. In particular cases, such as cold ice environments, a few hundred of meters can be reached.

Field applications are numerous and concern either geological, engineering, environmental or archaeological surveys:

- Determination of the thicknesses of soil horizons and depth to the water table
- Detection of air-filled subsurface cavities, buried channels and tunnels
- Mapping of contamination plumes, hydrocarbon leaks
- Non-destructive checking of road layers, masonry structures and bridge piers
- Detection of buried objects in archeological surveys
- Determination of ice or permafrost thickness
- Water content estimations from GPR velocity analyses.

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3.2 Methodology

A typical GPR system has three main components: transmitter and receiver directly connected to an antenna, and a control unit (timing). The transmitting antenna radiates a short high-frequency EM pulse into the ground, where it is refracted, diffracted and reflected as it encounters changes in dielectric permittivity, electric conductivity, and magnetic susceptibility. The strength, or amplitude, of the reflection is determined by the contrast in the respective properties of the two materials. It must be noted that in most geological environments, the magnetic susceptibility equals 1 and only electrical conductivity and dielectric permittivity will affect GPR wave propagation.

This means that a pulse which moves from dry sand (dielectric permittivity of 5) to wet sand (dielectric permittivity of 30) will produce a very strong reflection, while one moving from dry sand (5) to limestone (7) will produce a relatively weak reflection.

In most common surveys, the frequencies used extend from some ten MHz to some GHz. Antenna frequency is one major factor affecting depth penetration and vertical resolution. The higher the frequency of the antenna, the shallower into the ground it will penetrate, whereas the vertical resolution will be higher.

Electromagnetic waves travel at a specific velocity which is proportional to the inverse square root of the permittivity of the material.

$$V = \frac{C}{\sqrt{\epsilon_r}}$$

Where:

- V Velocity of electromagnetic waves
- C Speed of light in vacuum
- ϵ_r Relative permittivity of the material.

Table 1 gives dielectric permittivity and propagation velocity for different materials.

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Table 1 - Dielectric permittivity and propagation velocity for different materials

Material	Dielectric Constant (-)	Propagation Velocity (m/ns)
Air	1	.30
Ice (Frozen soil)	4	.15
Granite	9	0.10
Limestone	6	0.12
Sandstone	4	0.15
Dry sand	4 to 6	0.12 to 0.15
Wet sand	30	0.055
Dry clay	8	0.11
Wet clay	33	0.052
Asphalt	3 to 6	0.12 to 0.17
Concrete	9 to 12	0.087 to 0.10
Water	81	0.033
Metal	∞	0

Table 2 gives examples of radar wavelengths evolution for various antenna frequencies, associated with different materials.

Table 2 - Radar wavelengths (metres) for various antenna frequencies and velocities (m/s)

Material	air	ice	limestone	Granite	Wet sand	Water
Permittivity ϵ_r	1	4	6	9	30	81
Velocity in m/ns	0.300	0.150	0.122	0.100	0.055	0.033
Frequency in MHz	Wavelength in metres					
25	12.00	6.00	4.90	4.00	2.19	1.33
50	6.00	3.00	2.45	2.00	1.10	0.67
80	3.75	1.88	1.53	1.25	0.68	0.42
100	3.00	1.50	1.22	1.00	0.55	0.33
200	1.50	0.75	0.61	0.50	0.27	0.17
300	1.00	0.50	0.41	0.33	0.18	0.11
500	0.60	0.30	0.24	0.20	0.11	0.07
1000	0.30	0.15	0.12	0.10	0.05	0.03

Attenuation can be approximated by the formulae:

$$\alpha = 1640 \frac{1}{\rho \sqrt{\epsilon_r}}$$

Where:

- α Attenuation
- ρ Resistivity in ohm-m
- ϵ_r Relative permittivity of the material.

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In general, materials with a high dielectric permittivity will slow the radar wave and reduce the penetration depth correspondingly. Materials with high conductivity will attenuate the signal rapidly. With a dielectric permittivity of 81 for soft water, water content drastically raises the dielectric of a material. Metals are considered to be a complete reflector and do not allow any amount of signal to pass through.

Laws of electromagnetic wave reflection and refraction are the same as for seismic waves, following the Snell-Descartes laws.

- The angle at which the wave enters into an interface is determined by Snell's law: $V_1/V_2 = \sin \lambda_1/\sin \lambda_2$ where V_1 and V_2 are the velocities of the waves through the upper and lower materials, and λ_1 and λ_2 the incident and refracted angles.
- The angle of reflection is equal to the angle of incidence (reflection law).

4. Units and abbreviations

4.1 Units

Only the ISO **International System** of units ([ISO 80000-1](#)) shall be used in all relevant measurements, processing and reporting.

4.2 Abbreviations

GIS	Geographical Information System (chart database)
DGPS / GPS	Differential / Global Positioning System
RTK	Real Time Kinematics (DGPS system)
GPR	Ground Penetrating Radar
ρ (Rho)	Resistivity in Ohm-metres
ns	10^{-9} seconds
α	Attenuation in db/m
ϵ_r	Relative dielectric permittivity of a material

5. GPR layout

Contractor shall request from Company all available information, to finalize his technical proposal, such as geological context (water table depth, lithology), results of previous geophysical investigations, access to the site and state of the ground surface.

Contractor shall endorse Company's requirements in terms of profiles location (measurement grid), and in term of antenna specifications. If Contractor considers that the proposed measurements array and antenna frequency may not achieve Company's objectives, Contractor shall propose an alternative layout, which shall be properly justified and submitted to Company's approval.

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5.1 Determination of measurement grid

Determination of measurement profiles location will be established on the basis of Company's objectives.

As shown on Figure 1, GPR is generally performed on several parallel, closely spaced lines. Perpendicular lines may be added to optimize the resolution of the survey.

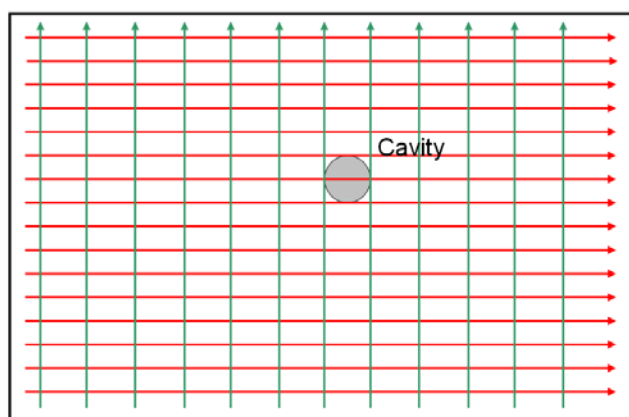


Figure 1 - Radar grid measurements

Company recommends a grid spacing of half the size of the searched object. For example, cavities of 2 meters diameter will be investigated with a grid spacing of 1 m for the main axis (red lines) and 2 m in the secondary axis (green lines).

It must be noted that if a real 3D acquisition is needed, spacing of a quarter of wavelength should be reached between two adjacent profiles, so that 3D processing techniques (migration) can be achieved.

5.2 Selection of antenna frequency and acquisition parameters

Antenna choice is one of the most important factors in survey design.

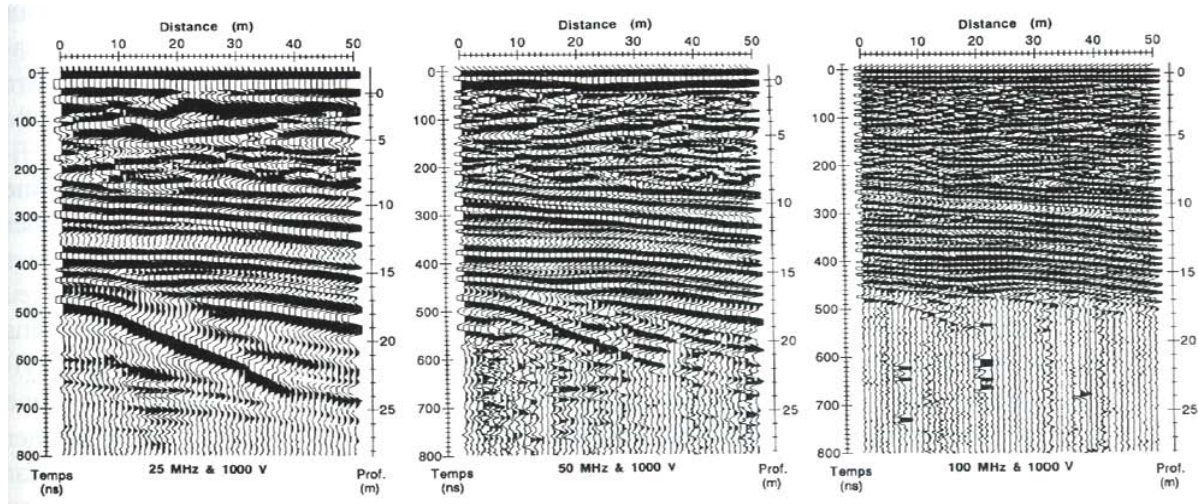
Figure 2 presents an example of acquisition performed with different frequency antennas.

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**Figure 2 - Acquisition performed with different frequency antennas
Left: 25 MHz, centre: 50 MHz and right: 100 MHz (From Jol, 1995)**

Higher frequencies give better resolution in the near-surface with less penetration depth, while lower frequencies have good penetration depth with poorer resolution in the top few metres.

The selection of frequency shall be made after a first test performed at the beginning of the survey in close collaboration with Company's representative.

Contractor shall clearly define in his technical proposal, the type and specifications of the selected antenna which will be mobilized on site to perform the preliminary test (frequency, bi-static or mono-static, shielded or unshielded...).

Location of the test profiles shall be determined in close collaboration with Company's representative. If possible, test profile will be located over a target (cavity or object) defined by Company.

The objectives of this test are for Contractor to select the best suited antennas with appropriate acquisition parameters, to detect Company's targets.

Company recommends selecting at least two type of antenna, one with lower frequency to insure a sufficient investigation depth, and a second with higher frequency to enhance resolution on targets located in the nearsurface.

Contractor shall clearly define, once testing is completed, the acquisition parameters adapted to each selected antenna. It means at least:

- Acquisition time in ns
- Number of scans per second and pulling speed
- Range gain
- Stack number.

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6. Equipment

Contractor shall provide all necessary equipment to perform the work including 100% spare parts to limit any delay in the operations. All the different equipment shall be regularly maintained and calibrated using the manufacturer's procedure.

Calibration certificates shall be presented to the Company Representative before the start of the acquisition.

6.1 Data acquisition unit

The data acquisition unit shall have at least the following characteristics:

- Compatible with a large set of antenna from at least 40 MHz to 400 MHz
- Scan rates of at least 120 scans per second at 512 samples
- Maximum recording time of at least 8000 ns
- Manual or automatic gain curve selection with at least 5 number of segments
- Digital Stacking capability to enhance signal/noise ratio
- Low-pass and high-pass filters
- Operating temperature range from at least -10° C to +40° C
- Water resistant for survey in hard environment conditions.

6.2 Antenna

Contractor shall propose a large choice of antennas from at least 40 MHz to 400 MHz.

In urban areas, or steep topography (cliff), antennas of more than 40 MHz shall be shielded to avoid above-ground interference; in more open environments, the limit can be fixed at 150 MHz, as unshielded antennas give higher penetration.

Note: Contractor shall propose antennas for velocity analysis characterisation (see below chapter "Work Procedures" for more details), which means at least one set of two separate antennas to perform a Common Mid Point acquisition (CMP), or if a borehole is available, a specific borehole antenna to perform a Vertical Time sounding (VT).

7. Positioning

7.1 Positioning system

Positioning of the spread shall be performed with DGPS, preferably an RTK system. Equipment, procedures and calibration shall comply with General Specifications **GS EP POS 003** and **GS EP POS 004**.

Before the start of the site works, the DGPS or RTK system shall be verified by comparison with a reference point of known coordinates and elevation. At Company's request, or if any doubts remain about the accuracy of the DGPS / RTK positioning system, this check shall be repeated after completion of the work.

The local geodetic system to be used shall be the one provided by Company.

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7.2 Positioning accuracy

The coordinates of each profile (X, Y, Z) shall be known with a decimetric accuracy (+/- 10 cm).

8. Work procedures

8.1 Calibration

The acquisition equipment (data acquisition unit and antennas) shall be well maintained and properly tested / calibrated as per the manufacturer's procedures. Calibration / test certificates shall be made available to Company before the start of acquisition.

If the encoder survey wheel is used in the positioning procedure, a specific calibration of the device shall be carried out at the beginning of the survey.

8.2 Velocity characterisation

Contractor shall perform, at the beginning of the survey, specific measurements to accurately determine the electromagnetic waves velocity of the investigated materials.

This can be done by either a Common Mid Point (CMP) acquisition procedure and/or a Vertical Time sounding (VT).

Common Mid Point Procedure:

In CMP acquisition, the distance between the antennas is increased step by step while keeping a common midpoint. Velocity is determined by fitting a hyperbola to the reflected waves for different time depth (see Figure 3).

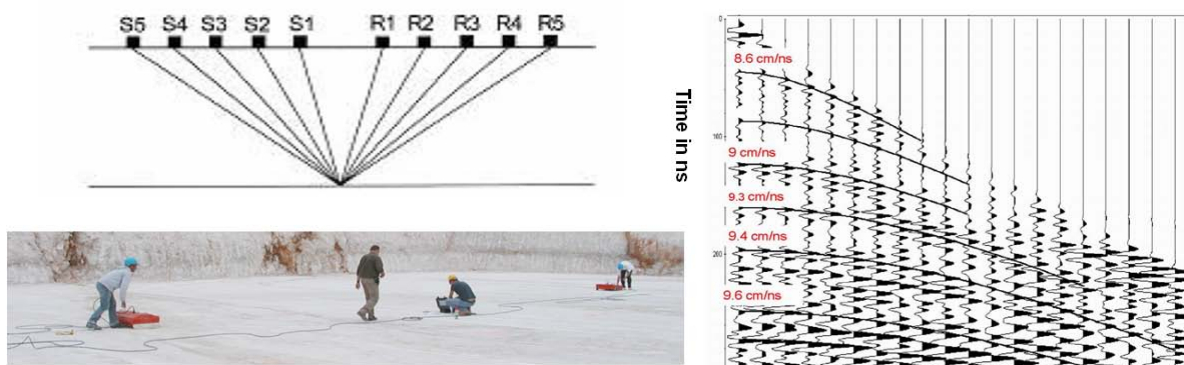


Figure 3 - Common Mid Point acquisition procedure and interpretation

Vertical Time sounding procedure:

This procedure needs an existing borehole to introduce the receiving antenna. Measurements are performed step by step with one trace recorded at each depth location. Velocity is determined by picking this first arrival at each different depth.

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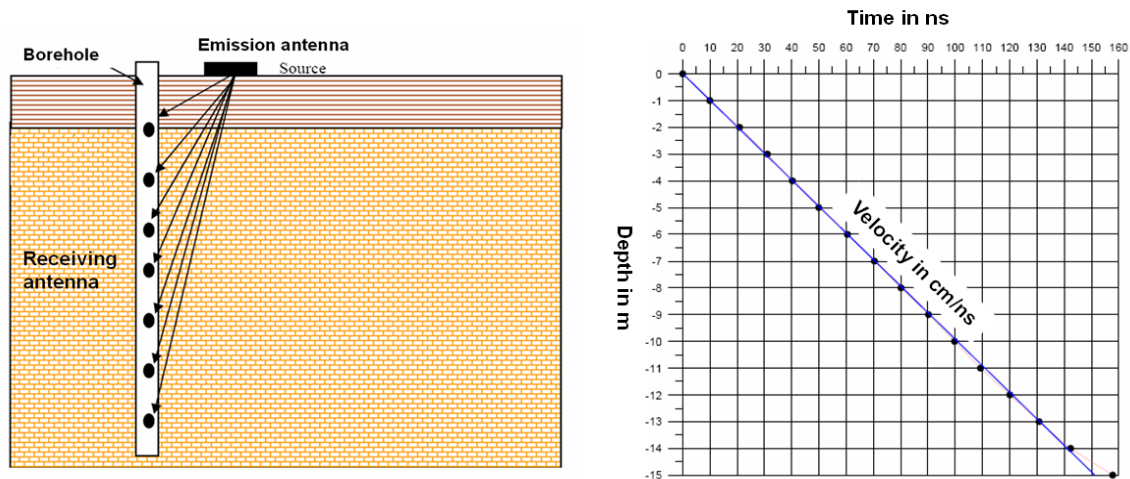


Figure 4 - Vertical Time acquisition procedure and interpretation

8.3 Acquisition - QA/QC

QA/QC of acquired data shall be performed on site by Contractor. The raw data shall be of high professional quality, yielding no ambiguities in the measurements.

Contractor shall inspect all connectors and cables jumpers for dirt, oxide or damage which may cause data quality problems.

Contractor shall be vigilant about the risk of battery weakness, which may appear during the acquisition, especially for long profiles.

Contractor shall mobilize the equipment necessary for the Geophysicist to perform a pre-interpretation on site, including data interpretation software, a PC and a printer for the production of QC documents.

If necessary, a second phase of complementary measurements can be decided on the basis of the first results, in order to precise extension and amplitude of the main anomalies.

Contractor shall inform Company's representative, when discrepancies occur between geotechnical information (e.g. boreholes) provided by Company and GPR profile results.

Reference profile:

A reference profile shall be defined in agreement with Company's representative. If necessary, this profile will be rerun to check reliability of measurements; for example in case of heavy rain occurring during a survey, which could degrade quality of measurement by introducing signal attenuation. The decision to continue the survey in bad weather conditions will be made by comparison with the quality of the reference profile.

This reference profile shall be rerun at the end of the survey to ensure that no variability has affected the equipment during the survey.

8.4 Interpretation

Interpretation shall be carried out on processed GPR profiles.

Processing shall include at least the following steps:

- Zero Time correction
- High-pass, low-pass or band-pass filtering
- Filtering to suppress the DC component
- Background removal
- Range gain adaptation
- Frequency wave number filtering (useful in case of lateral reflectors)
- Deconvolution to enhance resolution
- Migration using the velocity law obtained with CMP or VT procedures.

The different phases of processing shall be illustrated on a figure showing the initial raw data, and the changes brought about by different steps of the processing.

Contractor shall present in his final report examples of interpreted GPR profiles relating to the main anomalies presented in the final 2D radar synthesis results map (see example Figure 5).

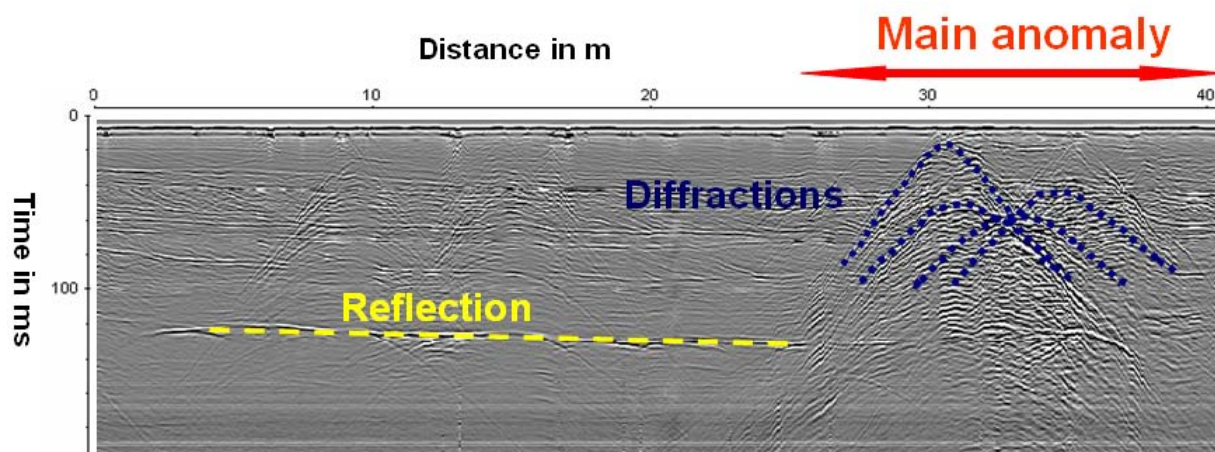


Figure 5 - Example of interpreted 400 MHz GPR profiles (unmigrated data)

8.5 Correlation with other available datasets

Contractor shall present in the final report, a specific chapter to comment on the correlation between GPR results, and all available complementary information such as borehole logs, geologic maps, data from outcrops, and other surface or borehole geophysical methods.

Contractor shall propose a complementary boreholes campaign to investigate the areas of anomalies. This recommendation shall be clearly illustrated using a set of correlation charts for each of the selected areas.

9. Personnel

Contractor shall provide in his proposal the organisation and composition of the team involved in the survey. Curricula Vitae of all personnel shall be included in the technical tender.

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9.1 Management

Contractor shall nominate a **Project Manager** who shall be in charge of whole project on both technical and administrative grounds; he shall be the Contractor Representative. If he cannot be involved in the site survey, the Project Manager shall nominate a **Party Chief** to be responsible for the whole acquisition and interpretation work. The Project Manager and/or Party Chief shall be fully experienced in Ground Penetrating Radar (GPR) data processing and interpretation.

During the operations, the Party Chief shall act as sole Contractor Representative and shall sign the Daily Work Sheets.

The Project Manager and Party chief shall remain assigned by Contractor to the project for the whole duration of the project. The Project Manager and Party Chief shall be entirely familiar with the Contract.

9.2 On site

The Contractor survey crew shall consist nominally of a minimum of 3 personnel, comprising the following roles and responsibilities:

- 1 x Party Chief in charge of the survey, liaison with Company's Representative, data QA/QC and pre-interpretation on site
- 1 x Operator geophysicist in charge of acquisition recording
- 1 x Surveyor in charge of positioning.

One to three local helpers may assist the team for line clearing and equipment transportation.

10. HSE

Contractor is required to adhere at all times to Company's Health, Safety and Environment standards. In particular, reference is made to General Specification **GS EP GPA 202**.

10.1 Contractor's responsibility

As part of the Project Execution Plan, a complete hazard identification and risk assessment (HAZID and HIRA) shall be provided by Contractor. The procedure for evacuating injured personnel (MEDEVAC/EVASAN procedure) shall be included in this safety plan.

Company's general safety instructions will be supplied to Contractor who shall review them critically, and point out any incompatibility there may be with his own safety plan.

When the survey works take place at an oil or gas production site operated by company, Contractor shall report to the Company site manager. Before commencement of the field works, Company will provide to Contractor any specific regulations and/or work permit procedure relating to the survey site.

All matters concerning the safety of all survey personnel present during the field works at the survey site shall be Contractor's responsibility. Contractor's responsibility also includes briefing any Sub-Contractors on the safety procedures for the different equipment and tasks.

Before commencement of the survey works, a pre-job/kick-off meeting shall be organized by Company and Contractor. This meeting shall be attended by the Representatives of Company, Contractor and Sub-Contractors, and any other parties involved in the survey works, including

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the Company site manager and safety manager, and local authorities (if required). The purpose of this meeting shall be to review the scope of the survey works to be carried out, and to identify any other activities involved on or off site. Minutes of the meeting shall be drawn up and signed by both Company and Contractor Representatives.

In adverse weather conditions, Contractor may be required to cease the survey operations, when it is considered that such adverse conditions may affect the safety of survey personnel and equipment, or the quality of the site works. Such adverse conditions shall be defined by common agreement between the Contractor and Company Representatives.

10.2 Emergency on site

As mentioned above, Contractor is required to submit his safety plan to Company, for each project or different area within a project, before mobilisation, and including an Emergency Response Plan (ERP) detailing medical evacuation from the worksite. Such planning shall explicitly involve the structures and facilities of Company where appropriate (vicinity of worksite). The Contractor safety plan shall be submitted to Company for endorsement before the start of the operations.

Contractor shall submit to Company a crew list of all persons actually on site, by the time of the initial mobilisation, or any subsequent crew changes during the Work.

10.3 Incident / Accident reporting

Any incident or accident shall be investigated, even if not resulting in lost time injury (near-misses). The reports shall be forwarded to Company's Representative within 24 hours. An investigation form shall be included as an appendix to Contractor's safety plan.

11. Reporting

11.1 Project Execution Plan

Contractor shall provide to Company a Project Execution Plan at least one week before the start of the survey. The Project Execution Plan shall detail in particular:

- The work procedures
- The safety plan including ERP and source handling
- The project management and organisation, including all contact details.

11.2 Daily Work Sheet

Daily Work Sheets are prepared by Company and shall be signed by Contractor Representative. Details are provided in the Particular Technical Specifications. In addition, Contractor shall provide to Company the following information:

- Daily data records and QA/QC of the data records
- List of personnel on site.

Whenever a profile has been completed, a QA/QC of the profile shall be issued to the Company Representative no later than 24 hours after the completion of the profile.

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11.3 Field Report

This Report shall include but not limited to:

- Log of daily events
- Site location map
- Results of acquisition tests with selected antennas and associated acquisition parameters (time duration acquisition in ns, number of scan/s and pulling speed, range gain ...)
- Results of Common Mid Point (CMP) acquisition procedure and/or Vertical Time sounding (VT)
- List of equipments and technical descriptions
- The number of measured profiles with a location map
- Positioning procedure
- Example of raw data and associated processed GPR profiles
- Preliminary conclusions.

The Field report shall be provided to Company before the start of the demobilisation.

11.4 Final Report

The report shall be an **Expert Report**. It shall be structured, concise and include clear and practical conclusions with respect to the survey objectives.

The final Report shall be presented in two (2) volumes:

- Volume 1: Survey Results including data examples, track plots and charts.
- Volume 2: Technical appendices including Equipment description, logs and other technical documents as required by Company Representative.

Title: The final report shall be entitled:

- Name of recipient - Company affiliate/subsidiary/project
- Site reference and location name, Country
- "Survey Report for:"
- Title: Survey name
- Name of the structure(s), field(s)
- Contractor name
- Start/end dates of onshore work.

Certification: The first page of the report shall show certification, specifically:

- Name of Party Chief in charge of the field work
- Name of person responsible for interpretation

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- Name and signature of QA/QC issuing authority
- Date of issue.

11.4.1 Draft Final Report

One draft copy of the final report, with all relevant maps and illustrations, shall be submitted to Company, for review and approval.

Contractor shall issue the final report after incorporation of Company's amendments or addenda.

11.4.2 Final Report Content

The Final Report shall comprise the following:

- **Volume 1: "survey results"**

Section 1: Abstract giving a brief description of the operations

- Date of survey
- Location of measured profiles with key coordinates and situation plan
- Summary of main survey results
- Conclusion and recommendations.

Section 2: Results

- Introduction
- General situation plan
- Summary of local geological / geotechnical information
- Objectives defined by Company
- Comments on final results synthesis map with location of GPR anomalies
- Examples of interpreted GPR profiles related to the main anomalies.
- Comments on correlation between GPR results and all available complementary information such as borehole logs or other geophysical methods
- Conclusion summarising the main results
- Recommendations for the positioning and the depth of boreholes to investigate GPR anomalies.

Location maps and situation plans shall comply with the Total General Specifications **GS EP GEO 401**.

Section 3: Charts & profiles

- Location map of measured profiles
- Topographical charts

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- Final results synthesis map
- Charts illustrating correlation between GPR profiles and other available geophysical results as microgravity, electrical resistivity tomography or seismic reflection profiles.

Charts scales will be defined in Technical Particular Specifications.

- **Volume 2: “Operations report”**

Section 1: Technical Report

- Achieved scope of work
- List of equipments
- Percentage times of operations, transit, stand-by and breakdown
- Positioning procedure
- The results of the positioning system accuracy check and monitoring
- Results of acquisition tests with selected antennas and associated acquisition parameters (time duration acquisition in ns, number of scan/sec and pulling speed, range gain ...)
- Results of Common Mid Point (CMP) acquisition procedure and/or Vertical Time sounding (VT)
- Comments on data quality
- Comments on processing with example of raw data and associated processed GPR profiles
- Geological / Geotechnical logs (if any).

Section 2: Appendices

- Appendix 1: Log of daily events
- Appendix 2: Personnel involved
- Appendix 3: Detailed description of the equipment including positioning system
- Appendix 4: All positioning data
- Appendix 5: Raw Data of the whole set of investigated profiles with field notes (on a numerical support). In the format specific to the equipment, and also converted to SEG-Y format.

11.5 Deliverables

Reports and charts shall be compiled as specified in these General Specifications, and provided in paper and electronic format. All reports and charts shall thus comply with the following requirements:

- a) Five paper copies, unless otherwise specified in the Particular Technical Specifications
- b) Electronic data (charts and reports) shall be also provided as two copies.

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Final Survey Report

Electronic data shall be provided in the following formats:

- Text documents: Word for Windows 2003; and unprotected Adobe Acrobat PDF
- Drawings, charts: AutoCad 2008 and unprotected Adobe Acrobat PDF
- Images: geo-referenced JPG or TIFF format.

GIS Requirements

As a separate deliverable, the data acquired and the charts shall be provided in a format fully compatible with requirements of the Company's GIS (Geographical Information System, or survey database). Reference is made to General Specification **GS EP GEO 401**.

Ancillary Data

In addition to the above results of the survey, Contractor shall include the ancillary data detailed below. Items to be included as annex to Final Report, in digital format (stored on CD / DVD or storage disk):

- Raw data
- Observer's log (ascii)
- Positioning data (ascii).

12. Other references

Following documents are applicable:

- Standards: **ASTM D 6432 - 11**
- Total General Specifications: **GS EP GEO 210, GS EP GEO 211, GS EP GEO 212, GS EP GEO 213, GS EP GEO 214 and GS EP GEO 216.**