INEOS Shale

SEISMIC SURVEYING METHODOLOGY

EAST MIDLANDS SEISMIC SURVEY 2017

CONTENTS

1. GENERAL BACKGROUND TO A SURVEY 3
2. HEALTH, SAFETY AND THE ENVIRONMENT 4
3. STAGES OF A SEISMIC SURVEY 5
3.1. Permitting, Planning and Agreements 5
3.2. Topographical Surveying – 'Pegging' of Source and Receiver Positions 7
3.3. Field Operations 9
4. Managing Seismic Operations in an Agricultural Environment 20
4.1. Deployment, Retrieval and Maintaining Receiver and Source Equipment 21
4.2. Vehicle activities 24
4.3. Livestock 25
4.4. Bio-Security Measures 27
4.5. Shot hole source locations 28
5. HIGHWAYS 29
6. UTILITIES 31
7. GOLF COURSES 32
8. PEAK PARTICLE VELOCITY (PPV) MONITORING 33
9. SECURITY AND PUBLIC RELATIONS 34
APPENDIX 1: STAND OFF DISTANCES 36
1.1 RECOMMENDED SAFE DISTANCES FOR ENERGY SOURCES 36
1.2 STAND-OFF DISTANCES FROM ENVIRONMENTAL RESTRICTIONS AND HERITAGE SITES 38
1.3 GPDO AND RESTRICTIONS 38
APPENDIX 2: LICENSE AGREEMENT CRITERIA FOR WORK IN THE ESTATES 40
2.1 AGREED STAND-OFF DISTANCES 40

1. GENERAL BACKGROUND TO A SURVEY

INEOS Upstream Limited (INEOS) intend to carry out a seismic survey covering approximately 250 square kilometres in the counties of Nottinghamshire, Derbyshire and South Yorkshire (Rotherham). Works are expected to commence in Q2 of 2017 and be completed within six months. The survey will be conducted in accordance with the provisions of the Petroleum Act 1998 under Petroleum Exploration and Development Licences (PEDLs) 200, 299, 304, 307, and 308 as issued to INEOS by the Department of Energy and Climate Change (the relevant functions of which, in relation to the licences, have now been transferred to the Oil and Gas Authority - OGA).

Seismic surveying is a transient geophysical technique that uses the principles of seismology to allow deep subsurface geology to be imaged and mapped in either two or three dimensional (2D or 3D) detail. The method requires a controlled seismic source, positioned on or near surface to generate a high frequency seismic reflection signal which passes through the various subsurface rock strata. At changes in rock type and density, part of this signal is refracted and reflected back to surface where a series of microphones (geophones) connected by a small diameter cable, or individual stand-alone recording nodes receive its return. By recording this 'two way' time, the depth, extent and characteristics of rock strata can thus be determined and imaged.

Such a technique is commonly employed throughout the United Kingdom by exploration companies as part of their assessment of an area for potential hydrocarbon and mineral reserves. Power, utility and engineering concerns involved in the design and construction of power stations, underground gas storage facilities or similar type projects also routinely use seismic surveying techniques.

An acquisition programme will normally comprise of a series of individual survey lines, with positional and spacing parameters of the line programme being dependant on the required subsurface target depth and degree of resolution that is required. Commonly for 2D surveying subsurface data is acquired on a line by line basis producing a series of individual 'depth and length' profiles. For 3D acquisition data is acquired from a grid or 'patch' of survey lines covering a specific area of land. This provides a multi directional image beneath the surface. INEOS proposes a mixture of 2D and 3D surveying techniques within its PEDL's across the East Midlands

Seismic surveying operations will be undertaken in accordance with Schedule 2, Part 17 Class K (Mineral Exploration) of the Town and Country Planning (General Permitted Development) Order 2015 (GPDO). Formal written notification of the survey proposal will be submitted to the local Minerals Planning Authority (MPA) at least 28 days prior to works commencing. This requires INEOS to specify the nature and location of the development, and to demonstrate that the proposed activities would be carried out in a way to cause minimal environmental impacts or harm the amenity of local residents. In accordance with Article 5 of the GPDO, permitted development rights may be removed if the development would cause such effects.

2. HEALTH, SAFETY AND THE ENVIRONMENT

INEOS has a strong commitment to Health, Safety and the Environment, this being reflected in the Company's Corporate Health Safety, and Environmental Policies. Field crew operations will be carried out to industry accepted standards in accordance with the Company Safety Manual and guidelines laid down in the IAGC Land and Marine Geophysical Operations Safety and Environmental Manuals. In addition, the Company complies with all enactments, regulations, codes of practice and working rules relating to safety, health and welfare. A full operational risk assessment will be undertaken before deployment that will continue to be reviewed and revised where necessary throughout the project.

A full Project Specific Safety Plan and Emergency Response plan will be developed ahead of any field operations.

INEOS will take all necessary precautions to prevent damage and/or pollution to the environment. Emphasis will be placed on ensuring the survey does not compromise the landowner's and occupier's management requirements and practices applicable to the Basic Payment Scheme and Entry Level and Higher Level Stewardship Scheme.

Environmental sensitivities within the survey area will be determined through:

- The initial consultation process outlined in the following sections;
- A desktop search and appraisal of archaeological and ecologically sensitive areas across the proposed survey area;
- The results of additional surveys and assessments as outlined in the following section.

Mitigating measures developed from these assessments and the consultation process that will be followed with the relevant bodies will be implemented into the Project Specific Safety plan.

In general, such measures may prevent surveys taking place within certain "standoff distances" from particular environmental features with any restrictions or conditions placed on a survey strictly adhered to and incorporated into an operational working plan.

Any "stand-off" distances agreed with the relevant bodies and local landholders will be added to the table shown in APPENDIX 1 and included within the Project Safety Plan.

Further details of the Environmental Method Statement will be submitted to Natural England and the Mineral Planning Authority as part of INEOS's GPDO submission.

3. STAGES OF A SEISMIC SURVEY

There are a number of distinct stages that are followed as a seismic survey is planned, permitted and executed. Each of these stages can take different amounts of time depending on the level and complexity of the survey and the environment within which it is planned to be acquired.

Specific detail relating to each of these key stages is given in the following sections and outlines how seismic operations will be managed in and around specific areas of the survey and the potential infrastructure and industries encountered.

3.1. Permitting, Planning and Agreements

All hydrocarbon related seismic surveys can only be undertaken subject to the exploration company having been awarded a Government exploration licence for a particular area of interest.

Such a PEDL is awarded by the OGA (formerly known as the Department of Energy and Climate Change) and runs for an initial term of five years.

A PEDL permits the undertaking of Exploration activities that includes seismic surveying, however these activities are subject to the relevant planning procedure, relevant consents from statutory bodies affected, notification to applicable authorities and placing agreements with all affected landowners.

The licence does not give the exploration company any rights of access without agreement.

Depending on the type of operation undertaken and areas within which they are planned, the following permits and notifications maybe required: -

3.1.1. Permits/ Written Assessment

- An agreement with affected Landowners and occupiers.
- Formal written notification of the survey proposal submitted to the local Minerals Planning Authority (MPA) at least 28 days prior to works commencing to apply for a General Permitted Development Order (GPDO)
- Conservation of Habitats and Species Regulations 2010 - If development were proposed within a Natura 2000 site (Special Protection Areas and Special Areas of Conservation and their candidates) or in a Ramsar site, liaison between the MPA and Natural England would be necessary. If Natural England considers that there is potential for a significant impact to occur, an Appropriate Assessment would be required to assess whether there could be an adverse effect on the integrity of the European site. In practice, the operator requires to justify to Natural England why the survey is necessary and assess how it will affect the integrity of the site.
- Ancient Monuments and Archaeological Areas Act 1979 – if work takes place within a Scheduled Monument, Scheduled Monument Consent or a licence under Section 42 of the Act must be gained to permit ground disturbance/ geophysical survey.

- Explosives Act 2014 – INEOS may require a licence to store and transport explosives from the Local Authorities, Police, or HSE, depending on the nature of the explosives used, quantities stored, whether an Explosives Certificate is required, and whether or not relevant separation distances are met in storing the explosives.

- Permission will be sought to agree strategic temporary placements of welfare vans to prevent unauthorised fouling of the countryside by project personnel. Subject to a pre deployment risk assessment.

- Permission will also be required for any guarding or signage to be placed on private land.

3.1.2. Notification and Consultation Required

- Petroleum Operations Notice (PON) 14b – INEOS will notify the OGA of the intention to undertake onshore geophysical surveys (including seismic survey). Notification will be required 28 days before the survey is commenced using a proscribed form (PON14b form), which would be also used to report completion of the survey.

- Water Resources Act 1991 (Section 199) – INEOS will notify the Environment Agency prior to carrying out seismic surveys.

- INEOS will liaise with the Highways Agency, Council Highway Departments and the Police to inform them of the potential for large and slow moving vehicles and equipment deployments.

- INEOS will notify the Coal Authority of works in areas known to have coal potential.

- A desk based archaeological and ecological appraisal of the survey area will be constructed prior to notification, with further assessment of areas identified as being of particular sensitivity in advance of works being undertaken (for example, areas designated for their cultural heritage or natural heritage interest on an international, national or local level).

- Following the above studies INEOS will consult with Natural England, Environment Agency, Historic England and non-statutory bodies including Wildlife Trust and RSPB in planning the survey to identify sensitive areas and to develop appropriate mitigation measures, stand-off distances and exclusion zones if needed. The Mineral Planning Authority will further consult with each of the statutory bodies ahead of issuing the GPDO.

3.1.3. Consultation with Landowners and Occupiers

Where seismic source or receiver points occur on private land, all affected owners and occupiers are initially approached by a chartered surveyor in order that the survey proposal can be explained in full, and their agreement in principle to the works sought.

A licence agreement will then be put in place identifying the basis for the permission. To assist the topographical team, the chartered surveyors, make a request to each landowner and occupier for information relating to local underground installations, particularly private water supply pipes, electricity cables and land drains and cropping.

Throughout all aspects of a survey, liaison is maintained with all relevant parties regarding safe working practices, access timings and any other matters relating to the operational undertaking. If a

landowner or occupier has any further or ongoing questions they should be addressed to the chartered surveying team.

3.2. Topographical Surveying – 'Pegging' of Source and Receiver Positions

Once various environmental and cultural heritage constraints are established and the appropriate permission has been granted to commence activities, and a seven-day notice has been served on landowners and occupiers then access to the land can be undertaken.

During this stage a number of activities are undertaken that include the following: -

- The Chartered surveying team will walk the land to undertake 'pre-entry record of conditions' assessing and recording the condition of the land in written and photographic format, cropping patterns and access points for the seismic equipment to ensure each survey point is free from any restrictions that may hinder both seismic activities and activities the landowner and occupier may need to undertake and point out to the seismic surveyors obstacles and known features.

- An Ecologist will also walk the land to assess any local environmental/cultural heritage restrictions that need to be adhered to in positioning source and receiver points within a landholders' property. Any standoff distances and exclusion areas will be communicated to the survey team who will position the source and receivers.

- If there are any utilities located on a landowner's property the utility company may send a locator to more accurately locate any subsurface utilities with pegs, ahead and or together with the seismic survey team.

- A team of seismic surveyors (usually 2-3 operatives) will also walk the land; or via an ATV (All-Terrain Vehicle) where appropriate, using GPS technology to visit each theoretical source and receiver location. These locations will then be refined taking into account landowners requirements, endeavouring to locate positions following road and field boundaries where possible and agree positions where it is not, any restrictions raised by the Ecologist, stand-off distances as well as the greater constraints as laid down in the first stage of planning. These positions will then be marked with a flexible metal wire with a flag and reference number and the grid coordinates of each location noted.

Figure 1: Illustrates a receiver/source location marked with a flexible metal peg and flag

- The chartered surveyors, Ecologist and Seismic Surveying team may walk the land together to assess pre-entry conditions, local environmental restrictions and to place source and receiver locations.

- An assessment will also be made at this time as to the type of seismic source that will be used at each location. This will be dependent on terrain, access to the area, environmental restrictions, subsurface constraints and geophysical objectives. Vibratory source is the preferred option and the decision making process for establishing if the vibrator trucks can be used is as follows:

    - Can a fleet of vibrators access the source location easily?
    - Is the ground hard enough to support the vibrators?
    - Is the stand-off distance possible with three vibrators inline?
    - If the answer to any of the above is 'NO' then a drilled shot hole will be considered.

- The seismic surveying team will be working to strict industry standard safe distances for both charge and vibroseis operations, and specific safe operating distances stipulated by the Statutory Undertakers and Pipeline Operators outlined in Appendix 1 and will identify any no-go areas that vehicles or operations may not enter.

- A map will be developed and issued to the landholder showing the agreed entry and exit points to the field or property along with a clear indication of which type of source (vibroseis or explosive) is planned for the points within the landowners' boundaries.

- Once source and receiver locations have been marked on a landowners' property, landowners will have 7 days to review and comment on the marked location.

After this point the source and receiver locations become final and the information in the form of access maps and source programmes is passed onto the drilling and acquisition crew. The charted surveyors will confirm these final points with the landowners and occupiers.

(Landowners and occupiers are requested to leave all 'Pegs' in the ground until they are removed at the end of the survey, unless they consider that damage may be caused to their equipment or property in which case they should contact the Chartered Surveyor to discuss and request removal).

3.3. Field Operations

Now that the final positions are confirmed and the markers are in place, maps will be issued to three distinctive teams namely Line Crew, Vibroseis operators and the Drillers with their ancillary Loaders and Shooters. These maps will indicate the source or receiver locations, access points and the routes to be taken within the individual properties.

On the source maps nearby utility services and constraint locations will be marked up to ensure that no encroachment occurs. These crews will be supported by the Agricultural Liaison Officers (ALO's). The Part Chief is ultimately responsible for undertaking the survey operations in a safe and efficient manner compliant with all the rules, regulations and project constraints.

Each landowner and occupier will be allocated an Agricultural Liaison Officer or a number of Agricultural Liaison Officers dependent on the size of the holding, with whom they can liaise with for the duration of the surveys. All communication must be with the respective Agricultural Liaison Officer, who will work to ensure that the surveys can proceed within the given timeframes and that the day to day requirements of landowners and occupiers can be considered. All security measures on landholdings must be given to the respective Agricultural Liaison Officer only, to ensure that access can be arranged in a timely manner. The Agricultural Liaison Officer will ensure that landowners and occupiers are updated on movements on their property and provided with adequate notice regarding the seismic crew being in attendance on their property and any requirement to move stock.

The different stages of field operations are explained more fully below.

3.3.1. Geophone, Battery and Recorder Deployment

The deployment and retrieval of the geophones, batteries and recording units, harvesting of data and changing batteries is undertaken by teams of 4 field operatives taking foot access or with an ATV and carrying the appropriate equipment along each of the marked out survey sections in turn.

Below are images of a single Geophone, Battery and Recording unit.

Figure 2: Illustrates a single geophone

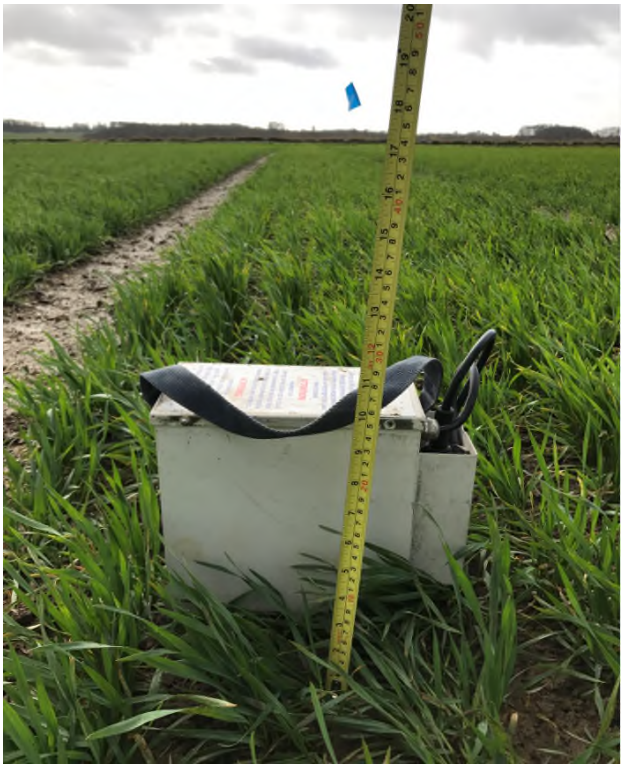

Figure 3: Illustrates a single battery pack

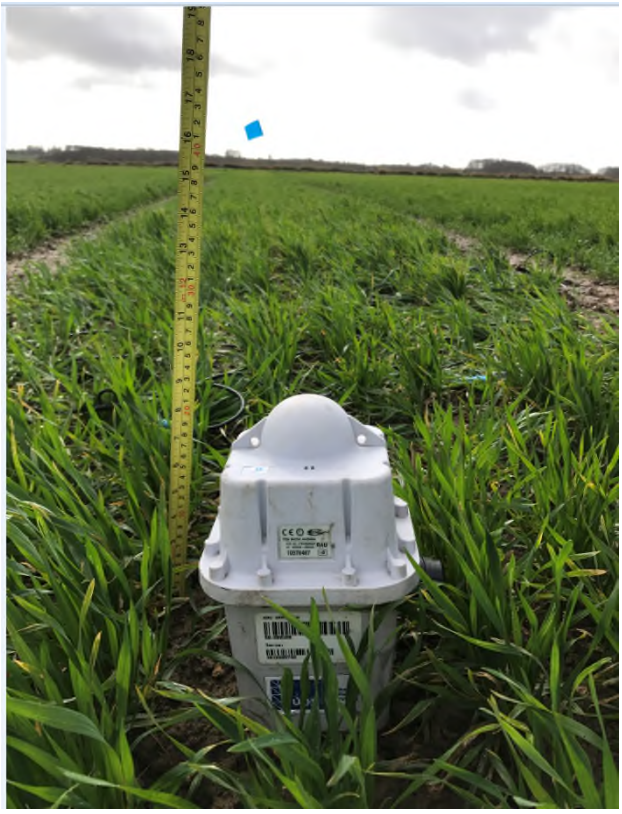

Figure 4: Illustrates a single recording unit

Coupling of geophones with the ground surface is essential to ensure good data quality, and this is achieved by ensuring the 7.0 centimetre metal spike positioned at the base of each geophone case is pushed into the surface by foot.

A group of 6 -12 geophones connected by a cable are nominally placed in a circle (2-3m diameter) around the pegged location and connected to the battery and recording unit.

The configuration and number of geophones maybe altered depending on the environment they're deployed in, details and the circumstances of this are outlined in the following sections.

An example of this type of deployment is shown below: -

Figure 5: Illustrates 6 geophones deployed around the marker peg, battery and recording unit in a 2 metre grass field margin

Figure 6: Example of a single geophone within a group planted into the ground of an arable crop

This group of 6-12 geophones, battery and recording unit constitutes a single receiver location and is not connected to any other receiver locations in the survey.

The receiver deployment process normally has negligible disturbance or damage to the ground surface.

The following activities for geophone/battery/recorder deployment, retrieval and maintenance should be noted.

- For 2D surveys recording equipment is left in situ for approx. 2-5 days before being retrieved.
- For 3D surveys recording equipment will be placed on the ground for approx. 7 to 10 weeks at a time, depending on acquisition rates.
- Retrieval and redeployment of the recording equipment may take place several times during this period due to the size of the survey. If the equipment is picked up to be later redeployed, then the marker peg will be left behind. Only when the equipment is picked up for its final time will the marker peg be removed.
- Receivers are deployed over an extensive area to record each individual source point.
- The recording units will be recording continuously once deployed.
- Batteries will be exchanged on a regular basis depending on their charge capability.
- Access will be required routinely to maintain equipment, change batteries and to harvest data from the recording units.

3.3.2. Seismic source generation

There are a number of options available for seismic sources, the most commonly employed types are 'Vibroseis' sources and the use of small seismic charges deployed down shallow shot holes. Each of these sources generates the sound signal to propagate into the ground but their method of operation is different.

Factors influencing the selection of source type can include weather, ground conditions, ease of access, timings, cropping schedules and environmental constraints. The decision on source type is generally made during the surveying stage although some alternatives may be made once data acquisition commences.

3.3.2.1. Vibroseis Sources:

An image of a Vibroseis truck is given below: -

Figure 7: An image of a single Vibroseis truck unit

Once on a source location a Vibroseis trucks lowers a steel plate on to the ground which is then hydraulically vibrated passing a variable frequency energy source into the ground.

- The trucks usually work in a fleet of 3 vibroseis units; driving to the source location with the middle truck positioned on the source point. All three units then lower their plates and vibrate the ground in unison.
- The plates below each truck hydraulically vibrate the ground for between 20-30 secs with increasing frequency. This procedure is known as a 'sweep' and the 3 trucks operating in this method act as a single source at the source location.
- The trucks will remain on location for a brief period of time to allow the reflected signal to be recorded by the Geophone units. This is known as the 'listening time'.

- The trucks may repeat the same hydraulic vibration at the same location or move up in convoy to the next location to repeat the process.
- The trucks are typically followed by a support vehicle.

Below is an image of 3 vibroseis units in operations together.

Figure 8: Image of 3 Vibroseis Trucks working together

- The vibroseis source method is a non-invasive source commonly used on road based surveys, within urban areas, and across agricultural farmland when ground conditions allow.
- It is a relatively fast and efficient method that can cover several kilometres in a working day and offers the flexibility of varying signal frequencies and magnitudes that can be deployed into the ground.
- Each truck can weigh up to 32000.0 kilograms that is spread over the four axels, with all terrain tyres.
- Depending on terrain type and source requirements 1-3 trucks could be used on a given source location.

3.3.2.2. Shot Holes and Seismic Charges:

- This more invasive source involves the loading and detonation of a small explosive charge at the base of a shallow pre-drilled hole.
- Shot holes are drilled after surveying is complete and in advance of any shooting activities. Shot holes are typically between 8-10m in depth.
- When using shot holes and seismic charges as a seismic source then a single shot hole and charge maybe used as the source or a combination of shot holes and charges in close vicinity to each other maybe used. This will be dependent but not limited to source requirements, directionality and near surface geology constraints.

- Some shot holes can be drilled in a matter of minutes however others may take longer depending on the geology within the area. An overview of the techniques used to drill these holes is given below. The wiring will be located at least 0.5m below ground level.
- Once drilled, the desired seismic charge is deployed down the hole and back filled with the appropriate wiring left available for later detonation. This process is called 'pre-loading'.
- Varying seismic charges can be deployed down the hole which is usually no larger than 600g, with an upper limit of 2kg (fired in single shot) under the terms of the GPDO.
- Each shot hole may be left pre-load and not fired for a number of weeks until the acquisition & blasting team is ready for detonation and is subject to the appropriate permitting and approvals being in place.
- Whilst shot holes are pre-loaded and to comply with the permitting process mobile security units will patrol the survey vicinity night and day to ensure the area is not disturbed.
- On the day of recording a blasting team will prepare the seismic charge for detonation and work with the acquisition team under the leadership of the Party Chief to fire a given source at the appropriate time before moving to the next location.
- As with Vibroseis sources a given 'listening time' is observed before the detonation of the next shot hole or Vibroseis location.
- A slight background muffled thud can be heard immediately after such a detonation that will be dependent on the size of charge fired, the near surface geology and the lay of the land.
- Note that shot holes/Seismic charges can be used in parallel with Vibroseis trucks with one shot type being followed by another.

3.3.2.3. Shot hole drilling - Augering

- This process utilises a small mechanical auger unit fitted to a lightweight 6WD Polaris quad bike or small tractor.
- The technique produces an approximate 10.0 centimetre diameter hole and results in some spoil being brought to the surface.
- Should holes be pre-augered a number of days prior to the loading of the seismic charge, then to ensure the hole remains open and does not collapse and infill, plastic piping is used to temporarily case each hole.
- Casing is withdrawn immediately after the charge is loaded, and the hole tamped and backfilled where possible with the spoil and 10.0 millimetre washed pea gravel.

Figure 9: An example of a Polaris quad mounted auger unit

3.3.2.4. Shot hole Drilling-Sonic/Air Drilling:

- The drill unit is mounted on the rear of a small agricultural tractor which can be fitted with low ground pressure tyres should wet conditions prevail.
- The sonic drill operates by means of a rotating and vibrating drill bit which causes the surrounding soil and near surface superficial deposits to 'fluidize', thus allowing quick penetration with minimal or no spoil resulting.
- Hole size is similar in diameter to that produced by the augering process.
- Loading of the seismic charge, which for this technique is undertaken as part of the drilling operation, is conducted prior to 'pull out' via the hollow drilling stem.
- No temporary casing of the hole is required for this operation.
- As minimal spoil is produced, each hole is tamped and backfilled with a number of sodium bentonite 'sticks', this material being an inert clay which expands when in contact with water, thus sealing the hole and providing a low permeability barrier.

Figure 10: Tractor mounted Sonic Drilling Rig with Water bowser (Note white bentonite sticks)

- In some soil types where harder or boulder rocks are encountered within the eight-metre target depth it will be necessary to utilise an alternative air drilling rig.
- This rig is similar to the sonic set up but instead of a water bowser mounted on the front of the tractor it will instead be mounted with an air compressor.
- Air will be blown down the drill stem to remove the drill cuttings to the surface. The spoil will backfill the hole once the seismic charge is loaded.
- It should be emphasised that no drilling muds or fluids, other than clean water, are used as part of the augering, air and sonic drilling processes.

Figure 11: Tractor Mounted Rotary Drill Rig with Compressor

3.3.3. Data Acquisition

- Data acquisition is coordinated through the recorder and communication truck and is led by the Party Chief.
- The team within the recording truck ensures that for each source fired there are sufficient receivers deployed on the ground to initiate the source.
- The team within the recording truck coordinates which locations the vibroseis trucks should move to next or which shot hole should be fired and coordinate the timing between all equipment.
- The team will also Quality Control data harvested from the recording units to ensure it is of sufficient quality to meet the geophysical objectives.
- Communication between the different teams is generally by handheld radio.

Figure 12: An example of the recording and communication truck

3.3.4. Retrieval of equipment and Restoration

- Once all data acquisition has taken place across a given area the Geophone groups, batteries, recording units and survey peg with flag will be retrieved.
- All equipment will be carried out off any fields by hand or via an ATV to a waiting collection truck.
- Seismic charge wires are removed from each hole and additional backfilling of source locations is undertaken if required using pea gravel.
- An auditable system is implemented in day to day operations to account for all recording equipment and survey pegs as they are deployed and retrieved to help identify any lost or stolen equipment.
- For field restoration spoil and apparatus up to 0.5m below ground is removed from site and, as added security for livestock grazing in permanent pasture, each SP hole is additionally sealed below plough depth using a small concrete plug, backfilled with topsoil and reseeded.

- All litter and materials will be removed (ongoing) leaving no trace of the survey crew operations.

4. MANAGING SEISMIC OPERATIONS IN AN AGRICULTURAL ENVIRONMENT

Since seismic operations are planned across a wide area of land they come into contact with a number of different businesses, infrastructure and environments and as such the preferred method of operations needs to be adapted to their surroundings to limit the impact on local businesses.

Seismic is planned over large agricultural areas for this survey. Below is an overview of how INEOS seismic operations will be adapted and managed within these areas to allow simultaneous seismic and agricultural activities.

Landowners are requested to work closely with their Agricultural Liaison Officer (ALO) so the seismic team can understand key agricultural operations taking place on the land to better plan their seismic activities. All communications must be through the ALO and time spent recorded.

- Licence agreements will have been reached with the landowners and occupiers for seismic operations to take place between 7am to 7pm conducted on a 7 day a week basis.
- Subject to daylight hours, INEOS may wish to extend the working day if deemed to be an operational necessity. On those rare occasions approval will be required from the landowners to operate outside the 7am-7pm window.
- No seismic activity will be conducted between dusk and daybreak. Should any timing restrictions be placed on the survey, then these would be strictly observed.
- Mobile security patrols will continue where permitted throughout the day and night to secure the area and seismic equipment.
- All vehicles with road tyres will stay on existing tracks and will not drive on fields. This includes the recording truck that will be strategically placed in locations that has good access.
- Any vehicles that require access to fields will do so via agreed entry and exit points with the landowners and will follow the existing tramlines and will not run on grass field margins.
- When deploying, retrieving or maintaining the geophones, batteries and recording units, access will be on foot or via an ATV.
- All land will be reinstated to a condition as near as reasonably practicable to that existing prior to entry and as evidenced in the pre-entry record of condition.
- Areas that become inaccessible due to weather and wet ground conditions will be handled in the following manner:
    - Party Chief will instruct the ALO where the preferred areas of operations are planned in the coming days/weeks.
    - ALO works with the landholder, informing of what activities are planned on the land in the coming days/weeks

- If the landholder and ALO decide and agree that the ground is too wet for the planned activities, with high probability of causing irreparable damage to topsoil, this is information will be fed back to the Party chief who'll update the plans in consultation with the ALO. The decision to suspend the work in the wet areas will be respected by all parties and will either be carried out at a later date or cancelled if improvements are not forthcoming in the timescale needed to efficiently record data in this area.

4.1. Deployment, Retrieval and Maintaining Receiver and Source Equipment

- Where possible receiver and source locations will be placed within tramlines or grass field margins to minimise interruption to agricultural activities.

Below is an image of receiver equipment deployed around a tramline

Figure 13: Receiver equipment deployed across a tramline, note the geophone cables across the tracks.

- Agricultural vehicles will be able to drive over the cables that connect geophones together. Batteries and recording units are sufficiently small and the marker peg is flexible that agricultural vehicles should have sufficient clearance to drive over them. Below is an image of this: -

Figure 14: Example of an agricultural vehicle driving over recording unit, battery and marker peg.

Figure 15: Example of an agricultural vehicle driving over recording unit, battery and marker peg.

- This should mean that agricultural spraying operations and other operations that do not require cultivation can be undertaken without the need to lift and re-deploy receiver equipment. It is requested that landowners and occupiers inform their ALO of any intended agricultural activities so the seismic Party Chief can make an assessment of any work that may need to be undertaken on the equipment during this period and likely safeguards that require to be put in place.

- It is noted that certain agricultural operations (e.g. ploughing, harvesting) will require seismic equipment to be lifted and redeployed to facilitate these activities. The landholder is requested to work with the ALO to agree the area of activity, the timings that the equipment should be lifted and redeployed and the location of receivers to be moved to help manage simultaneous seismic and agricultural operations.

- An image of a geophones group, battery, recording unit and marker peg deployed in a grass field margin is shown in Figure 5.

- No signs will be erected on a landowner's property without the consent of the landowner.

- Any land drains discovered shall immediately be marked and reported to the landowner.

- If seismic activities are planned during the game shooting season (October until February in any one year) then agreement will be made with the landowner and occupier to identify exclusion zones and exclusion times during this period to prevent unauthorised access. It has been agreed that the seismic crew will not enter into these areas two days before an organised and informed shoot and the day that a shoot is taking place. The Party Chief may request that receiver equipment is deployed within the exclusion zone prior to the agreed time and left unhindered until it is agreed the field operations team can retrieve the equipment.

- If landowners and occupiers have any other activities that may require restricted access to certain areas, then these should be discussed with the ALO to agree a plan with the Party Chief on how best to manage seismic activities across the area.

- Where geophones are required to be placed within a grass amenity area they will be appropriately marked out with canes and high visibility tape to help prevent trips on cable and equipment. Some examples of this type of deployment are shown in the following diagrams and a decision on the diameter of deployment will be made in the field.

Figure 16: Receiver equipment deployed in a grass amenity area

- It is requested that the handling of all geophone, recoding units and batteries are only handled by the field operations team for technical and safety reasons as the recording units are continually recording seismic data.

- In agreement with landowners and occupiers welfare vans will be deployed in appropriate locations to prevent unauthorised fouling of the countryside by project personnel.

4.2. Vehicle activities

- Refuelling of vehicles will be undertaken within designated safe areas.
- Vehicles taking access to agricultural land are supplied with the appropriate commercial spill kit. Spill kits will also be available from the mechanic and security vehicles.
- Only fully trained survey personnel operate the vehicles.
- In the unlikely event a fuel or oil spillage occurs from a vehicle, this is immediately reported to the relevant landowner in addition to the Environment Agency Incident Response Hotline.

4.3. Livestock

- INEOS acknowledges the potential risk to livestock of deploying equipment within fields containing livestock and will implement the following mitigations and steps to help manage this risk.
- Step 1. If possible the landowner or occupier will be requested to work with the ALO to move livestock to an alternative field; either temporary to allow deployment, or for the duration of seismic activities within that field as a last resort.
- Step 2. If this is not possible the geophone receivers and cables for a given location will be buried to the depth shown in the following diagram and the recording unit and battery deployed under a stock proof container secured to the ground.
- Step 3. If burial of geophones is not possible they will be tightly deployed together with the battery and recording unit under the stock proof container.

INEOS is currently working with landowners and chartered surveyors acting for landowners and occupiers to design and procure such a container to meet livestock requirements. Below is an image of the proposed design

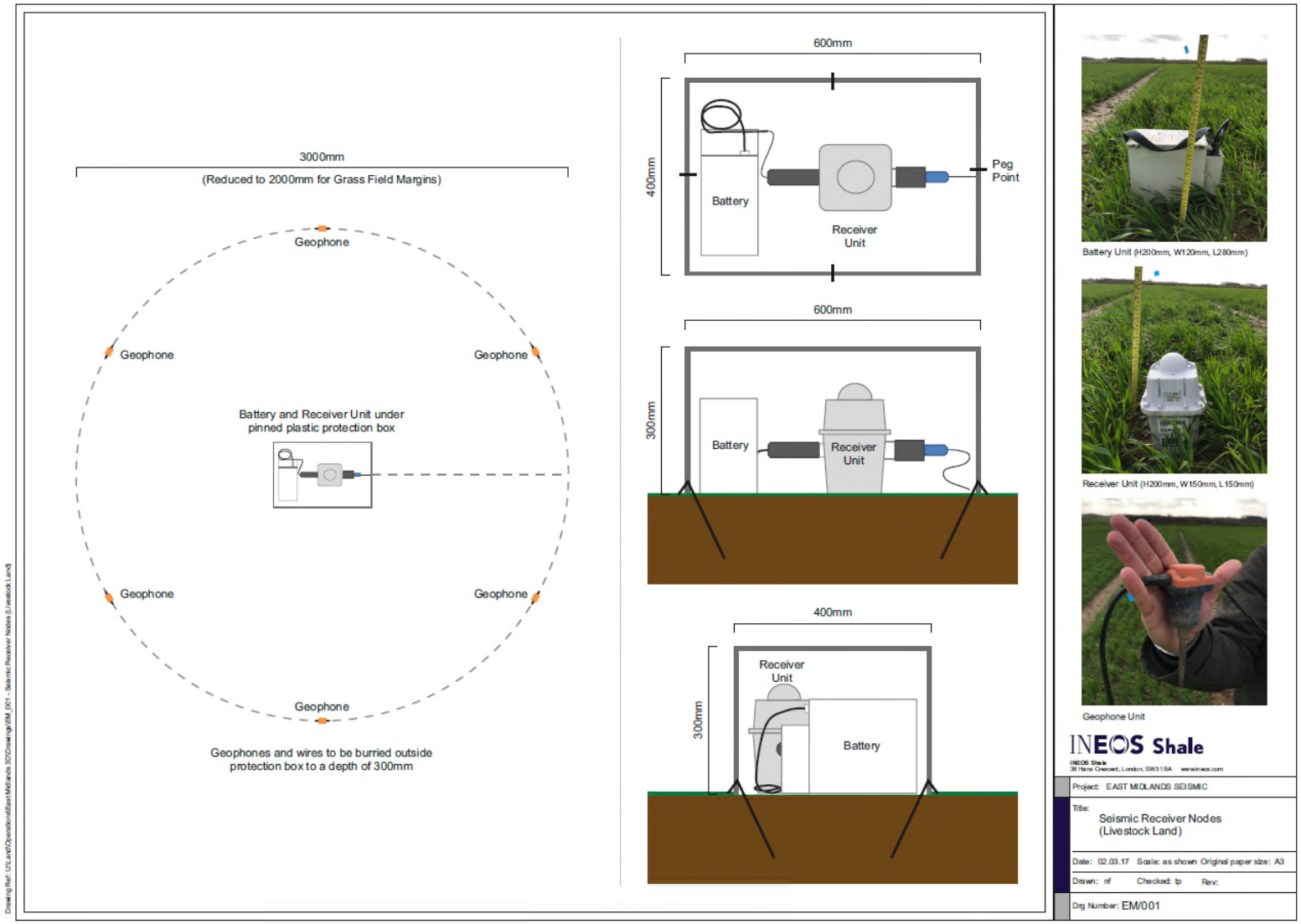

Figure 17: Seismic Receiver Nodes

4.4. Bio-Security Measures

Bio-Security measures will be discussed and agreed with landowners and occupiers where required and in particular on landholdings where indoor and outdoor pigs and dairy cattle exist and measures may include the following. Landowners and occupiers should forward any known required bio-security measures to the chartered surveyors in advance of the seismic activities commencing.

- Any seismic crew and equipment entering the landholding will comply with all the biosecurity measures the farm has in place.
- The designated ALO will work with the landowner and occupier to understand any systems the landholding has in place and the areas where biosecurity measures are implemented.
- Equipment, vehicles and personnel will undergo the appropriate disinfectant wash-down required to enter specific areas.
- No personnel will enter the landholding when that person has been on another landholding with the same type of stock in the last 48 hours.
- The survey team will aim to move source and receiver locations to the edge of field boundaries or away from the fields with pigs and dairy cattle. Where this is not possible the steps as outlined within the 'livestock' section (4.3) will be implemented.

Where forestry is present on a landholding, Forestry Commission guidelines will be followed to prevent spread of pests and diseases on wheels, equipment or boots. These guidelines are outlined in the following web link:

https://www.forestry.gov.uk/england-keepitclean

Key points relevant to the survey include:

- Clean soil and debris from boots, clothing (including PPE) and other equipment (including geophones, augers etc.) before leaving any site.
- Ensure machinery is cleaned regularly, and positioned so as not to spread material around the site.
- Remove any build-up of soil and debris on vehicles including wheels, cabs and foot wells, before leaving any site
- Use proper off-site wash-down and disinfection facilities regularly, including disinfecting geophones, flagging poles/ receiver markers, wheels, drills and augers, and shot hole casing.
- Each vehicle would have a basic biosecurity kit including a flexible bucket, hoof pick for removing soil and stones from boots, water container and brush. This would be used to clean wheels and boots/ clothing before leaving the site. The pick and brush would be frequently disinfected. Propellar (for metal tools) and Cleankill sanitising spray (for boots and clothing) are both effective against harmful tree and plant pathogens.

- The landowner would notify the ALO of any know pests or diseases affecting forestry or when there is an existing Statutory Plant Health Notice in place. Additional guidance for that pest or disease would then be followed by the survey team

  (*https://www.forestry.gov.uk/pestsanddiseases*)

- Any trees or vegetation considered to be infected during the survey (not previously notified) will be highlighted to the landowner by the Environmental Clerk of Works. The landowner would report these to the Forestry Commission using "Tree Alert"

- The survey team would not remove or dispose of any infected material, but would report it to the landowner for proper treatment. If infected material causes a hazard, the survey would not take place in that area.

4.5. Shot hole source locations

- For source locations that require drilling, consideration will be given to accommodate farming activities to ensure shot holes are not affected by land cultivations and agricultural operations.

- Landowner and occupiers are requested to work closely with their ALO's to understand planned activities so the seismic Party Chief can plan appropriate mitigating measures to allow cultivations to continue.

- Pre-drilled shot holes will be accurately located and 'buried' to a depth of 0.5m to allow cultivations to safely pass over the source location. GPS is used to locate the hole and manually opened and data acquisition undertaken.

- In areas where landowners have informed the ALO of land drains or land drains are detected, the initial 1.0 metre depth of each position is slowly and carefully hand drilled to ensure no drain is present. Should a drain be detected, then the source location is repositioned within a minimum 1.0 metre radius of the original position and the detection process repeated.

- In the unlikely event that drain damage occurs the restoration will be completed to the reasonably acceptable satisfaction of the landowner and occupier and as follows. The cut drain will be excavated for a distance of at least one metre to either side of the cut, rodded up and downstream for a distance of 10 metres, either side of the cut drain, suitable like for like replacement pipe of the same size will be provided and be appropriately jointed on the up and downstream side. This will then be protected and backfilled, once inspected by the landowner and occupier. All reinstatement drainage work will be undertaken be a suitably qualified land drainage contractor.

5. HIGHWAYS

- In certain areas source and receiver locations will be located along highways and grass verges.
- INEOS will work with the local highways authorities to comply with legislation to undertake seismic activities along highways.
- In agreement with local authorities' receivers, batteries and recording units placed along grass verges will be deployed together under a high visibility container together with appropriate signage. Below is an image of the container with the equipment deployed beneath it.
- INEOS will develop a Traffic Management Plan (TMP) for approval with the highways authorities prior to commencement of activities along a highway.
- The TMP will include accepted routing of vehicles and means of traffic control during surveys (e.g. arrows, stop/go board). This will minimise disruption to other road users and ensure safe working. Any time restrictions (for example, to avoid peak periods of traffic including school drop off and pick up times) will be strictly followed.
- Road sweeping and wheel cleaning will be used if conditions result in dust or mud being tracked onto the road.

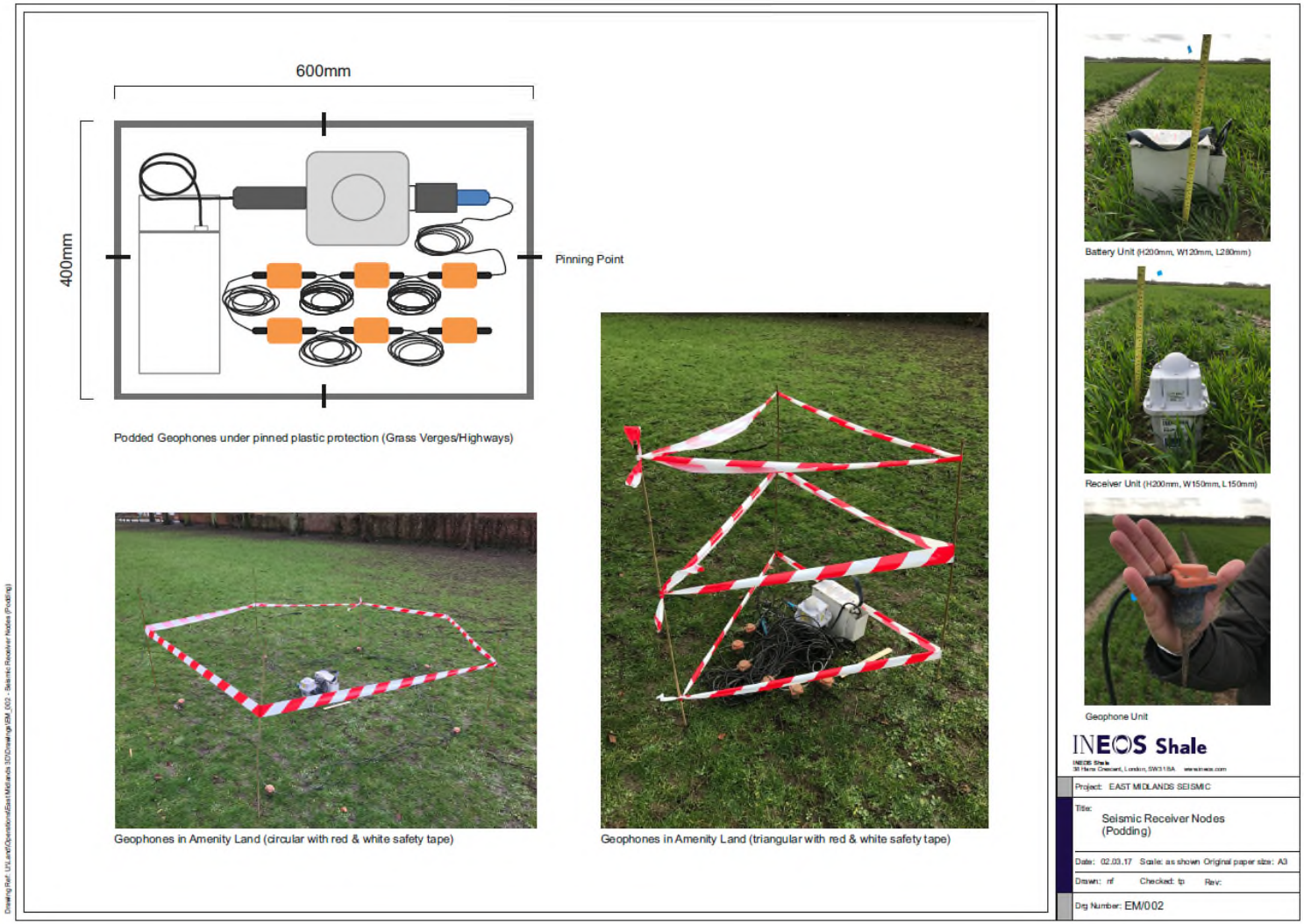

Figure 18: Seismic Receiver Nodes - Highways

6. UTILITIES

- Within the area of operations utility service providers will be encountered and the following procedures will be follows: -
- INEOS will contact each of the service providers to ensure that these services are identified and protected.
- Each utility company will be provided with a survey map marked with proposed source and receiver locations along with a request for a suitably scaled map identifying the utility companies' asset positions and the contact details of the local asset engineer to establish an agreed safety distance.
- It is best practice to have the main utility asset locations marked out by the asset operator and its position GPS recorded. This ensures the actual asset location is recorded.
- The information will be used to alter the survey design to ensure all restrictions and conditions are applied.
- The industry approved stand-off distances to general utilities are illustrated in Appendix 1.
- Upon request the PPV (Peak Particle Velocity) monitoring results can be supplied relative to each asset.
- For private utilities, landowners and occupiers are requested to supply any details on private or known utilities to their ALO. Source and receiver locations will then be adjusted to meet the industry standoff distance outlined in Appendix 1.
- For private utilities that lie within the proximity of planned sourced points and that cannot be accurately identified on the surface, the survey teams will have available at all times a professional CAT (cable avoidance tool) scanner. The operators of the CAT will be certified to a UK recognised accreditation. This training and certification has been updated for six surveyors recently and in preparation for this survey. The surveyors will identify the subsurface utilities that lie within proximity of planned source point and move then to the correct stand-off distances if required.

7. GOLF COURSES

- When undertaking seismic surveys on golf courses, the geophones will be deployed in a similar way to a grass amenity area which is illustrated in Figures 16 and 18.
- Locations will be agreed with the operator of the golf course and an attempt will be made to locate geophones in the rough.
- The operator of the golf course will be notified at least 24 hours before of access on foot and locations to harvest data or change batteries in geophones.
- All field operations staff will wear appropriate PPE including hard hats and fluorescent jackets on site.
- The crew on site will make themselves known to golfers playing the course.
- Where possible operations will be planned to take place first thing in the morning (7am) or last thing in the evening (6pm).
- Access for the vibroseis units will be taken at agreed times and along existing tracks and not on any greens or fairways and no geophones will be located on any green, fairways or tees.
- If notified of competition days, access for the surveys will be avoided on those days.

8. PEAK PARTICLE VELOCITY (PPV) MONITORING

- When undertaking both seismic charge and vibroseis operations within close proximity to buildings, utility services etc., PPV monitoring will be conducted to strict British Standard safety tolerances.
- The monitoring will identify the transient ground vibration levels experienced at or near the surface. Seismic energy sources are designed to direct the sound energy downwards but due to the varying near surface geology some of this energy is directed sideways, this degrades rapidly with distance and the distance varies with different unconsolidated surface geology.
- A vibration consultant as part of the seismic crew will be engaged to undertake PPV monitoring audits as needed.

9. SECURITY AND PUBLIC RELATIONS

- For the duration of the seismic survey INEOS will engage the services of an experienced and accredited security team to cover the following activities.
- To guard and protect the high value technical equipment used during a seismic survey throughout the prospect area.
- To patrol and secure the area where shot holes are pre-loaded with seismic charges.
- Should the need occur they will respond to any incidents or protester demonstrations. They will be in close liaison with the local police constabulary. (Historically there has been a positive side effect of their presence in that local theft and fly tipping incidents have reduced during the patrolling operations)
- INEOS has already taken steps to inform the local County, Metropolitan, and District and Parish councils of the upcoming survey.
- INEOS plans to hold other events to inform the public about what they can expect to see, when operations will commence and how long they will last. Landowners will be notified of the dates of these events.
- A public notice will be placed in the local free press newspapers.
- In addition, an advance information leaflet will be delivered to individual properties within the proximity of the surveys operations giving a local field office contact number for enquiries.
- A response plan is detailed below to assist landowners, occupiers and owners of assets.

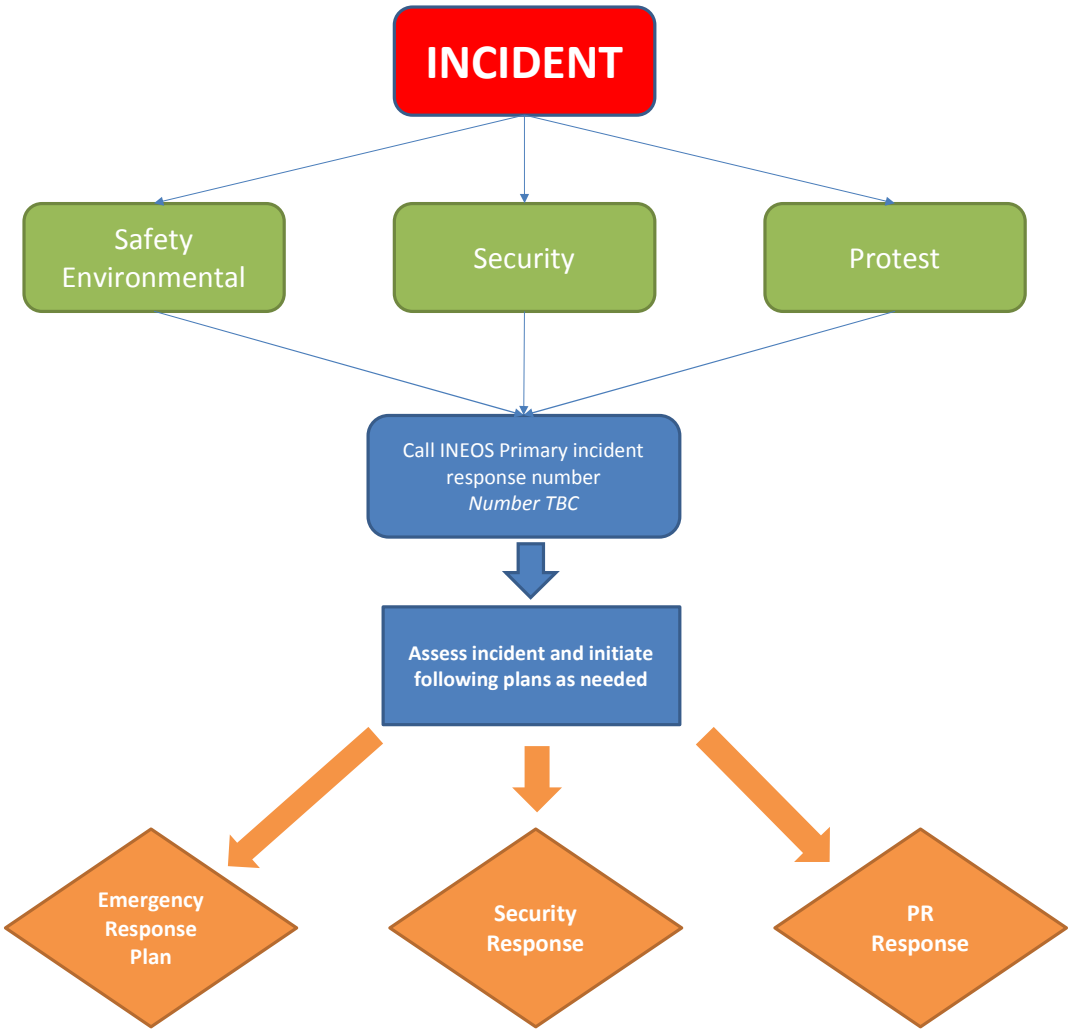

Figure 19: Response Plan

- For all types of incidents landowners and occupiers are requested to contact the INEOS Primary Incident Response number first.
- Incident response numbers will be supplied to all landowners, occupiers, chartered surveyors acting for them and asset owners prior to the commencement of operations.
- Once established the specific details of each of the responses plans will be available for discussion upon request.
- Landowner and occupier permission may be required to assist the security team with protestor response actions.
- No landowner or occupier or asset owner should approach any incident and on notification of any incident follow the procedure above and make no approach or attend the relevant location.

APPENDIX 1: STAND OFF DISTANCES

1.1 RECOMMENDED SAFE DISTANCES FOR ENERGY SOURCES

Recommended safe distance for Explosive Energy Sources

Total Charge Size	**0.09kg**	**0.18kg**	**0.25kg**	**0.5kg**	**1.0kg**	**2.0kg**
Buildings						
Occupied dwelling	50m	50m	50m	50m	50m	50m
Listed building	50m	50m	50m	50m	50m	50m
Industrial building	10m	18m	25m	25m	50m	100m
Agricultural building	10m	18m	25m	25m	50m	100m
Church/ Mosque	50m	50m	50m	50m	100m	100m
Graveyard	50m	50m	50m	50m	100m	100m
Services						
HP gas pipelines	10m	18m	25m	25m	25m	50m
MP & LP gas pipelines	5m	5m	5m	10m	15m	20m
HP water pipelines	10m	18m	25m	25m	25m	50m
MP & LP water pipelines	5m	5m	5m	10m	15m	20m
Sewage pipelines	5m	5m	5m	10m	15m	20m
O/H Power pylon (main)	25m	25m	50m	50m	50m	50m
O/H Power pylon (sub)	15m	20m	25m	25m	25m	25m
O/H Electric cables	*No less than 2.5 x detonator lead length*					
U/G Electric cables	5m	5m	5m	10m	15m	20m
U/G Telecom cables	5m	5m	5m	10m	15m	20m
General Utilities						
Roads	5m	5m	5m	5m	5m	5m
Railways	10m	10m	10m	10m	10m	10m
Manholes/culverts	5m	5m	5m	5m	5m	5m
Bridges/tunnels	10m	18m	25m	25m	50m	100m
Water wells	25m	25m	50m	50m	50m	50m
Fibre-optic junctions	5m	10m	10m	10m	15m	20m
Aqueducts	10m	18m	25m	25m	25m	50m

Explanation notes:

Buildings: Legal requirements within the GPDO restrict shot holes to 50m from occupied dwellings. The maximum charge permitted will not exceed 2Kg.

INEOS shall not go closer than quoted distances to a hazard unless specifically requested in writing by the asset owner, to fulfil the survey requirements. If this is the case vibration monitoring by an independent body will be used to determine actual PPV values at the revised distances. More restrictive distances specified by local authorities, regulatory bodies or utility companies will be adhered

RECOMMENDED SAFE DISTANCES FOR VIBRATORY ENERGY SOURCES (m) (Thomas)

INEOS Shale

Drive level (% peak force)	**15**				**30**				**50**				**75**				**90**			
No. of vibrators	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Houses and other dwellings	5	10	20	35	10	20	35	50	15	25	40	60	25	35	50	75	45	55	70	100
Strong industrial buildings	5	5	10	20	10	10	20	30	10	20	30	40	20	30	40	50	30	40	50	60
Listed or fragile buildings	25	30	40	50	30	40	50	75	40	50	75	100	50	75	100	100	100	100	100	100
Hospitals	25	30	40	50	30	40	50	75	40	50	75	100	50	75	100	100	100	100	100	100
Petrol storage tanks	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
Culverts, man-holes	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Bridges, tunnels	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
Electricity sub-stations	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Electric cables	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
HP gas, oil and water pipes, parallel	4	4	4	4	5	5	5	5	7	7	7	7	10	10	10	10	20	20	20	20
HP gas, oil and water pipes, crossing	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
MP and LP oil, gas and water pipes parallel	1.5	1.5	1.5	1.5	2	2	2	2	3.5	3.5	3.5	3.5	5	5	5	5	10	10	10	10
MP and LP oil, gas and water pipes crossing	1.5	3	4	5	2	5	7	10	3.5	7	10	15	5	10	15	20	10	15	20	25
Radio masts	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
Telephone boxes	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Fire hydrants	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Telephone fibre-optic junctions	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Sewage pipelines	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Sewer rising main, iron or steel	4	4	4	4	5	5	5	5	7	7	7	7	10	10	10	10	20	20	20	20
Sewer rising main, plastic	2	2	2	2	3	3	3	3	5	5	5	5	7	7	7	7	10	10	10	10

Comment

Items highlighted in yellow: - Recalibration to take account of the latest guidelines provided in BS5220-2:2009 (Section B4.4 (underground services))

1 All distances apply to middle of nearest vibrator pad.
2 Contractor shall not go closer than quoted distances to a hazard unless specifically requested in writing to do so to fulfil the survey requirements, in which case vibration monitoring by an independent body should be used to determine actual PPV values.
3 Distances should be decreased suitably where local conditions dictate.
4 More restrictive distances specified by any local authorities or utility companies must be adhered to.

1.2 STAND-OFF DISTANCES FROM ENVIRONMENTAL RESTRICTIONS AND HERITAGE SITES

- Stand-off distances from Trees – dependent on the Root Protection Zone, which would be determined in the field (following a method statement as agreed with Natural England/ MPA/Forestry Commission)
- Scheduled Monuments – as per the tables for explosive and vibratory source in section 1.1
- Watercourses, including field drains, irrigation pipes and standing water bodies – 8metres.
- Private Water Supplies (identified by landowner or manager) – dependant on drive levels or charge size as outlined in the above charts
- Known badger setts (identified by landowner, site manager or pre-operational survey) – 30metres
- Known holts, nests, corridors for otter, water vole, bats or other protected mammals (identified by landowner, site manager or pre-operational survey) – as determined by site specific survey undertaken by an ecologist.

1.3 GPDO AND RESTRICTIONS

The survey operations must meet certain requirements laid out in Class K of the GPDO. There are particular restrictions within the order that must be followed during the survey that include: -

- No explosive charge of more than 2kg will be used.
- No excavation will exceed 10m in depth or 12 square m in surface area.
- No structure assembled or provided will exceed 15m in height.
- Development must be carried out in accordance with the details in the notification unless the MPA has agreed otherwise in writing.
- No trees on the land will be removed, felled, lopped or topped, or any damage caused, unless the MPA has agreed in writing and in agreement with the Landowner.
- Restoration (including removal of structures, waste, sealing boreholes, levelling of the topsoil and seeding and replanting) must be completed within 28 days of cessation of operations unless agreed otherwise by the MPA in writing.
- Development must cease no later than six months after the elapse of the relevant period unless the MPA has otherwise agreed in writing
- Wildlife and Countryside Act 1981 (as amended) – INEOS and their contractors may not kill or injure any wild bird or damage their nests or eggs, disturb some species of breeding birds, kill or injure certain animals (e.g. otters, water voles, bats, red squirrels, and several invertebrates, reptiles and amphibians) or damage their shelter or destroy certain wild plants. Certain requirements relating to certain non-native plants must also be addressed. The 1981 act also makes it an offence to carry out or permit someone else to carry out a controlled activity on an SSSI without Natural England's permission.

- For all types of incidents landowners and occupiers are requested to contact the INEOS Primary Incident Response number first.
- Incident response numbers will be supplied to all landowners, occupiers, chartered surveyors acting for them and asset owners prior to the commencement of operations.
- Once established the specific details of each of the responses plans will be available for discussion upon request.
- Landowner and occupier permission may be required to assist the security team with protestor response actions.
- No landowner or occupier or asset owner should approach any incident and on notification of any incident follow the procedure above and make no approach or attend the relevant location.

APPENDIX 2: LICENSE AGREEMENT CRITERIA FOR WORK IN THE ESTATES

2.1 AGREED STAND-OFF DISTANCES

- No Investigations shall take place:
    - within 15 metres of any veteran trees notified by the Licensor to the Licensee;
    - within 15 metres of any irrigation mains notified by the Licensor to the Licensee;
    - within 50 metres of any historic structures or monuments
    - within 15 metres of any release pens for game.