

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 211

Onshore Geophysical Site Survey Seismic refraction geophysical survey
--

01	08/2012	Update following the EP reorganization, March 2011
00	01/2011	First issue
Rev.	Date	Purpose of the revision

Owning entity: DEV/TEC	Managing entity: DEV/TEC/GEO
------------------------	------------------------------

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 2 of 20

Contents

1. Scope	4
2. Reference documents.....	4
3. Seismic refraction survey objectives and methodology	5
3.1 Seismic refraction survey objectives	5
3.2 Methodology	5
4. Units and abbreviations.....	5
4.1 Units	5
4.2 Abbreviations	6
5. Seismic spread layout	6
5.1 Determination of receivers and shots number	6
5.2 Spread length determination	7
5.3 Offset shot location	8
5.4 Investigated profile.....	8
5.5 Measurements accuracy	9
6. Equipment and Procedures.....	9
6.1 Seismic recorder	9
6.2 Seismic receiver.....	10
6.3 Source	10
6.4 Cable	11
7. Positioning.....	11
7.1 Positioning system	11
7.2 Positioning accuracy	11
8. Work procedures.....	11
8.1 Calibration.....	11
8.2 Acquisition - QA/QC.....	11
8.3 Interpretation.....	12
9. Personnel.....	13
9.1 Management.....	13



General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 3 of 20

9.2	On site	13
10.	HSE.....	13
10.1	Contractor's responsibility	13
10.2	Emergency on site	14
10.3	Incident/accident reporting	14
11.	Reporting	15
11.1	Project Execution Plan.....	15
11.2	Daily Work Sheet	15
11.3	Field Report	15
11.4	Final Report	16
11.5	Deliverables	19
	Bibliography.....	20

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 4 of 20

1. Scope

The content of this General Technical Specification indicates the minimum standards required by Company for seismic refraction 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 (Exhibit A2).

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 the award of Contract.

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 the surveyed area is acceptable
- **Interpretation phase.**

Reports shall include measured and computed data and interpreted cross-sections 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
ISO 80000-1	Quantities and units – Part 1 General

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 5 of 20

Total General Specifications

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 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 Positioning System

3. Seismic refraction survey objectives and methodology

3.1 Seismic refraction survey objectives

Seismic refraction shall be used to achieve an accurate and continuous definition of the soil layering down to a maximum penetration depth of 80 m. Seismic refraction results are used to:

- Characterize the seismic velocities (V_p) and thicknesses of superficial layers overlying a substratum. In particular, velocities give indication on soil compaction, rock weathering and rippability and water level.
- Determine the depth of the weathered/fractured and/or compact bedrock top levels. Since the depths are calculated at the impact points as well as at the receiving points, a continuous and detailed bedrock relief is obtained along the entire receiver line.
- Characterize lateral changes of soil and rock properties along the entire investigated profile, including fractured zones, contact zones, deep depressions, channeling, etc.

The seismic refraction has also other applications in connection with civil engineering projects:

- Determination of groundwater level in the superficial soil layers
- Selection of sand and gravel deposits
- Evaluation of the exploitation feasibilities for quarry sites.

Correlation between velocity classes and geology shall be done on the basis of existing boreholes results and/or geological information.

3.2 Methodology

The seismic refraction method utilizes the refraction of seismic waves on geological layers and rock/soil units in order to characterize the subsurface geological conditions and structures.

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)
SEG-2	Society Exploration Geophysicists format 2
SEG-Y	Society Exploration Geophysicists format Y
Vp	P-wave velocity
WGS 84	World Geodetic System 1984

5. Seismic spread layout

The standard spread shall comprise 24 receivers with 5 shots (one in the centre, 2 at each end of the spread, and 2 at an offset equal to half the spread length). In geologically complex areas, the spread shall be upgraded to 48 receivers with 7 shots. Details are provided in the following subsections.

Contractor shall endorse Company's requirements in terms of spread layout. If Contractor considers that the proposed spread layout may not achieve Company's objectives, Contractor shall propose an alternative layout, which shall be properly justified and ultimately approved by Company.

5.1 Determination of receivers and shots number

The standard spread shall comprise 24 receivers with 5 shots (one in the centre, 2 at each end of the spread, and 2 at an offset equal to half the spread length). A typical layout is presented in Figure 1.

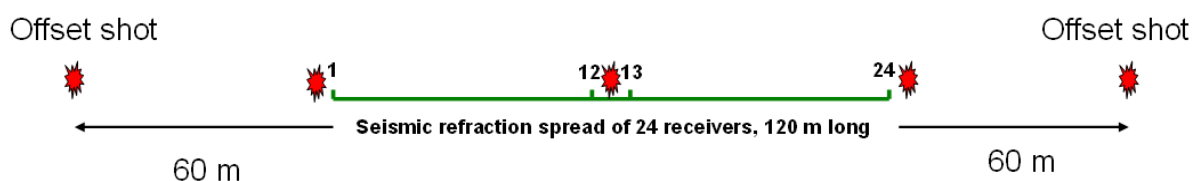


Figure 1 - Standard seismic spread layout, 24 channels-5 shots

In geologically complex areas, the spread shall be upgraded to 48 receivers with 7 shots. A typical layout is presented in Figure 2.

Onshore Geophysical Site Survey
Seismic refraction geophysical survey

Rev.: 01

Effective date: 08/2012

Page: 7 of 20

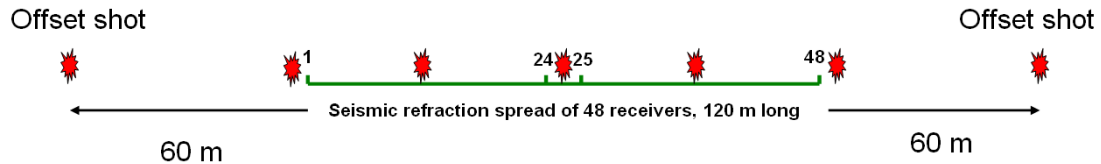


Figure 2 - Upgraded seismic spread layout, 48 channels-7 shots

5.2 Spread length determination

The spread length is calculated as the distance between the two end receivers No. 1 and No. 24 (No. 48 for upgraded spread).

The length of the spread depends of 2 main parameters:

1. Targeted investigation depth
2. Velocity contrast between the different seismic horizons.

Without any site information, the spread length shall be taken as **six (6)** times the targeted investigation depth. For example, a 20-m investigation depth requires a 120-m long spread.

When site geological information is available, the spread length shall be computed using the formulae given here below.

Formula for 2 layers:

$$X_c = 2.e.\sqrt{(V_2 + V_1)/(V_2 - V_1)}$$

Formula for 3 layers:

$$X_{c_2} = 2.e_2 \sqrt{\frac{V_3 + V_2}{V_3 - V_2}} - 2.e_1 \frac{V_3 \sqrt{V_2^2 - V_1^2} - V_2 \sqrt{V_3^2 - V_1^2}}{V_1 \cdot (V_3 - V_2)}$$

Where:

- X_c / X_{c_2} : Critical distance (minimum distance to observe refracted wave on substratum)
- V_1 and e_1 : Estimated velocity and thickness of the first layer
- V_2 and e_2 : Estimated velocity and thickness of the second layer
- V_3 : Substratum velocity

The spread length shall be at least **twice** the here-above computed critical distance X_c .

Contractor shall clearly specify the proposed computational method and especially the estimated velocities and layer thicknesses. In any case, Contractor shall perform a pre-interpretation on site after performance of the first acquisition in order to check the effective investigated depth. Contractor shall adapt the spread and/or the shot point locations, if the required penetration depth is not obtained.

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 8 of 20

5.3 Offset shot location

Offset shot distances shall be determined to achieve a proper recording of the refracted waves at the substratum interface along the entire receiver line.

With sub-horizontal geological layers, the offset may be chosen as half the length of the receiver line, and should be checked after the first shot.

In geologically complex areas, the offset shot distances (offset 1 and offset 2 - see Figure 3) shall be set so as to record the refracted waves all along the entire receiver line.

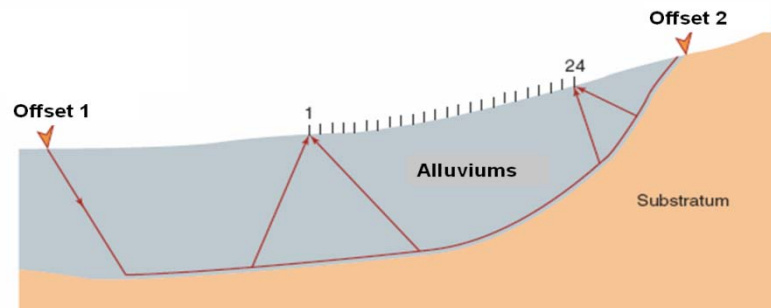


Figure 3 - Offset shot location

Contractor shall perform a pre-interpretation on site. The offset shot location shall allow a proper Plus-Minus interpretation over the entire receiver line.

5.4 Investigated profile

The investigated panel under a seismic spread is located in a plan perpendicular to the geological interfaces. Where the layers are sub-horizontal, this plan is vertical. For dipping substratum (e.g. cliff), the plan is not vertical. The refracted waves will follow the shortest path, which may introduce a lateral effect (Figure 4).

In such a case, Contractor shall propose contingencies to be approved by Company Representative.

Onshore Geophysical Site Survey
Seismic refraction geophysical survey

Rev.: 01

Effective date: 08/2012

Page: 9 of 20

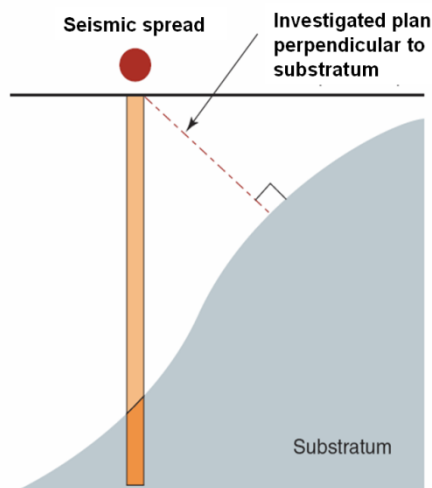


Figure 4 - Effective investigated plan in seismic refraction

5.5 Measurements accuracy

Contractor shall achieve an accuracy of +/- 10% on layer depth determination. For example, a substratum found at 10 m depth shall be detected between 9 and 11 m.

6. Equipment and Procedures

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 Seismic recorder

The seismic recorder shall have at least the following characteristics (reference is made to typical equipment such as Geometrics Stratavisor or Geode, DMT Summit or equivalent):

- Number of channels 24 or 48 as a minimum, depending on the number of receivers and on the Particular Technical Specifications
- Minimal sampling rate of 4 kHz
- Pre-trigger option with a minimum of 4,096 samples
- Triggering option on positive, negative or contact closure with adjustable threshold
- Stacking possibility
- 24 bits A/D converter
- Cross talk: -125 db for frequency of 20 - 30 Hz
- Data format: SEG-2 standard and SEG-Y.

Onshore Geophysical Site Survey
Seismic refraction geophysical survey

Rev.: 01

Effective date: 08/2012

Page: 10 of 20

6.2 Seismic receiver

For a receiver line length between 60m and 480 m, the receivers shall be geophones with a natural frequency of 8 Hz to 14 Hz.

The coupling of the geophones with the ground shall be ensured in order to maximise the signal/noise ratio.

Contractor shall provide in his tender, the response curve and sensitivity of the geophones proposed for the project.

6.3 Source

Source choice is of primary importance for data quality. Three types of source are available for land seismic acquisition: explosive, weight drop source, and shotgun. A **vibratory source** is not acceptable to Company. The source selection depends on the required investigation depth.

6.3.1 Explosive

Explosive is the preferred source to achieve a good signal to noise ratio. This source shall have a high velocity of detonation, i.e. more than 5000 m/s (type BAM or NC4).

Caps shall be of instantaneous type or zero time.

If the use of explosives is prohibited on the site (e.g. urban or industrial area context, military area, high voltage aerial line, etc.), Contractor shall propose an alternative that is appropriate to the spread length.

6.3.2 Weight drop source

Contractor shall propose a weight drop source whose characteristics are appropriate to the spread length.

The following table gives examples of source energy characteristics in relation to the required investigation depth.

Investigation depth (m)	Seismic spread length (m)	Energy (J)	Example of sources
10 - 15	60	100	5 kg hammer
20 - 30	120	1000	DELMAG tamper
40 - 60	240	2500	Source VAKIMPAC
> 80	480	5000	Source SOURSILE

It shall be noted that the 5 kg hammer source will not be accepted by Company for a seismic spread longer than 60 meters, even with a stacking procedure.

6.3.3 Shot gun source

Shot gun sources (efficient only in coherent and compact sediments soils) shall be considered as an alternative when explosive and weight drop sources cannot be operated. Contractor shall provide all characteristics of the intended sources. (Example of source: Sissy, Betsygun).

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 11 of 20

It shall be noted that a shot gun source will not be accepted by Company for a seismic spread longer than 120 meters, even with a stacking procedure.

6.4 Cable

The cable shall be mounted with water proof connectors. It shall be noted that a cable with simple Muller connectors is not acceptable to Company except in desert areas.

7. Positioning

7.1 Positioning system

The spread positioning shall be performed with DGPS or preferably a 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 fixed point with 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.

7.2 Positioning accuracy

The coordinates and elevations (X, Y, Z) for each spread receiver and shot point shall be known with a centimetre accuracy in order to integrate topography in the data interpretation.

8. Work procedures

8.1 Calibration

8.1.1 Zero time procedure

Zero time procedure is of primary importance for ensuring data quality and shall be properly described by Contractor in his technical proposal.

Reciprocal time theory shall be checked on raw data during field work.

8.1.2 Acquisition equipment

The acquisition equipment (source, geophones and recorder) 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.

8.2 Acquisition - QA/QC

QA/QC of acquired data shall be performed on site by Contractor. The raw data shall be of high professional quality, leading to no ambiguities in the picking of first arrival waves at every receiver (refer to Figure 5).

The source shall be selected so as to obtain a minimum signal/noise ratio of 5 (i.e. noise amplitude lower than 20% of signal first break amplitude).

Onshore Geophysical Site Survey
Seismic refraction geophysical survey

Rev.: 01

Effective date: 08/2012

Page: 12 of 20

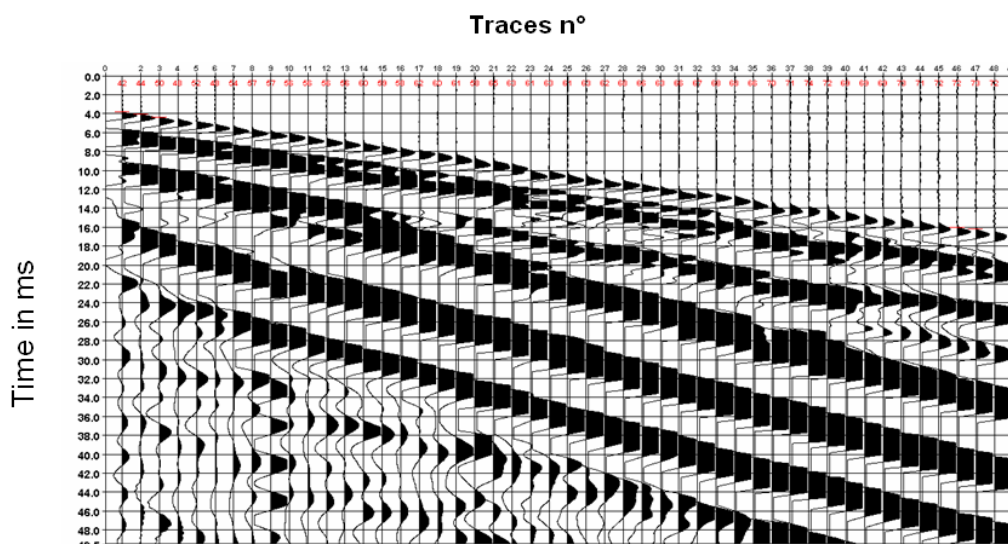


Figure 5 - Example of good data quality acquisition in seismic refraction

In the case of noisy, non-interpretable or incomplete data, the seismic profiles shall be **rerun**.

Reciprocal time theory shall be checked during field work.

The number of reversed traces shall not exceed 10% of the total number of active traces.

The number of dead traces shall not exceed 5% of the total number of active traces.

Two consecutive dead traces will not be accepted by Company.

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

Where discrepancies occur between geotechnical information (e.g. boreholes) provided by Company and acquired seismic results, Contractor shall re-interpret the seismic data to propose new velocities and thicknesses in agreement with the geotechnical results.

8.3 Interpretation

Interpretation shall be done using the Plus-Minus method consisting in:

- Determining the velocity variations on the Minus curve (in order to detect substratum velocity changes possibly correlated to geological changes)
- Calculating the delay time (Plus) curve (related to overburden thickness).

Automatic inversion of the first arrival times **is not accepted** without a preliminary calculation of the delay-time (Plus) and substratum velocity (Minus) curves.

Correlation between velocity classes and geology shall be done on the basis of available geotechnical information.

Contractor shall recommend complementary boreholes in order to ground truth the geophysical results.

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 13 of 20

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.

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 technically involved, the Project Manager shall nominate a **Geophysicist** to be responsible for the whole acquisition and interpretation work. The Project Manager and/or Geophysicist shall be fully experienced in seismic refraction data processing and interpretation, including Plus-Minus interpretation.

The Party Chief shall be a qualified geophysicist/geologist, specialised in seismic refraction acquisition. During the operations, the Party Chief shall act as sole Contractor Representative and shall sign the Daily Work Sheets.

The Project Manager and Geophysicist shall remain assigned by Contractor to the project for the whole duration of the project. The Project Manager, Geophysicist 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 5 personnel, comprising the following roles and responsibilities:

- 1 x Party Chief in charge of the survey and relation with Company's Representative
- 1 x Geophysicist in charge of data QA/QC and pre-interpretation on site
- 1 x Operator in charge of acquisition recording
- 1 x Surveyor in charge of positioning
- 1 x blaster licensed to handle and set off explosives.

2 to 6 local helpers shall assist the team in equipment transportation, line clearing and seismic spread installation.

If the use of explosives is prohibited, the blaster will be replaced by a technician who will be in charge of the non destructive weight drop source manipulation

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.

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 14 of 20

Dedicated procedures shall be developed in the safety plan for the use of explosives, weight drop or shotgun sources.

Company's general safety instructions will be supplied to Contractor who shall read 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 the Company site manager and safety manager, and local authority (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 at or off the 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 in 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 Emergency Response Plan (ERP) and 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 endorsed by Company 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 in an appendix to Contractor's safety plan.

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 15 of 20

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 (Exhibit A2). In addition, Contractor shall provide to Company the following information:

- Daily records and QA/QC of the 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 said profile.

11.3 Field Report

This Report shall include but not limited to:

- Log of daily events
- Location map
- Test records
- Calibration reports
- List of equipments and technical descriptions
- The number of seismic spreads recorded with geometry specifications
- Raw data examples
- Preliminary description of each interpreted seismic profile
- Preliminary synthesis of velocity classes identified on site
- Preliminary correlation between velocity classes and geological formation on basis of available geotechnical information
- Preliminary conclusions.

The Field report shall be provided to Company at the completion of the demobilisation.

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 16 of 20

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 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
- 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 surveyed with key coordinates and situation plan
- Summary of main survey results
- Conclusion and recommendations

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 17 of 20

Section 2: Results

- Introduction
- General situation plan
- Geodetic parameters and datum
- Location map of the performed seismic refraction profiles.
- Summary of local geological/geotechnical information
- Achieved scope of work
- The number of seismic spreads recorded with geometry specifications
- Raw data examples
- Description of each interpreted seismic profile (refer to Figure 6)
- Synthesis of velocity classes identified on site
- Correlation between velocity classes and geological formation on basis of available geotechnical information
- Conclusion summarising the main results.
- Recommendations for the positioning and the depth of boreholes to ground-truth the interpretation of the seismic refraction.

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

Section 3: Charts & profiles

- Track plots
- Topographical charts
- Raw and Interpreted profiles.

Horizontal and vertical scales will be defined in Technical Particular Specifications (Exhibit A2).

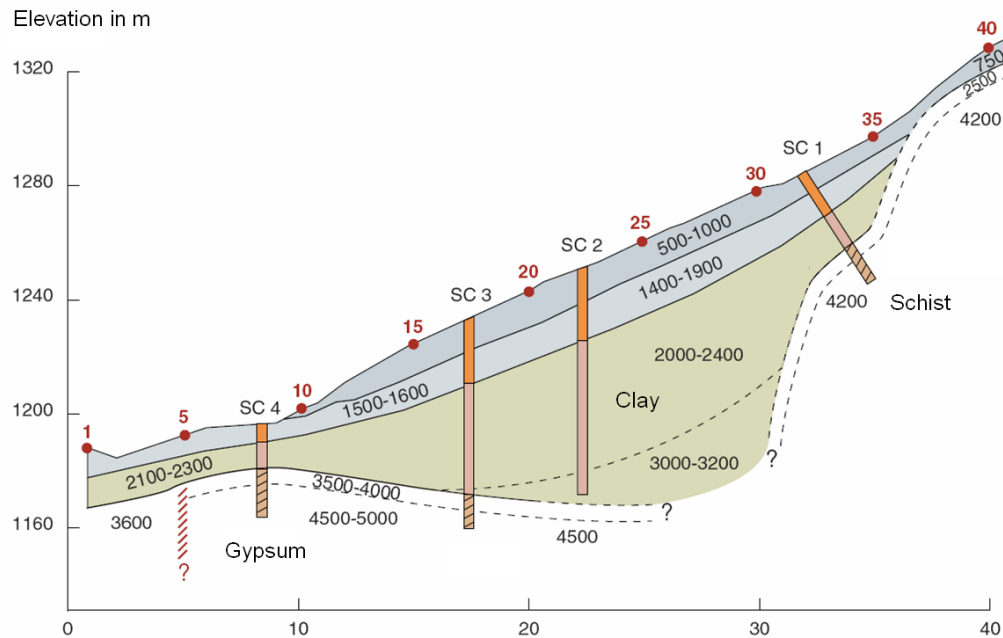


Figure 6 - Example of interpreted profile
(from “Seismic refraction in applied geophysics” - edited by LCPC)

- **Volume 2: “Operations report”**

Section 1: Technical Report

- Achieved scope of work
- Percentage times of operations, transit, stand-by and breakdown
- Geodetic parameters and datum
- The results of the positioning system accuracy check and monitoring
- The results of all calibrations, trials and tests
- The settings and all recording parameters used
- List of equipments
- Recorded traces
- Geological/Geotechnical logs (if any).

Section 2: Appendices

- Appendix 1: A detailed field note for each seismic spread, with name and specifications of each shot (location and distance), and acquisition parameters
- Appendix 2: personnel involved
- Appendix 3: daily survey diary
- Appendix 4: detailed description of the equipment including positioning system
- Appendix 5: All topographical data

General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 19 of 20

- Appendix 6: Raw data in SEG-2 and SEG-Y formats
- Appendix 7: First arrival time diagrams with Plus-Minus curves (each spread).

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 in two copies.

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 form (stored on CD/DVD or storage disk):

- Raw data in SEG-2 / SEG-Y format
- Observer's log (ascii)
- Positioning data (ascii)
- First break times (ascii).



General Specification		GS EP GEO 211
Onshore Geophysical Site Survey Seismic refraction geophysical survey		
Rev.: 01	Effective date: 08/2012	Page: 20 of 20

Bibliography

ASTM D 5777-00 (2006) - Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation

Good Practices in Applied Geophysics (AGAP) - Seismic Refraction technical note (92.1 SIS 01)