4.0 PROJECT DESCRIPTION

This chapter of the Environmental Impact Statement describes the main components of the proposed underground gas storage facility at Islandmagee, Co Antrim. Consideration is also given to construction activities associated with the works and the operation and maintenance of the completed facilities. The above ground facilities for the proposed development are primarily located adjacent to the existing power station at Ballylumford. The caverns themselves will be located beneath the eastern side of Larne Lough and will be accessed via a wellpad located on a site which is presently in agricultural use, in the townland known as Ballydown. Once completed, the facility will be capable of storing up to 500 million cubic metres of natural gas, with an injection capability of 12 million cubic metres per day and a withdrawal capability of 22 million cubic metres per day.

4.1 Proposed Development

The proposed development works comprise the following main construction elements, full details of which are also included on the planning application drawings:

4.1.1 Gas Plant Facility

- Ground works and piling to create level platform to incorporate:
  - Main facility office and operational control building (footprint of approx 360m²)
  - Compression plant
  - Dehydration plant
  - Metering equipment
- Access road and new facility entrance from main B90 Ballylumford Road
- Creation of hardstanding area for car parking

The overall estimated post construction footprint of the main gas plant facility including the access road is approximately 16,700m².

4.1.2 Sea Water and Brine Pumping Facilities (Leaching Plant)

- Removal of *c.*17,000m³ of outcropping bedrock
- Construction of Pump House containing:
  - 2 No. 2MW variable speed Leaching Pumps
  - 2 No. 2MW variable speed Brine Discharge Pumps
- Electrical sub station (containing transformers for leaching plant electricity supply)
- Brine tanks (holding tanks for monitoring and temperature control of brine, prior to discharge)

The overall estimated post construction footprint of the Leaching Plant area (including hardstanding and access) is approximately 6,110m².

4.1.3 Wellpad

- Reprofiling of slope to provide flat pad area measuring 110 metres by 45 metres which will host drilling rig during early construction phase
- Seven wells each capped with a wellhead, contained in cellars below ground level
- Enhancement and extension of existing access lane from main B90 Ballylumford Road

The estimated post construction footprint of the wellpad will be approximately 4,800m²

4.1.4 Sea Water Intake Pumping Station

- Excavated sump into the bedrock on the foreshore at Castle Robin Bay/Bell's Port, which will be covered by a pump house and will contain 4 no pumps for seawater intake.
- 2 No. intake pipelines extending below the seabed from the intake sump approximately 50 metres to the seabed at the -4m contour.

The overall estimated footprint of the sea water intake pumping station is 175m²

4.1.5 Connecting Pipelines

The facilities will be connected together by sub-surface pipelines as follows:

4.1.5.1 Seawater Intake Pipeline

The seawater intake pipeline will run between the Seawater Intake Pumping Station and the Wellpad via the Leaching Plant.

The 450mm Ø seawater intake pipeline will measure approximately 2,570m in total, divided into two sections:

- **Section A** (725m) directionally drilled triple sub surface pipeline extending from the Wellpad to a junction point where the sea water and brine pipelines diverge. For this section of the pipeline route, a Horizontal Directional Drilling (H.D.D.) rig is proposed to create a sleeved sub surface tunnel in which the seawater intake, brine outfall and gas pipelines will travel together from the Gas Plant Facilities to the Wellpad site. Through this section, the sea water pipeline will have high pressure specification.
- Section B (275m) dual conventionally trenched sub surface pipeline (occupying same trench as brine outfall pipeline) from the HDD pit to the Sea Water and Brine Pumping Building. Through this section, the sea water pipeline will have a high pressure specification.
- **Section C** (2,285m) dual conventionally trenched sub surface pipeline (occupying same trench as brine outfall pipeline) from the Sea Water and Brine Pumping Building to the point at which the sea water and brine pipelines diverge.
- **Section D** (285m) a solo conventionally trenched sub surface pipeline from the point at which the sea water pipeline diverges from the brine pipeline to the Seawater Intake Pumping Station.

Details on the methodology for pipeline installation by conventional trenching and directional drilling are included later in Section 4.3.2.

4.1.5.2 Brine Outfall Pipeline

The brine outfall pipeline will run between the Wellpad and the Outfall Discharge Point via the Brine Leaching Plant.

The 450mm Ø pipeline will measure 3,880 m in total, divided into four sections

- **Section A** (725m) directionally drilled triple sub surface pipeline extending from the Wellpad to the HDD pit beside the Gas Plant. For this section of the pipeline route, a Horizontal Directional Drilling (H.D.D.) rig will create a sleeved sub surface tunnel in which the seawater leaching, brine outfall and gas pipelines will travel together from the Gas Plant Facilities to the Wellpad site. Through this section, the brine pipeline will have a high pressure specification.
- **Section B** (275m) dual conventionally trenched sub surface pipeline (occupying same trench as seawater leaching pipeline) from the HDD pit beside the Gas Plant to the Sea Water and Brine Pumping Building. Through this section, the brine pipeline will have a high pressure specification.
- **Section C** (2,285m) dual conventionally trenched sub surface pipeline (occupying same trench as seawater intake pipeline) from the Sea Water and Brine Pumping Building to the point at which the brine outfall diverges from the sea water intake, and the construction method switches to H.D.D..
- **Section E** (595m) directionally drilled single sub surface pipeline extending from the brine outfall H.D.D. pit to the Outfall Discharge Point. The H.D.D. will have an angled trajectory from the junction point at Dundressan and will drill through the surface basalt and underlying sedimentary rocks, passing beneath the base of the cliff and travelling approximately 15-20m below the seabed surface before angling upwards again and breaking through the surface at, or very close to, the outfall discharge point.

4.1.5.3 Gas Pipeline

The gas pipelines are designed with the following specifications:
• field pipeline to cavern pad: DN 250/ANSI 1500 PN 250.
• pipelines on cavern pad: DN 150/ANSI 1500 (well head API 5000) PN 250.
• pipeline for first gas fill: DN 200/ANSI 1500 PN 250.

The 406mm Ø gas pipeline will be a pre-coated steel pipe and will travel approximately 755m sub surface between the Wellpad and the Gas Plant Facility. Of this route, approximately 725m will travel through the Horizontal Directionally Drilled section alongside the sea water leaching and brine outfall pipelines to the HDD pit adjacent to the main gas plant and the final 30m to the Gas Plant Facility will be buried using conventional trenching. A short connecting pipeline will also extend from the Gas Plant Facility to the national grid connection point at the Ballylumford Pressure Reduction Station.

4.1.6 Temporary Set Down and Storage Compound

The first aspect of the project will be to establish temporary portakabin type construction offices and equipment lay down areas, adjacent to the site, together with the necessary associated connections to existing infrastructure i.e. water, power and waste disposal. Given the limited room available on the site it is likely that some of these facilities may need to be situated outside the permanent site boundary. A temporary set down area and storage compound has been identified approximately 850 metres north west of the site on an existing but currently disused area of hardstanding owned by Northern Ireland Electricity (NIE), shown on Figure 4.1. It is proposed that this area will be leased from NIE for the duration of construction.

In order to minimize heavy construction traffic outside the immediate plant area it is anticipated that a temporary concrete batching plant will be set up within the temporary set down and storage compound, similar to that shown in Plate 4.1.

Plate 4.1 Typical Concrete Batching Plant

0 50 100 200 300 400 500
m
N
BRINE OUTFALL
SEA WATER INTAKE
Sea water Intake Pumping Station
c. 285 metres sea water pipeline (conventionally trenched) (SECTION D)
c.595 metres (horizontal distance) brine pipeline (directional drilling) (SECTION E)
c. 2,285 metres brine and sea water pipelines (conventionally trenched) (SECTION C)
Temporary Construction Set-Down Area (Existing Hardstanding)
Sub - Surface Sea water and Brine Pipelines
POWER STATION
Sea water and Brine Pumping Facilities (Leaching Plant)
c. 275 metres brine and sea water pipelines (conventionally trenched) (SECTION B)
Main Gas Plant Facilities
Access road
Vent
Sub - Surface Sea Water, Brine and Gas Pipelines
c. 725 metres brine, sea water and gas pipelines (directionally drilled) (SECTION A)
Access road
Wellpad
Proposed Cavern Locations (top of Caverns approx 1,500 metres beneath the seabed)
LARNE
LARNE LOUGH
ISLAND MAGEE
CLIENT
ISLANDMAGEE STORAGE LIMITED
PROJECT
ISLANDMAGEE STORAGE PROJECT
TITLE
LAYOUT OF FACILITIES
SHOWING PIPELINE LENGTHS
RPS Consulting Engineers
ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST BT12 6RZ
TEL : 028 9066 7914
FAX : 028 9066 8286
www.rpsgroup.com/Ireland
Drawing No. :
FIGURE 4.1
Drawn By : SG
Checked By : MB
Approved By : MB
Date : 25/11/09
Scale : 1:12,000
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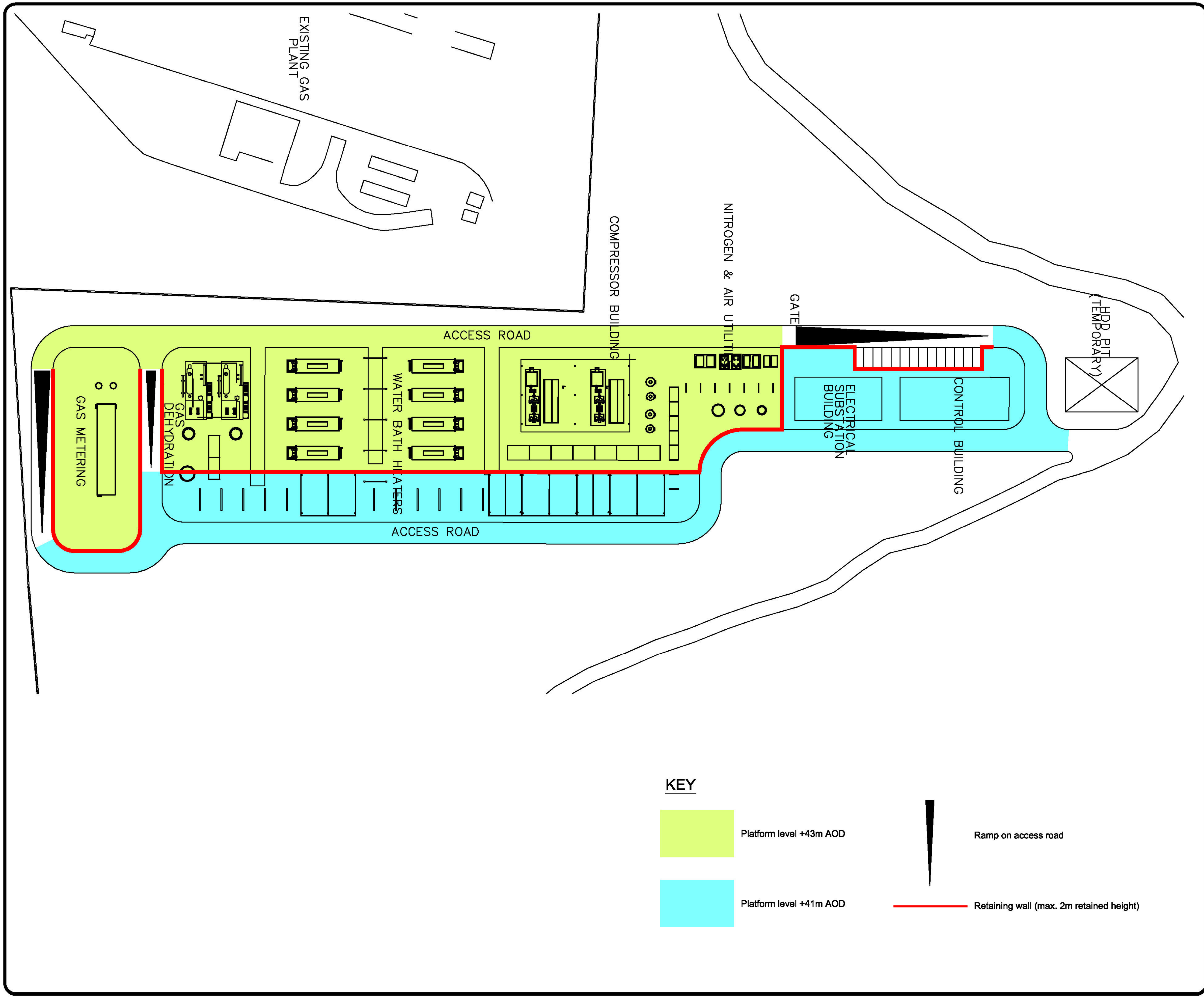
3. Plant layout provided by CB&I.



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Hydrock Consultants
Over Court Barns
Over Lane
Almondsbury
Bristol BS32 4DF
TEL: 01454 619 533
FAX: 01454 614 125
E-Mail: bristol@hydrock.com
or visit www.hydrock.com

Client

Islandmagee Storage

Project

ISLANDMAGEE STORAGE PROJECT

Title

Proposed Earthworks Platform Levels at Gas Plant Site

Drawing Status

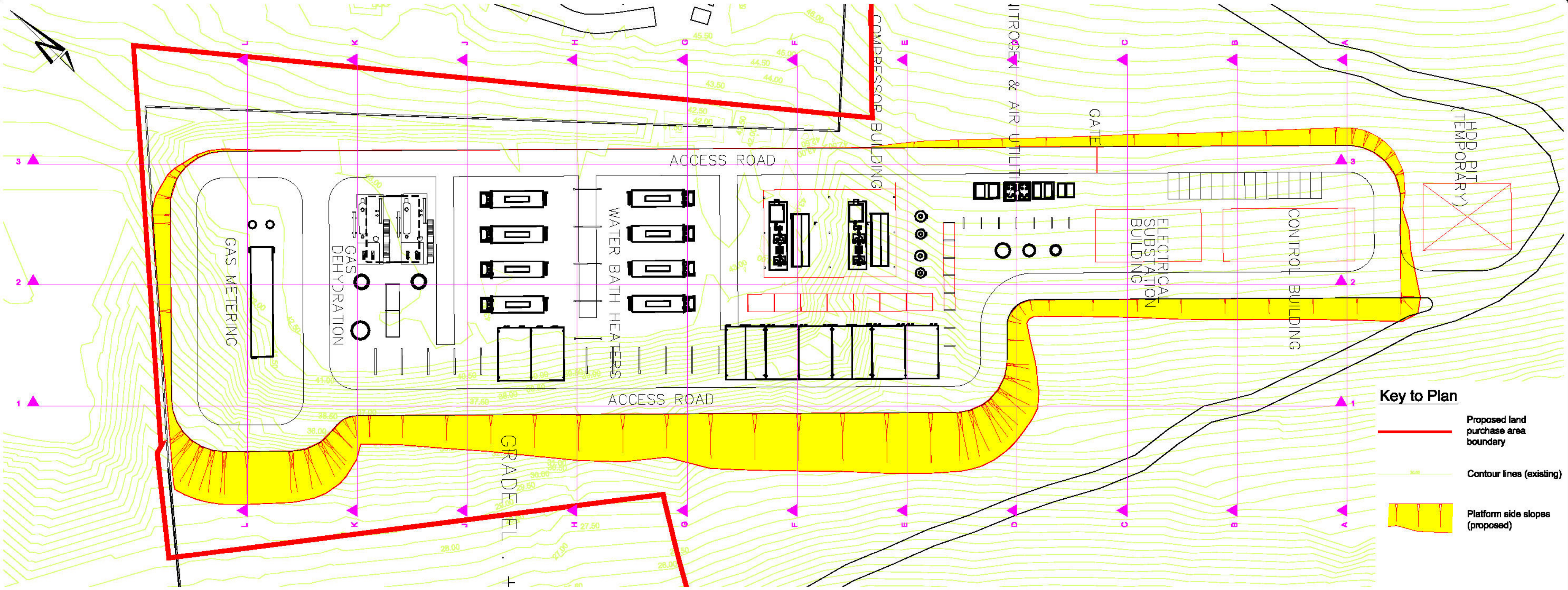
INFORMATION

Job No. C09141

Drawn	Checked	Scale at A3	Date	Issue Date
RG	KP	1:1000	23/10/09	23/10/09

Figure 4.2

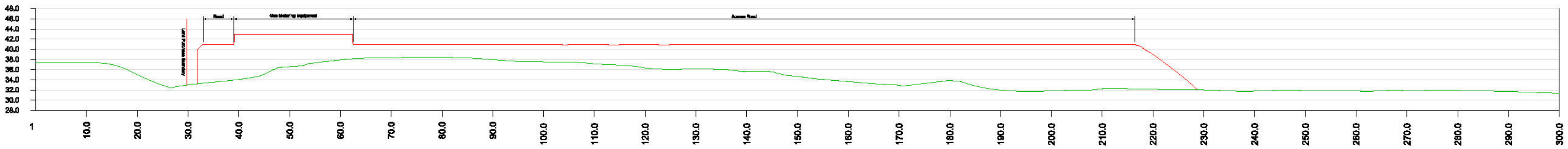
Revision A



Plan (Scale 1:500)

Key to Plan

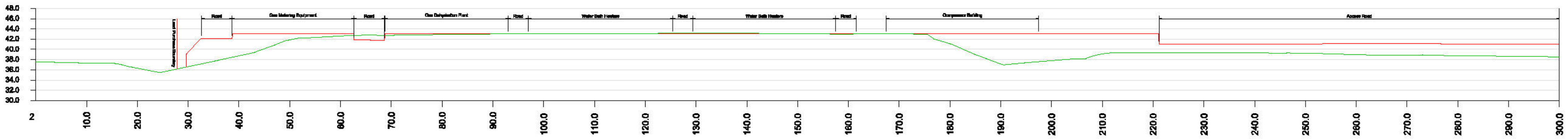
- Proposed land purchase area boundary
- Contour lines (existing)
- Platform side slopes (proposed)



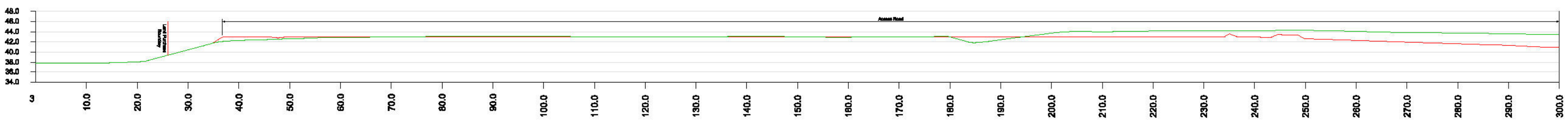
Cross Section 1 (Scale 1:500)

Key to Cross Sections

- Existing ground profile
- Proposed ground profile



Cross Section 2 (Scale 1:500)



Cross Section 3 (Scale 1:500)

Notes:

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3. Contours based on topographic surveys provided by RPS.
2. Plant layout provided by CB&I.

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Hydrock Consultants
Over Court Barns
Over Lane
Almondsbury
Bristol BS32 4DF
TEL: 01454 619 533
FAX: 01454 614 125
E-Mail: bristol@hydrock.com
or visit www.hydrock.com

Client: Islandmagee Storage

Project: ISLANDMAGEE STORAGE PROJECT

Title: Earthworks Plan & Cross Sections - Gas Plant Sheet 1 of 2

Drawing Status: INFORMATION

Job No. C09141

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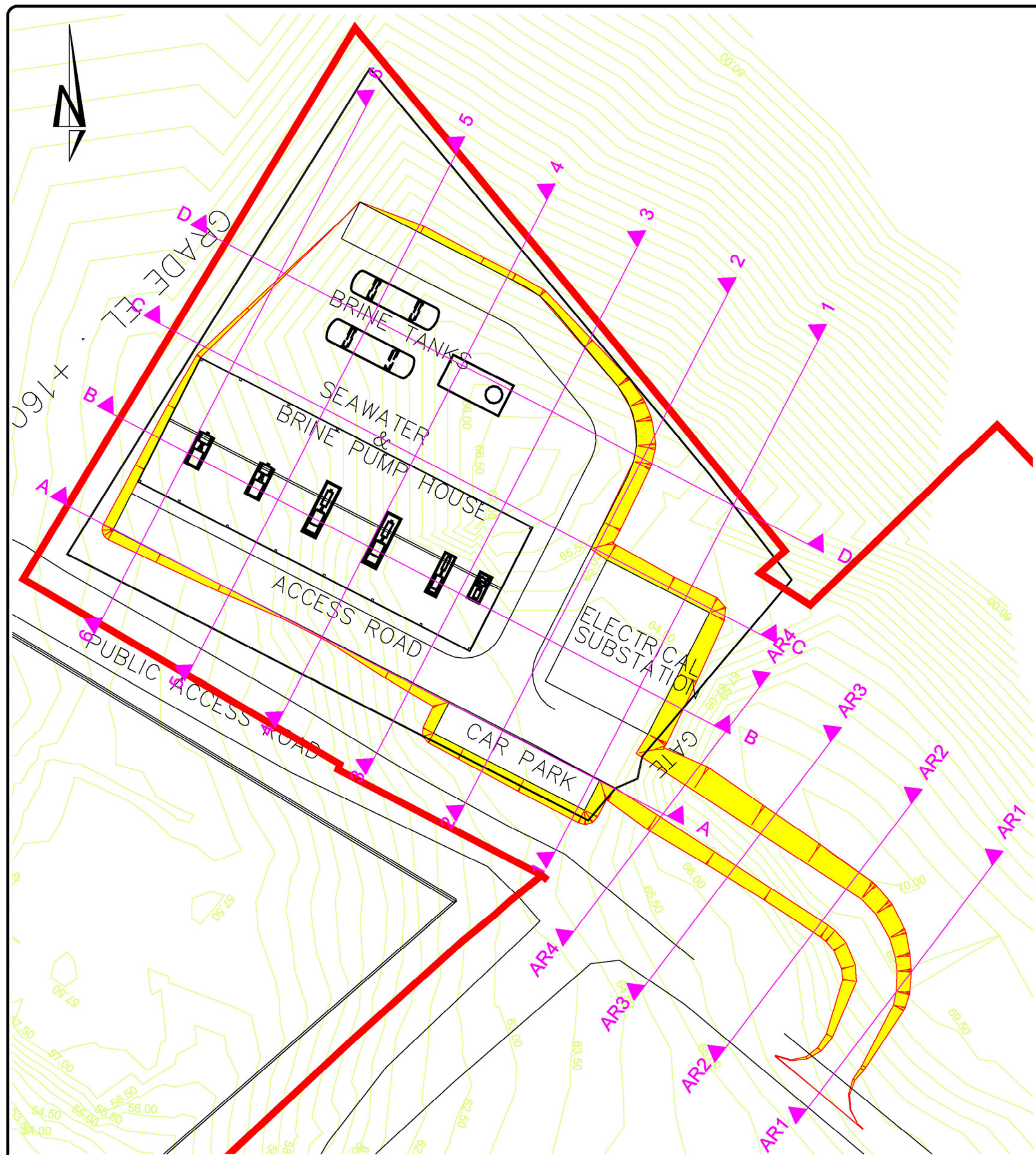
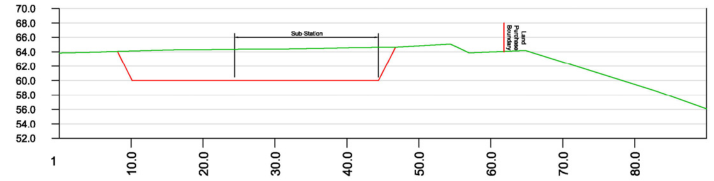
Figure 4.3

Revision A



Plan (Scale 1:500)



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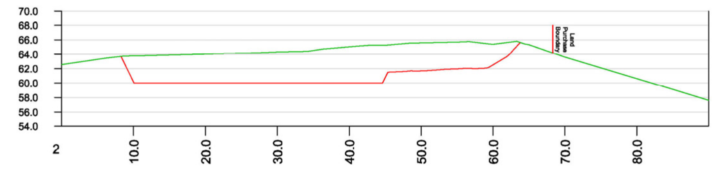

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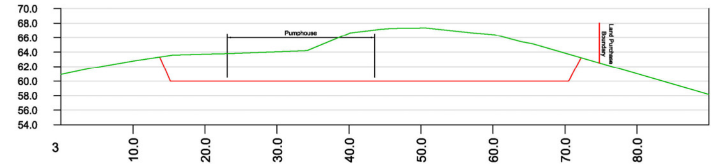

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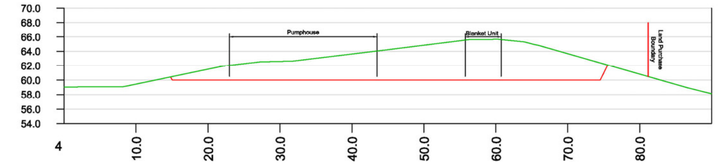
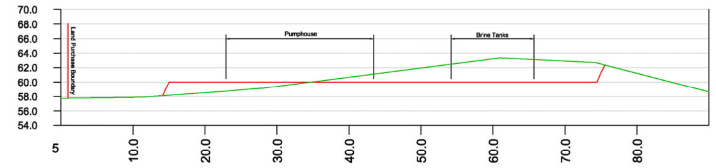


Cross Section4 (Scale 1:500)



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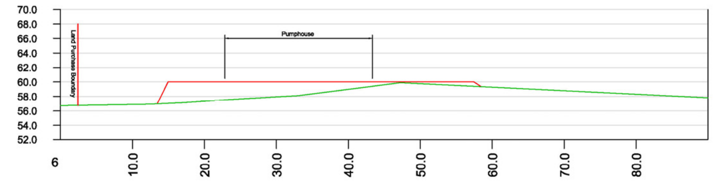

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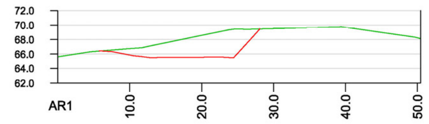
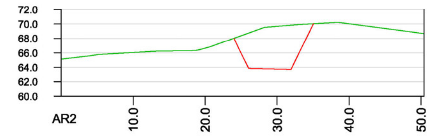
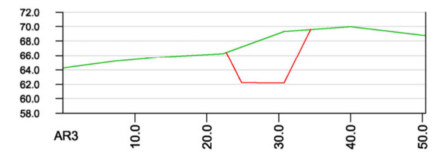


Cross Section AR1 (Scale 1:500)



Cross Section AR2 (Scale 1:500)



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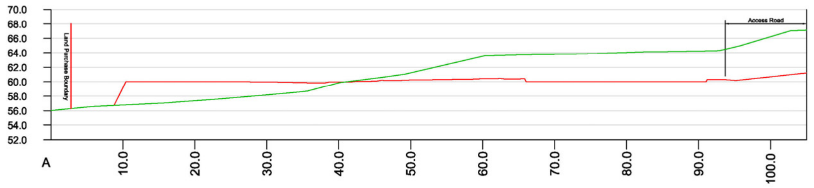
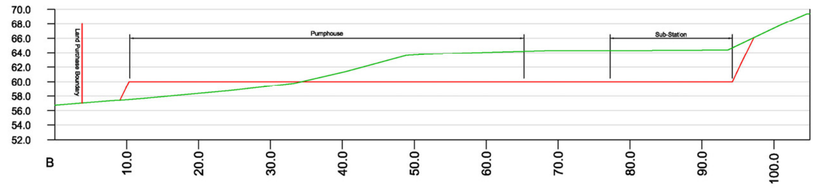
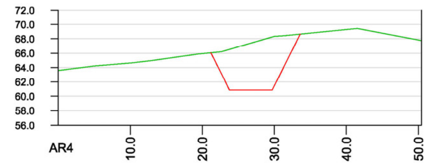


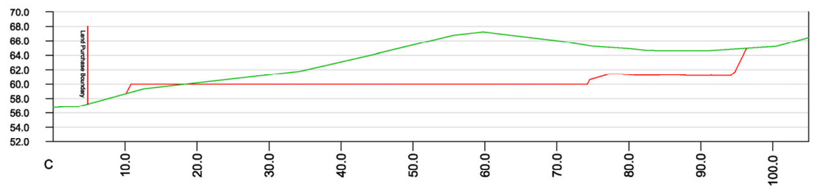
Cross Section A (Scale 1:500)



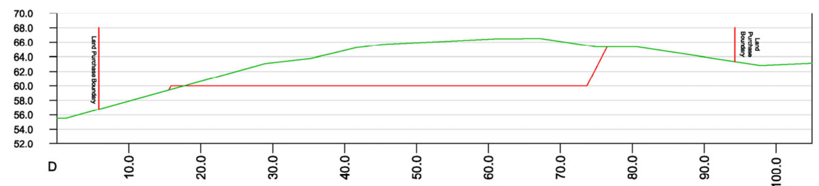
Cross Section B (Scale 1:500)



Cross Section AR4 (Scale 1:500)



Cross Section C (Scale 1:500)



Cross Section D (Scale 1:500)

Key

- Proposed land purchase area boundary
- Contour lines (existing)
- Platform side slopes (proposed)
- Existing ground profile (on cross sections)
- Proposed ground profile (on cross sections)

Notes:

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3. Contours based on topographic surveys provided by RPS.
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Hydrock Consultants
Over Court Barns
Over Lane
Almondsbury
Bristol BS32 4DF
TEL: 01454 619 533
FAX: 01454 614 125
E-Mail: bristol@hydrock.com
or visit www.hydrock.com

Client: Islandmagee Storage

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Figure 4.4

Revision: A

4.2 Gas and Brine Facilities

This section describes the sequence of construction planned for the gas and brine facilities and the potential environmental impacts anticipated during the works and the techniques used to mitigate them.

Access to the Main Gas Plant Facilities and Leaching Plant will be from the B90 Ballylumford Road. A new entrance and access lane will be created for both of these sites. Traffic movements will be managed by implementation of a traffic management plan drawn up in agreement between Islandmagee Storage Limited and the Department of Regional Development (DRD) Roads Service. Access to the construction areas will be restricted with temporary fencing supplementing the existing site fencing with an appropriate level of surveillance security.

4.2.1 Civil Engineering Works

In order to create stable platforms for construction of the Gas Plant and Leaching Plant facilities, excavation and filling will be required. To avoid the need for importing fill and exporting surplus materials, a balanced earthworks strategy, as described in the following sections has been developed.

4.2.1.1 Main Gas Plant Facilities

The platform levels proposed have been designed to ensure that they are compatible with the proposed layout of the facilities at each location. It is proposed that all of the fill required to create the working platforms will be obtained from land within and adjacent to the Main Gas Facilities and Leaching Plant sites, which will be purchased by Islandmagee Storage Limited. This will eliminate the need for importing of aggregate via the public roads. Similarly, it is proposed that any material arising from the proposed excavations that is unsuitable for use as engineered fill will be used in landscaping/screening, subject to acceptable classification and compliance with waste regulations, etc.

As described in Chapter 3 – *"Site Description"* the majority of the north eastern part of the gas plant site lies on the former earthworks disposal Area 2C, the main platform of which has been formed at a level of approximately +43m AOD. The south western part of the gas plant site lies within part of disposal Area 2D on sloping ground with the existing ground level varying between approximately +45m AOD and +38m AOD.

In order to accommodate the gas plant facilities it will be necessary to widen the existing fill platform at the northern end of the site. To minimise the volume of excavation and fill required to achieve this it is proposed that the majority of the platform be formed at +43m AOD (i.e. similar to the level of the current platform). The pipe rack, lower access road, electricity sub-station and control building can be constructed at a different level to the remainder of the facilities and it is proposed that the platform in these areas is constructed at +41m AOD.

The proposed platform levels are summarised on Figure 4.2 and cross sections showing the existing and proposed ground levels are provided on Figure 4.3.

Retaining structures with a maximum retained height of 2m will be required within the gas site at the interfaces between the different levels. Access roads (and the proposed car parking bays) will be inclined at maximum gradients of 1v:10h to accommodate the changes in levels as required.

4.2.1.2 Leaching Plant

The proposed site of the leaching plant is located at the crest of Ballylumford Hill. Within the main leaching plant site the existing ground level varies between approximately +57m AOD and +67m AOD. Along the alignment of the proposed access road to the leaching plant the ground level varies between approximately +65m AOD and +67m AOD.

As described previously, basalt is understood to be present immediately below existing ground level at the proposed leaching plant site. Abandoned quarry faces several metres in height are present in the area formed within the basalt rock mass and these show no signs of significant/large scale instability. Based on an initial review (and subject to confirmation by ground investigation at front end engineering or detailed design stage), it is considered that basalt excavated at the leaching plant site will be processed on site to provide high quality aggregate for use in the construction of other areas of the development.

In order to improve the screening of the leaching plant facilities, it is proposed to construct the platform for the leaching plant at a level of +60m AOD with an inclined access road (maximum gradient of approximately 1v:10h) constructed within a rock cutting, as shown on Figure 4.4. The surplus stone generated from excavating the level platform will be re-used in the gas plant site.

4.2.1.3 Proposed Source of Required Additional Fill Material

Based on the platform areas and existing/proposed ground profiles, the cut and fill volumes for the leaching plant and main gas plant facilities are as follows:

Table 4.1 Cut and Fill Volumes

Site	Estimated Volume to be Excavated	Estimated Volume of Fill Required
Leaching Plant	17,100 m^3	1,100 m^3
Gas Plant	4,000 m^3	31,600 m^3
Sub-totals	*21,100 m^3*	*32,700 m^3*

It should be noted that the excavation volumes given above are in-situ volumes, i.e. they do not allow for bulking. If it assumed that the basalt excavated from the leaching plant site will bulk by a factor of 1.2 between excavation and re-compaction as fill material, the overall volume of compacted fill provided by the excavation at the leaching plant site will be around 20,500 m³.

In addition to the aggregate that will be generated by crushing the basalt excavated from the leaching plant site, it is proposed, subject to consent from the Northern Ireland Environment Agency, that the remaining fill materials (approximately 12,000m³) are obtained by excavating and processing the former construction arisings placed within part of disposal Area 2D during construction of the Ballylumford "C" power station. The material placed within disposal Area 2D is understood to comprise mainly broken/excavated basalt, which can be recycled by crushing and screening on site to provide suitable aggregate.

The nature and thickness/volume of the fill material placed in disposal Area 2D will need to be verified by trial pits and sampling/testing as part of the front end engineering/detailed design stage. Excavation will not extend beneath the original ground level.

Use of the borrow areas will be subject to appropriate construction techniques to reduce the impact of the excavation. Topsoil will be stripped and set aside for reinstatement and careful consideration will be given to drainage. On completion of operations, the borrow areas will be fully reinstated.

4.2.1.4 Civil works methodology

It is envisaged that all of the proposed earthworks will be carried out using standard construction plant, i.e. tracked excavators/dozers, rubber-tyred dumpers and rollers etc. Temporary haul roads will be constructed on the proposed alignment of the permanent access roads to minimise disruption.

The method of excavation of the basalt at the leaching plant site will depend on the results of further investigation and assessment of the rock mass conditions (i.e. rock strength and fracture spacing) but based on the conditions observed in the disused quarry faces it is considered likely that the material could be excavated using mechanical plant (i.e. hydraulic breakers and rippers), rather than drilling and blasting but the final decision on the method of excavation will be determined by the contractor based on cost and programme, and also taking into account any environmental constraints (e.g. noise and vibration limits).

Key environmental control issues during this phase will be the minimisation of noise, vibration and dust associated with heavy plant working.

4.2.2 Construction of Buildings

During the pre-construction period the main contractor will undertake detailed project planning and produce construction procedures/method statements, waste management and emergency procedures as well as risk analyses, taking particular account of the safety and environmental impact aspects of the operations. Upon completion of this phase the site will be ready for the main contractor to commence the construction of the facilities.

Before detailed design is started, a full survey of the potential routes to the site will be made to determine the largest Pre-Assembled Unit (PAU) or modules that can be transported to the site without undue inconvenience to traffic or parties in the vicinity of the site. This will establish the design parameters for off site fabrication, which will reduce the on-site construction effort to the minimum practical. This will, in turn keep the disturbance to the surrounding area to a minimum. Modularisation and careful planning of the logistics of construction will reduce the need for using the lay down area, and will keep vehicle movements and on-site fabrication to a minimum.

Upon completion of the civil works for the gas and brine facilities and the Horizontal Directional Drill (HDD) to the wellsite, the first phase of building and equipment installation will start with construction of the leaching pump house area.

Building construction will typically be prefabricated steel framed and clad buildings similar to those shown in Plate 4.2 to Plate 4.5 below with cranes and scaffolding.

Plate 4.2 Installation of After Coolers

Plate 4.3 Installation of Compressors

Plate 4.4 Installation of Absorber Towers

Plate 4.5 General Construction Activity

Pipework for the facility will also be prefabricated and brought to site in modules to minimise the number of vehicle movements and the amount of installation work on-site.

The facilities involve large items of rotating machinery and vessels. The aim of the construction planning and design work is to reduce these to the minimum possible; however it is possible that there will be some heavy lifting operations.

Due to physical constraints these operations will require significant planning to ensure that environmental concerns are taken into account including noise, dust and access onto the site from the nearby road.

Following installation of primary equipment, piping modules and services (electrical and control systems) final welding, testing and painting will be completed.

As this is the most intensive period of construction, some volume of waste (packaging) and material off-cuts is likely to be generated. Islandmagee Storage Limited aim to minimise this through off-site fabrication and direct shipping from the fabricator, thereby avoiding bringing unnecessary packaging to the site.

As will be discussed later in Section 4.9.4.2, where required, diesel for construction plant will be supplied from dedicated bowsers within appropriately bunded refuelling areas. Drainage interceptors will also be installed within the temporary construction set down area. In addition to road drainage, run off from the site will be monitored for water quality and where required, wash down areas for construction plant located in contained areas.

4.2.2.1 Equipment Deliveries

It is recognised that the access to the facilities areas are restricted hence the emphasis on carrying out as much work as possible off-site to reduce the number of deliveries.

4.2.2.2 Cold Vent

The cold vent is a minor structure which is used to purge the gas inventory from the gas plant and boreholes above the level of the safety shut-off valves in the event of an emergency. The cold vent will be a stack measuring approximately 0.9m diameter and 40m in height. The stack is proposed to be painted a matte moss or olive green colour to reduce the visual impact when read against the hillside.

The vent stack will be connected to the main gas plant facility by a 450-500mm diameter sub-surface pipeline. In order to reduce the footprint of the works, the pipeline will be laid by open trenching methods beneath what will eventually become the access road to the stack.

The proposed site of the vent stack will require some slope stabilisation measures, which subject to detailed design, are likely to be achieved through a combination of slope drainage and toe support along the shoreline. To reduce the footprint and depth of the vent foundation, the vent stack will be secured by guy lines.

Following construction, there is no requirement for hardstanding around the vent stack itself and the ground will be reinstated to natural vegetation. The access lane leading from the main gas plant facilities will not be tarmaced and will be left as a gravel lane. A livestock/safety fence extending approximately 20 m from the stack will be required.

4.2.2.3 Plant Commissioning

The leaching and brine pumping facilities will be commissioned well in advance of the remaining facilities to enable the cavern leaching process to commence before the gas compression/dehydration facilities are required. The gas facilities will require testing (hydrotest and control loop checking) and inspection (together with the gas pipelines) before a first fill of gas is introduced from the SNIP AGI.

At this point the plant will become “live” and the operation and control procedures developed during the design stage will come into force, including environmental monitoring and procedures.

The plant will then undergo a series of performance tests likely to involve the injection compressors and one dedicated cavern to demonstrate the performance of the injection plant. This will include gas heating, pressure let down, metering, filtration and analysis systems before the gas is passed back into the Northern Ireland gas network. Emergency shut down, blowdown and fire & gas detection systems will also be thoroughly tested.

During this period, monitoring will be carried out for leakages. Noise emissions and venting will be tightly controlled and training undertaken for emergency response and normal operation.

Much of the sites to be occupied by the proposed gas and brine facilities will be finished in tarmac, paving or crushed stone for operational and safety reasons. However a ‘soft’ landscape treatment is proposed elsewhere within the site. Proposals include native hedgerow and tree planting within and adjacent to the site platforms and as an informal landscaped setting for the site administration and maintenance buildings. The measures proposed will help to filter views of buildings and structures on the gas plant and interrupt the appearance of massing of the development, and also conserve existing and/or create new areas of habitat value that will contribute to the site's overall biodiversity. In doing so they will help to integrate the gas storage facility within its wider landscape setting on Islandmagee and contribute to local ecological and landscape resources.

4.2.2.4 Summary

In summary the key aspects of the Islandmagee Storage facilities construction that will require monitoring and consideration are as follows:

- The contractor will prepare detailed construction procedures, method statements and risk assessments as part of the detailed design of the works, which will include detailed evaluation of Health and Safety and Environmental issues during construction.

- Traffic movements to and from site including equipment deliveries are to be limited, taking advantage of the local fabrication facilities in Northern Ireland or the local availability of roll-on/roll-off facilities at the nearby ports of Larne or Belfast. Consequently, the increase in traffic would relate to the construction workforce which could peak at 150 - 200 personnel depending on the shift systems adopted. Contractors will be encouraged to employ workers' buses for this purpose.

- A temporary set down area *c.*850m north west of the main gas plant facility site will be used to enable storage of construction materials near to the site and to allow planning of deliveries to mitigate against disruption to local residents.

- Drilling operations will create small quantities of waste material. This will require containment and subsequently transport to and disposal in an approved landfill. Disposing of the drilling waste is discussed in more detail in Section 4.9.7.

- Construction will involve heavy plant movements which may include mobile cranes, etc. resulting in temporary noise, dust and nuisance, albeit contained within the plant area. This will be minimised by the modularisation approach. Appropriate mitigation measures and monitoring will be considered in line with planning consent constraints.

- Particular attention is to be paid to not disturbing and/or contaminating existing land drainage systems.

- Equipment and materials imported to the site which will contain waste packaging will be kept to a minimum. Open burning of waste by the contractor will be prohibited (except in agreed and upfront circumstances).

- Control and monitoring of emissions upon plant commissioning will be built into procedures (as will normal operating procedures). Operator training for normal operation and emergencies will be implemented as well as co-ordination and practice of emergency response, in close liaison with Premier Power Limited and Premier Transmission Limited.

4.3 Pipeline Construction

4.3.1 Pre- construction works

Ahead of construction, the route will be surveyed and pegged out in consultation with the landowner/occupier. This will establish the precise alignment, particularly in relation to hedgerows, mature trees or environmentally sensitive sites. Insofar as possible, the route s of the pipelines have been chosen to minimise direct impact (see route selection section 1.4.1.3 in Chapter 1). Spring or well-fed water supplies and agricultural water supplies and pipes will be surveyed and monitored before, during and after construction.

Pre-entry surveys will be carried out to establish temporary fencing type, farm access and temporary water supplies or any other accommodation works that will be required during the construction period.

4.3.2 Construction: Pipeline Spread technique

Construction is proposed to take place by a technique known as “pipeline spread", defined as the unit of manpower and equipment necessary to construct a pipeline, from surveying the route through to reinstatement of the land. The rate at which the spread advances is determined by the nature of the terrain, the frequency of special sections and other factors.

In addition to the main spread, special teams will be set up by the appointed construction contractor to undertake any work associated with road and service crossings, or other sections which require some variation from the standard methods. For example, in sections of particular environmental sensitivity, modifications are made to the standard spread technique and/or to the timing of construction with a view to minimising environmental impacts in accordance with the mitigation strategy recommended in the EIS.

All construction activities are undertaken within a temporary fenced-off strip, which is referred to as the "working width". This may be increased in size adjacent to crossings to provide additional working areas and storage for materials or special plant. Conversely, its size may be decreased in areas of environmental sensitivity or if close to existing services. The accesses have been agreed with the relevant landowner and/or tenant. They will be carefully controlled and signposted.

The proposed length of trenched pipeline works which will use the pipeline spread technique will be approximately 2,845 metres in total. To mitigate against unnecessary ground disturbance, Islandmagee Storage Limited will be using the same trench to bury both the brine outfall and seawater intake pipelines for approximately 2,560m of the route. At a point approximately 150m south east of the cliff edge, within the townland of Dundressan, the seawater intake and brine outfall pipelines will diverge, with the seawater intake trench extending approximately 285 metres into Castle Robin Bay. At this point the construction method for the final 595 metres of the brine outfall pipeline leading to the discharge point will switch from pipeline spread to Horizontal Directional Drilling (H.D.D.). This technique will be discussed in more detail in Section 4.3.5.

4.3.2.1 Construction Sequence

The normal sequence of events during construction is described in the following paragraphs.

Fencing

Before any of the principal construction activities begin and after surveying the route, the first activity is to erect temporary fences along the boundaries of the working width, as previously agreed with landowners/occupiers. The fencing will usually be of wire strands supported on wooden posts or, in areas where livestock requirements dictate, including additional strands of wire, plain or barbed, and/or square mesh netting or as may otherwise be appropriate. Gates and stiles are incorporated into the fence wherever access must be maintained, e.g. public rights of way, farm tracks, or for livestock movements. Fencing and access requirements will have been agreed in advance with the landowners and occupiers. The working width will typically be 30m wide within the 40m easement, with the pipe offset from the centre line to allow for construction access. Figure 4.5 and Figure 4.6 illustrate the typical working width layouts that will be adopted.

Topsoil Stripping

Topsoil will be stripped and stored in a loose pile to one side of the working width (Plate 4.6). Subsoil will be removed and stored separately on the opposite side of the working width. The topsoil stack will be about 4 m wide at the base, 2.5 m high and kept free from disruption and compaction. All subsequent vehicle movements will be confined to the `running track', on underlying subsoil.

Following the topsoil strip in some areas, the working width may be graded flat or `benched' to enable safe working.

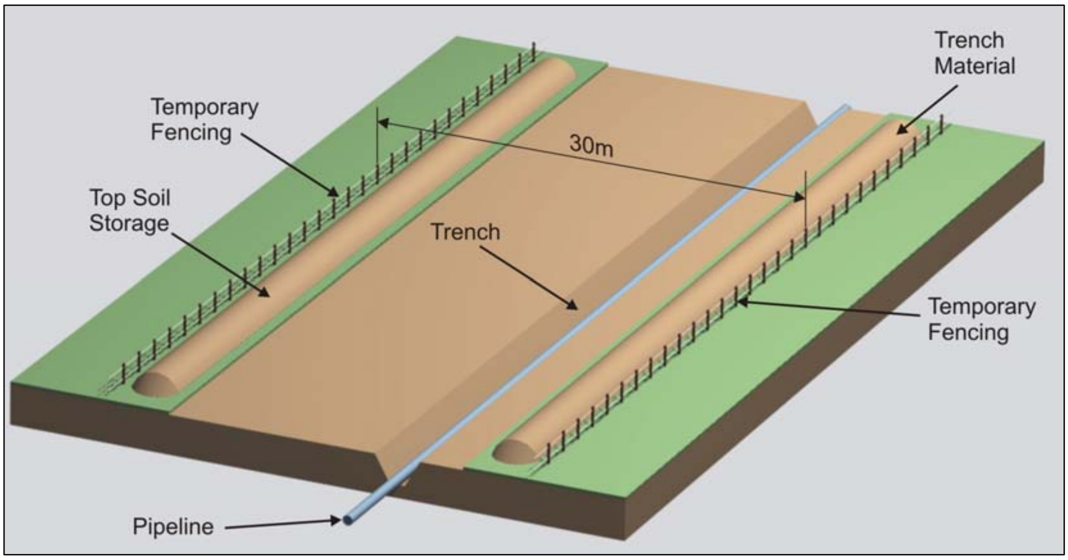

Figure 4.5 Working Width Layout – Mainline

Most hedgerows will be removed or coppiced to allow continuous access along the working width in agreement with methods approved by the Northern Ireland Environment Agency and the relevant landowner and/or tenant. Since hedgerows which have been removed must be replaced, only the minimum width required for construction is removed.

Figure 4.7 and Plate 4.7 illustrate the reduced working width at the crossing of hedgerows. Established trees are avoided, with both hedging and trees remaining within the working width protected with fencing material where appropriate. Where present, stone dykes will be dismantled and the stone safely stored for later reinstatement.

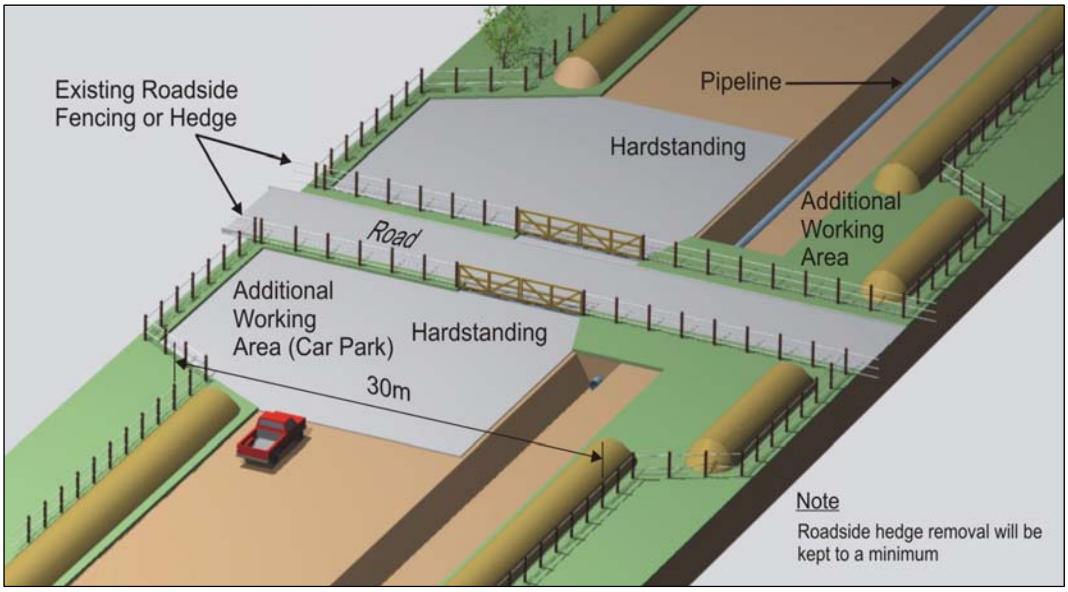

Figure 4.6 Working Width Layout – Crossing

Plate 4.6 Topsoil Stripping

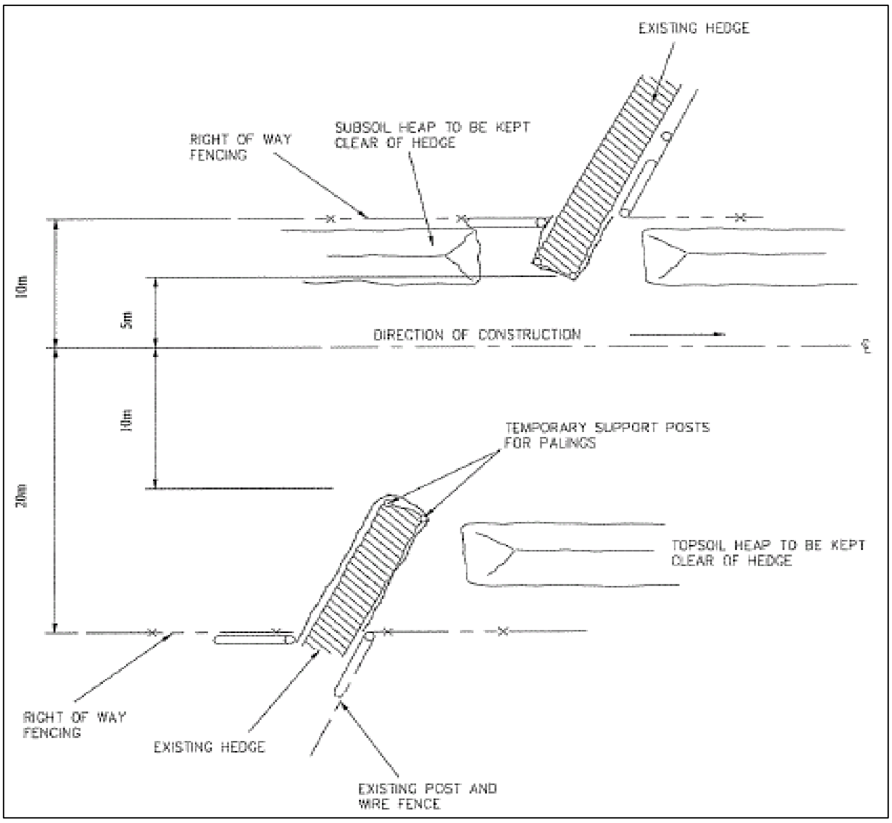

Figure 4.7 Reduced Working – Hedgerow Crossing

Plate 4.7 Example of Reduced Working Width at Hedgerows.

In areas of significant environmental sensitivity or very poor soil conditions, topsoil stripping may be omitted in favour of temporary roadways of a geotextile material and/or hardcore laid over the ground and the excavation limited to the width of the pipe trench alone. In other instances, where the topsoil is particularly shallow, the layer of topsoil and the layer of subsoil immediately below it may be stripped and stored separately.

Land Drainage Works

Particular emphasis is placed on ensuring that installed agricultural land drainage crossed by the pipelines is maintained/reinstated. In poorly drained areas, land drainage is required to enhance rooting conditions and structure in otherwise wet soils, and, on arable land, to extend the period during which soils may be cultivated without risk to soil structure. Drainage design varies according to soil type, cropping practice, landform, climate, and available technology.

At the detailed design stage, land drainage in each field will be carefully inspected and a record prepared. A pre-construction scheme will be developed in discussion with landowners/occupiers for those areas where such a scheme is deemed necessary. This may entail the installation of new header drains to intercept the existing land drainage, which will be cut by the pipeline trench. This serves to maintain the existing drainage system during the construction period whilst minimising the possibility of surface water entering the working area. During actual construction, all drains encountered during the trench digging operation are identified and recorded. An appropriate method of permanent reinstatement will be devised and agreed with the landowner/occupier or agent. Where the pipelines pass under a land drain the usual method of reinstatement is to install a replacement section of drain with a permanent, rigid support carrying it over the filled-in pipe trench. Where necessary, new lateral and header drains are laid to new outfalls to replace drains rendered inoperative by the pipelines.

Stringing

The sea water and brine pipelines will be constructed from lengths of polyethylene or possibly pre-coated steel pipe (pending detailed design), each 12m or 18m long. They will be initially delivered to a pipe storage yard, ideally somewhere close to the pipeline spread. Pipes are then transported to the working width and laid on wooden sleepers or cradles along a line parallel to the proposed trench. Gaps are left where access across the working width is required. Plate 4.8 shows linepipe being laid on wooden supports along the pipeline route.

Welding and Joint Coating

The pipes are welded together to make a continuous pipeline, and the welds are subjected to non-destructive testing/inspection. Any faults detected are repaired, or cut out and replaced, and then reinspected.

Steel pipes, if used, will arrive on site with a protective coating already applied except at their ends. After welding and inspection (radiography), the bare metal at the joints is cleaned and a coating applied to make it continuous along the pipeline. The pipeline's coating is then tested electronically along the whole of its length to detect any damage or other defects. These are repaired and the pipelines re-tested. Plate 4.9 shows front-end pipeline welding.

Plate 4.8 Pipeline Stringing

Plate 4.9 Front End Welding

Plate 4.10 Trenching Machine

Plate 4.10 shows a typical pipeline trenching machine. The depth of cover may be increased at road crossings and special sections. There will be an obligation on the part of the construction contractor to obtain consents from statutory authorities and statutory undertakers prior to crossing these features. Subsoil from the pipe trench excavation will be kept separate from the topsoil. At times it may become necessary to dewater the open trench. If so, and prior to such an activity commencing, a strategy for dewatering will be developed on an area by area basis in consultation with the Northern Ireland Environment Agency (NIEA), Rivers Agency and the affected landowners/occupiers. See also Chapter 12 *"Geology and Hydrogeology".*

Ditching of Pipe

Using side boom tractors or equivalent plant, and taking care to avoid damage to the pipe coating, the pipeline is lowered into the trench. Plate 4.11 shows a pipeline being lowered into a trench. By utilising standard factory coatings (3 layer polyethylene), the pipes will have protection from stones and flints. However, where field coatings have been applied, a bed of sand may be used to provide additional protection. The trench is then backfilled with the excavated subsoil. The subsoil is carefully compacted around and over the pipes up to the top of the trench. If it is necessary to dispose of surplus trench material, this will be transported away from site by a licensed waste contractor to a suitably licensed site in accordance with the requirements of the NIEA and the Waste and Contaminated Land (Northern Ireland) Order 1997.

Plate 4.11 Lowering Pipeline into Trench

Cleaning, Gauging, Testing

The pipelines are cleaned internally using a "pig" which is driven through the pipes by water or compressed air. A gauging pig is then driven through to check the internal diameter of the pipelines to enable irregularities to be detected and, if necessary, rectified. The pipeline is then hydrostatically tested by closing off the ends, filling it with water and increasing the pressure to a pre-determined level. On completion of pressure testing the pipelines are dried.

Commissioning

Once the pipelines have been sufficiently tested and the integrity of the system accepted, the pipelines are ready to be commissioned. The pipelines are dried following the hydrotest. In the gas pipeline, a slug of inert gas with pigs is used to separate the air and natural gas. The natural gas is introduced slowly into the pipeline with the pressure gradually raised to the Maximum Operating Pressure (MOP). In the brine pipeline, the brine is introduced slowly in the pipeline with the pressure gradually raised.

Permanent Reinstatement

Reinstatement including spreading of the stored topsoil and reseeding of pastureland is normally carried out within the same year as construction, unless prevented by adverse weather. Reinstatement can include deep cultivation or ripping of the subsoil if it has been significantly compacted, and spreading of the stored topsoil. Banks, walls and fences are reinstated and hedges replanted between protective fences. Permanent pipeline markers and cathodic protection test posts are installed at agreed locations, generally on field boundaries, so as to minimise interference with normal agricultural operations. Finally, the temporary fencing along the working width is removed, unless the occupier prefers it to be left in place until the re-seeded pastureland is fully established. In ecologically sensitive areas, reinstatement may be modified to suit the particular conditions prevailing. In addition to adapted construction methods, further measures may be taken, where necessary, to reduce the risk of third party damage to the pipelines. These may include increased depth of cover, thicker walled pipe, concrete slab placement above the pipelines or concrete weight coating applied to the pipe.

4.3.2.2 Road Crossings

There will be two road crossings and two local access crossings along the pipeline route Before construction of each traffic crossing, a methodology will be agreed with the Local Authority, DRD Roads Service and the PSNI in relation to the implementation of any traffic management system, vehicular access to various parts of the site (with particular regard to vehicles delivering pipes or oversize equipment), access to the Contractor's site accommodation and any other relevant matters.

In the event of a road having to be closed to construct the crossing, the Contractor will comply with the requirements of the Roads Service and the PSNI. Before the commencement of any work associated with traffic route crossings, by either open cut or trenchless techniques, the traffic route will be inspected and a photographic record taken.

4.3.2.3 Watercourses

Where rivers, drains and watercourses are encountered, construction methods to be used at watercourses will be of such a nature to avoid undue obstruction to the flow of water and will be agreed with the Northern Ireland Environment Agency, Rivers Agency and other relevant authorities. Every precaution will be taken to ensure that backing up in rivers, streams or ditches does not cause flooding of any land, either inside or outside the working width or backing-up of any drainage systems discharging into the concerned watercourse. Upon completion of the works watercourses will be fully reinstated to their original shape, condition and level so as not to affect their flow characteristics.

Excess amounts of suspended matter or silt or any offensive or injurious matter will not be allowed to be passed or discharged into watercourses and all discharges will comply with the requirements of the appropriate authorities in this regard.

Additional Working Areas may be necessary for construction at the crossings of traffic routes and watercourses to the following maximum extents:-

i) Road Crossing - 500m² total on each side of each crossing;
ii) Watercourse Crossing: - 100m² total each side of each crossing.

All areas of additional working will be as agreed with the statutory Authorities and affected landowners/occupiers.

4.3.2.4 Woodlands and Hedgerows

Wherever possible, pipelines have been routed to avoid woodland areas, but there may be occasions when belts of trees or hedgerows cannot be avoided and which the pipelines must cross. Construction techniques require that short sections of these trees or hedgerows be removed, although it is often possible to align the pipeline to cross at a naturally "weak" point and avoid any isolated mature or semi-mature trees. For hedgerow crossings, a new hedge incorporating suitably matched indigenous varieties will be planted within a suitable double post and rail or post and wire fence, which is maintained until the new hedge is established. For woodland, new trees can be planted but a strip 3m either side of the pipeline must be kept free of trees to prevent root damage to the pipeline coating. Construction methods used will incorporate the mitigation measures recommended in Chapter 5 *Terrestrial Flora and Fauna"* and Chapter 11 *"Landscape and Visual Impact"*.

4.3.2.5 Conservation Areas

Areas of archaeological or ecological conservation value including those having statutory designation will be treated as special crossings. The construction technique employed will depend on the nature and sensitivity of the area, but a restricted working width may be adopted. The limits of topsoil stripping may also be reduced, special arrangements for construction traffic may be included, and special reinstatement methods required. The approach to crossing these areas is developed in consultation with the relevant authorities and will follow the mitigation measures recommended in the relevant sections of the EIS. The pipeline route has been drawn to avoid any scheduled areas, but there is potential for previously unrecorded sites to be uncovered during the construction process.

4.3.2.6 Existing Pipelines and Other Services

Prior to construction work commencing, services crossed by and close to the pipelines will be positively located by trial pit excavation and/or by an indirect location method. This work will be carried out under the guidance and supervision of the responsible service authorities' inspectors, as required.

4.3.2.7 Crossing Construction Methods

Throughout most of the seawater and brine pipeline route (the sections extending from the main gas plant facility to the eastern shore of Islandmagee), the sea water and brine pipelines will both be constructed in the same trench utilising the same construction methods. However, during trenchless construction methods such as thrust boring and horizontal directional drilling, the pipelines may be constructed separately. All signs, safety devices, plant and equipment necessary to progress the operation smoothly and efficiently will be in place or available at the place of work before construction commences.

4.3.3 Thrust Boring

Thrust boring is a relatively simple trenchless procedure that limits surface disturbance and is most likely to be used for the main road crossings where the disturbance that a pipeline crossing by open cut would cause may be unacceptable. It may also be used at water courses. Two pits are dug, one at either end of the section to be thrust bored. A length of sacrificial pipe is then thrust through the ground beneath the obstacle until it reaches the reception pit on the far side. An auger tool is placed within the sacrificial pipe to remove the spoil material. After this process a new section of permanent pipe can be connected and thrust through into its permanent position while the sacrificial pipe is recovered.

Where required, thrust boring will be undertaken either by auger boring or pipe ramming techniques. Great care will be taken to avoid damage to the carrier pipe during all thrust bore operations. The line and level of the bores will be set out and the rate of penetration of the pipe will be controlled to suit the type of soils encountered. Care will be taken to prevent the formation of cavities.

Increased working width at the crossing may be required to facilitate the storage of the extra spoil generated by this increase in excavation size and to accommodate additional plant and vehicles. Where possible the locations of crossings will be selected to avoid the need for deep excavations.

To facilitate the drilling equipment, the normal pipe trench on the launch side will be enlarged in width and slightly deepened, to form a pit which is at least 12m long to accommodate a standard length pipe section

Thrust and reception pits will be designed to withstand all ground, thrust and surcharge pressures. Construction will be either of interlocking steel sheet piles or overlap trench sheeting, or proprietary trench boxes or a combination of any of these methods. All temporary piling and associated materials and all thrust blocks will be removed from site after completion of the work. Plate 4.12 shows a thrust bore machine at a road crossing.

The thrust blocks or anchors in all pits will be designed to withstand and adequately transmit the pressures exerted by the boring equipment.

Plate 4.12 Thrust Bore Machine

Thrust and reception pits will be kept dry at all times. Any pumping or dewatering will only be carried out with the consent of the Northern Ireland Environment Agency and after appropriate mitigation measures have been put in place.

4.3.4 Pipe Jacking

Pipe jacking is an alternative trenchless technique where, due to ground conditions or the length of the crossing, it is necessary to install a concrete sleeve. In all other respects, the construction techniques related to the thrust and reception pits are as for thrust boring.

Approved carrier pipe spacers are fitted to the carrier pipe which is then slid inside the sleeve such that the carrier pipe sustains no damage and sufficient pipe protrudes from each end of the sleeve to allow a safe tie-in. Plate 4.13 illustrates a pipe jacking technique.

Plate 4.13 Pipe Jacking

4.3.5 Horizontal Directional Drilling (H.D.D.)

This technique uses a steerable cutting head to bore under an obstacle and is particularly useful for wide and sensitive crossings. Detailed site investigation is essential in determining this method's feasibility since not all ground conditions are suitable. The working areas need to accommodate extra plant and equipment and to store any additional stripped topsoil.

Powered by a mobile rig, the drill enters the ground at a shallow angle to bore a small pilot hole. It is steered to follow a pre-determined constant radius to achieve the required clearance from the crossing.

Plate 4.14 shows a typical H.D.D. rig and Plate 4.15 shows an H.D.D entry point. The drill emerges on the opposite side of the obstacle, normally within the space of a shallow pit (as shown in Plate 4.16. The diameter of the drilled hole is then increased incrementally by subsequent pull through of a reamer until the hole is of a suitable size for installation of the pipe. A fabricated permanent length of pipe is connected to the end of the drill pipe by means of a swivel bearing, and the drill string rotated and withdrawn. As it is withdrawn it pulls the pipe string into position behind it. This part of the pipeline is later tied into the remainder of the pipeline system.

Plate 4.14 Typical Horizontal Directional Drilling Rig

Plate 4.15 HDD Entry Point

Three sub surface pipelines are required to run from the main gas facility to the wellsite; one 406mm gas pipeline and two 450mm sea water intake and brine outfall pipelines, as well as a service duct for power and control cabling. These pipelines will be drilled underground using the H.D.D. to cause the least disturbance or impact above ground. A pilot hole will be drilled through the sequence of Basalt and Cretaceous rocks prior to a carrier sleeve or pipe being fed into hole using equipment similar to that shown in Plate 4.14 and Plate 4.15. The carrier sleeve will be of a sufficient diameter to hold all three pipelines.

Plate 4.16 Horizontal Directional Exit Point

Pipe strings will be laid out in the vicinity of the H.D.D. area. Particular attention will be paid to handling and containment of drilling mud and drillings waste disposal, similar to the cavern borehole drilling.

Bentonite, a natural fine clay, is normally used as a drilling lubricant. It is pumped from tanks to the head of the drilling bit through the centre of the drill pipe. The lubricant mixes with the drillings, which are forced back along the hole under pressure, and into a recycling plant to recover much of the bentonite. Waste material is then transported away from site by a licensed waste contractor to a suitably licensed site in accordance with the requirements of the NIEA and the Waste Management Licensing Regulations (Northern Ireland) 2003.

Upon completion of this work, connections to the piping can be made up on the gas facilities site and down at the wellsite. Drilling operations (and HDD) will create waste. This waste will require containment and disposal in approved landfill or by other approved means (Section 4.9).

It is also proposed that the final 595m section of the brine outfall, from the top of the cliffs at Dundressan to the offshore discharge point east of Islandmagee at a water depth of -27m (CD) will be constructed using H.D.D.

For the offshore H.D.D. section, the HDD operations will be performed with a blind hole at the seaward end and therefore a discharge of drilling mud and cuttings to the marine environment will only occur during final breakout. The dispersion of the H.D.D. breakout sediments will be discussed in full in Chapter 9, *"Coastal Processes".*

Where H.D.D. construction methods are adopted, the necessary access, site location, receipt, storage and subsequent removal of drilling fluids, pollution control materials, noise control measures etc., will be adequately addressed and catered for during the entire period that the H.D.D. equipment is located at the site and until all surplus H.D.D. materials have been removed. Good working practices will ensure that this pipeline installation method imposes no significant impact on the land, and full NIEA and Rivers Agency consultation through the land drainage consent process, will ensure appropriate mitigation measures are in place for watercourse crossings.

4.3.6 General Pipeline Technical Considerations

The 406mm diameter gas pipeline will be made of steel and the 450mm diameter brine pipeline will be manufactured from PE-100 or Carbon Steel in accordance with the standard used in the UK. Thicker walled (Heavy Wall) steel pipe will be used for the gas pipeline where added protection is called for, i.e. where the pipelines cross major roads, watercourses and railways or at locations where the pipelines are routed through areas of high population density, or close to existing or proposed developments.

Pipeline construction will be confined to a fenced-off "working width" as shown previously in Figure 4.5 (page 4-19). This is normal practice for pipelines lying across open agricultural land. A site investigation survey will be undertaken before details of pipeline construction and crossing techniques can be finalised in consultation with relevant bodies such as the Northern Ireland Environment Agency, DRD Roads Service and DRD Rivers Agency, statutory undertakers, other interested parties and landowners/occupiers.

A land agent/permitting team will negotiate permanent rights of access within the pipeline easement in the form of a Subterranean Lease. An easement is a necessary requirement in order to gain access to the pipelines if and when the operator needs to carry out inspection, maintenance and repairs during the lifetime of the pipelines. Appropriate compensation payments for these rights will be agreed with farmers and landowners.

As part of these agreements to be entered into with landowners and occupiers, some land-use controls are necessary to maintain pipeline integrity, e.g. exclusion of building within the wayleave. Normal agricultural activities can continue as before except those involving deep workings (over 300mm) within the wayleave.

The land agent's remit will also include negotiating the land acquisition and access provision for all AGI requirements along the pipeline route.

In agricultural land it is normal practice to provide a depth of cover of not less than 1.1m over the top of the pipelines. At the road and watercourse crossings the depth of cover may increase to meet the specifications of the consenting statutory authority and/or statutory undertaker. Installing a concrete slab and/or increasing the pipe wall thickness may be necessary to increase protection further.

4.3.6.1 Corrosion Protection

It is essential to protect the pipeline system from external corrosion due to biological and chemical activity. This is achieved in two ways:

- a high integrity anti-corrosion coating applied during manufacture of the pipe, with further coatings applied at the welded joints during pipeline construction; and
- an impressed current cathodic protection system and/or a sacrificial anode arrangement where special circumstances require, to supplement the anti-corrosion coating.

There will be no significant internal corrosion since natural gas is dry and non-corrosive.

In designing the cathodic protection system it will be necessary to carry out a resistivity survey along the route to define corrosion levels. Other factors that may influence the design and location of the cathodic protection system are:

- availability of a conveniently located power supply;
- the location of any other cathodic protection systems in the vicinity of the pipelines;
- the pipeline diameter, wall thickness, coating material; and
- Constraints identified in this Environmental Statement.

The coatings applied to the pipelines will be inspected and tested electronically for coating damage immediately before laying. A pre-commissioning cathodic protection survey will be carried out and repeated at regular intervals as a continuing check during the operational life of the pipelines. In the event that protection is not to the required level then remedial work will be implemented.

4.3.6.2 Construction Impacts and Mitigation

Top-soil stripping, trench excavation and plant movements along the working width are the principal areas where construction impacts can arise due to damage to the soil structure through compaction. The main measure to mitigate soil composition damage is to carry out pipeline construction work when the soil is less susceptible to damage. This is usually the period between April and October.

Temporary Impacts

Temporary impacts associated with pipeline construction include:

- temporary loss of crop production within the working width
- temporary removal of some field boundaries along the working width
- increased risk of disease transmission associated with vehicle movements along the working width; disruption of field drainage
- noise and emissions
- traffic and transportation.

Crop loss within the working width is unavoidable, but the extent will depend on site details, including field area, production forecasts and loss of access. Resultant financial loss is a matter for compensation, to be agreed in discussion between the land agent and individual landowners and/or occupiers. "Records of Condition" of land along the pipelines route prior to construction will be agreed with the landowners/occupiers as an aid to assessing compensation.

Field boundaries within the working width will be partly removed to facilitate plant movement and to enable a continuous construction procedure. At hedge crossings the width of hedge removed will be sufficient to accommodate the pipe trench, stringing and running track only, in accordance with the EIS mitigation recommendations. Field boundaries will be reinstated according to a specification to be agreed with the landowners/occupiers and advice provided by NIEA.

Preventing the spread of plant and animal diseases is most important. It has been confirmed during consultation with the Department of Agriculture and Rural Development's Agri-Environment Management Branch that there are not known to be any soil-borne diseases nor is there any record of carcass burial pits in the locality of the pipeline route. If any disease is in the soil, it can be spread if the contaminated soil is moved from one site to another either by transporting the soil or through contaminated equipment or personnel moving between sites. Since the pipeline is a linear feature and construction will pass through different fields and other land as it progresses it is important that appropriate precautions are taken to guard against this means of transmitting soil-borne diseases. Provided general precautions are maintained, mitigation will be limited to normal good UK construction practice, following the DEFRA general precaution leaflet: *"Preventing the Spread of Plant and Animal Diseases: A Practical Guide"*

The crossing and/or cutting of drainage systems is also an area of potential sensitivity. Where they exist along the line of the proposed route, the excavation of a trench to a depth of approximately 1.8m (will have a localised impact on the existing field land drainage systems. The depth to the top of the proposed pipeline will be 1.1m and therefore close to but generally below the depth of a drainage system, where present. During trenching, any land drainage system crossed by the pipeline route will be cut. The immediate effects of disruption on pipes, ditches, or secondary features such as mole drains, and permeable fill, will vary with site conditions. Full restoration of field drainage is standard practice and drainage systems will normally be reinstated within the pipeline construction season. Where appropriate, replacement with a cut-off "header" drain will precede pipeline construction, in which case the drainage system is maintained independently of pipeline construction. Changes caused by settlement and siltation within excavated material are avoided by appropriate design and construction methods.
The possibility of problems from noise or emissions during construction is addressed in Chapter 7 "*Air Quality*" of this Environmental Impact Statement.

Traffic management during construction is addresses in Chapter 8 *"Material Assets"* of this Environmental Impact Statement.

4.3.7 Construction Constraints

Specific obligations will be included in the construction contractor's responsibilities to avoid or minimise environmental damage during construction and to avoid public nuisance. These include, as a minimum, the following requirements:

- to obtain construction consent approvals from landowners and occupiers, and from statutory authorities, statutory undertakers and environment bodies, in advance of pipeline construction;
- to ensure that all work is carried out within the agreed working width, using agreed accesses;
- to provide adequate notice to landowners/occupiers before commencement of works so that they have time to make any advance preparations;
- to ensure that all public roads affected by construction and/or construction traffic are kept clean and in a good state of repair;
- to maintain essential access for landowners/occupiers including passage of livestock;
- to maintain rights of way affected by construction and/or construction traffic;
- to restore drainage systems, should any be affected by the pipe trench;
- to adhere to restrictions on the felling or lopping of trees;
- to maintain the working width in a clean and tidy condition;
- to store and use materials in an appropriate manner to minimise the potential for accidental spillage:
- to reinstate all land to the condition found, or as otherwise agreed; and
- to abide by any conditions imposed by the statutory authorities.

Normal working hours for general activities such as top-soil stripping, welding, and pipe-laying, and the movement of vehicles and the running of motorised plant and equipment, are 07.00 to 19.00 hours. The exceptions to this could be during non-destructive and pressure testing and commissioning. These are continuous activities that generally only affect the ends of the pipelines and also in the event of special circumstances that may include Horizontal Directional Drilling operations. Drilling of the cavern wells will be a 24hr operation.

For all of the above obligations to be met, the pipeline construction contractor must be experienced in working in the UK, in complying with such conditions and have available the appropriate skilled staff, plant and resources.

4.3.8 Supervision of Construction Activities

A project management team will be appointed to oversee construction of the gas and brine pipelines and all other facilities. This team will ensure that all works are carried out in a safe, efficient and professional manner. Further, they will insist that all works conform to best construction practice, and are carried out in accordance with the requirements of all consents, authorisations or other permissions granted. They will also ensure that the terms of the operating licence as issued by the Health and Safety Executive are met following satisfactory inspection of construction and completion of pressure testing.

4.3.9 Operation and Maintenance

After the gas and brine pipeline systems are fully commissioned they will be operated and maintained in such a manner as to keep them safe and in good condition. Protective measures, inherent to pipeline design, together with regular monitoring will ensure that uncontrolled third party activities, which represent the major risk to pipelines, are virtually eliminated, and so are unlikely to cause damage.

Monitoring is normally carried out in the following ways:

- Periodic Visual Monitoring
  - A "care and maintenance" team will carry out visual monitoring. Their duties will include regular surveillance by inspection on foot and by overflying the route in a helicopter. Their observations will provide a record of changing ground conditions and third party activity along the pipelines and prevent any unauthorised third party activity from compromising their safety.

- Pigging
  - At regular intervals, special on-line equipment called "intelligent pigs" will be passed through the pipelines as an inspection exercise to check on the condition of the pipelines and detect any evidence of corrosion or damage.

- Cathodic Protection
  - System Monitoring consists of monthly checks of the Cathodic Protection (CP) station power unit and/or through the electronic monitoring system and twice a year soil potential measurements will be taken at the CP test posts. For ease of access these posts are normally sited adjacent to tracks and paths.

Operation and Maintenance Procedures will be implemented. As part of these procedures an Emergency Plan will be prepared to cover contingency plans and remedial measures. The emergency services and the local authorities will be consulted and provided with full details of contact telephone numbers and route plans, together with any other relevant information.

4.4 Wellpad Construction

The wellpad will comprise 7 boreholes directionally drilled into the Permian halite from an approximately 0.5 hectare site located in the townland of Ballydown, approximately 750m south east of the main gas plant facility. The site will be connected to the main facilities by a directionally drilled 406mm gas pipeline and two directionally drilled 450mm sea water and brine pipelines.

Access to the wellpad site is proposed to be derived from the B90 Ballylumford Road. The entrance will upgrade an existing lane access, which currently leads to agricultural sheds. Approximately 160 metres south west of the entrance onto the B90, the access to the wellpad will diverge from the existing lane and a new 300m section of lane will be constructed which will lead to the northwestern perimeter of the wellpad. The wellpad dimensions will be approximately 110m by 45m and have been specified to leave the smallest possible footprint during and post construction.

The ground falls approximately 3 metres from approx 8.25m to 5.25m AOD in elevation across the site in a northeast-southwest direction, parallel with the alignment of the wellpad and the shore. The wellpad area will be cut/filled to create a level platform at approximately 6.4m AOD with a gabion wall supporting the 2.25m cut face on the upslope side.

4.4.1 Construction Sequence

Prior to works commencing, all overhead power and telephone cables will be identified and protection goalposts erected. Underground services will be identified using CAT scans and/ or hand dug trial pits, and locations marked. In particular the location of the Belfast Transmission Pipeline and the Ballylumford heavy fuel oil pipeline will be clearly identified and safe working distances adhered to at all times.

The existing fences and, where necessary, hedgerows will be removed as required for the new entrance lane. Hedgerows and verges along the B90 will be cut back to accommodate sight lines as required. The existing wall adjacent to the lane entrance will also be removed. Waste materials from these activities will be removed from the site and transported by a licensed contractor for disposal in an approved landfill or green waste recycling centre.

4.4.1.1 Topsoil Strip

The new access road and site will be set out, including construction offsets and post and wire fencing erected to define the approved site limits. The topsoil is to be stripped from site using either of 2 methods. Method 1 will involve the use of a 360° excavator to strip the topsoil. The excavator will pick up a ‘bucket’ of soil, then rotate through 180° and then deposit the topsoil into road transport and removed off site. The 2nd method will involve the use of a tracked front end loader/ dozer with large tracks to minimise ground bearing pressures. This machine will either be used to ‘push’ or excavate and carry the soils to the relevant soil bund areas. The use of the tracked loader will be carefully monitored to ensure that it is only used when the soils are adequately dry. In addition tracking over the soil will be kept to an absolute minimum.

All excavation/moving of topsoil/subsoil will be carried out in suitably dry conditions with a view to minimising both tracking and disturbance of the existing soil structures. In the event of excessive rain, work would stop until the soil has dried. Upon completion of the topsoil/subsoil strip, the overburden will be cut and filled across the site to achieve the 6.3m AOD level required for construction of the drilling pad area.

Reinforced concrete protection slabs shall be cast over underground services and the gas pipeline in accordance with the requirements of the relevant utility company.

French drains shall be constructed to the north and east of the main site to intercept and divert groundwater from the site. The water shall be discharged back onto the field to the south of the site.

4.4.1.2 Subsoil Strip

The subsoil will be stripped using bulldozers and/ or graders, to stockpiles within the site confines. 360° Excavators will transfer the subsoil to lorries for removal off site.

The subsoil strip shall continue until the required construction levels are achieved.

4.4.1.3 Site construction

All site formations shall be mechanically rolled and suitably prepared to receive the road and site constructions respectively. The access roads and tracks shall be constructed using the designated road make-up, with a stone or tarmac finish. Geotextile membranes shall be used to preserve the interface between the stone and subsoil, thus facilitating any reinstatement requirements. It is estimated that 10,000 tonnes of crushed stone and tarmac will be brought to the site over a 4 week period and compacted to create the upgraded access road and wellpad.

The main wellpad area shall be constructed using the designated make-up, including the use of geotextile linings and bentonite matting providing interface protection and a sealant to the subsoil respectively. The perimeter interceptor ditches and culverts shall be included within the sealed areas.

Precast concrete rings which will form the wellhead cellars will be sunk in to the bedrock to a depth of 5.5m beneath the wellpad, together with culverts approximately 5m x 2m deep for piping access to each well head. A 30” drill conductor casing for each well will also be pre-set (hammered) to a depth of approximately 10m below ground during preparation of the wellpad areas and cellars.

The gabion retaining structures shall be constructed using clean stone delivered to site by lorry, with the gabion baskets assembled and filled on site. Handrails shall be erected where a falling hazard exists using a key-clamp system, or similar approved.

4.4.1.4 Operations

Road signage shall be installed and maintained throughout all construction operations. The condition of the access routes shall be monitored throughout the construction operations, and all debris removed from the highways, and sight lines maintained etc.

4.5 Sea Water Intake

This section describes the likely sequence of construction planned for the sea water intake pumping station located at Castle Robin Bay, the potential environmental impacts anticipated during the works and the techniques recommended to mitigate them.

Access to the sea water pumping station will be from the Brown's Bay Road via an existing gravel surfaced farm access lane, which will be extended from its present termination point across the last field to the site of the proposed work on the lower platform at Castle Robin Bay. Traffic movements will be managed by implementation of a traffic management plan drawn up by Islandmagee Storage Limited or their chosen contractor and DRD Road Service. Access to the construction area will be controlled with temporary fencing used to limit the area impacted by construction activities.

4.5.1 Construction Phase

In order to create a level platform for the construction of the sea water pumping station, some re-profiling of the existing ground levels will be required. The access track remaining from the construction of the SNIP will also be upgraded to facilitate access to the site by heavy plant. In order to minimise the need to import/export material from the site, it is envisaged that a balanced cut and fill operation will be employed in preparing the site, however this is subject to the material on-site being suitable which will be confirmed during the F.E.E.D. stage of the project.

The site for the proposed pumping station has been selected so that it is naturally screened from views from Islandmagee by the surrounding topography. The pumping station is also located in the southern part of Castle Robin Bay to avoid the more environmentally important grassland found in the northern portion of the bay and also to avoid having to cross the SNIP. The site will avoid the prominent rock stack located inside Castle Robin Bay which will be fenced off in advance of works commencing in order to avoid disturbance.

Substantial rock excavation is anticipated to form a deep sump for locating the pump intakes and inlet screens below the anticipated level of low water. Whilst it is expected that this excavation can be accomplished using mechanical methods and the proximity of the SNIP makes blasting an unattractive proposition, the need for blasting cannot be ruled out until more information is obtained on the nature of the material to be excavated. If it is determined during the detailed design phase that blasting is required, a detailed methodology will be prepared and submitted with the environmental management plan for approval by the NIEA prior to any works commencing.

The pumping station will consist of a reinforced concrete sump capped with a concrete cover slab which in turn is likely to be enclosed within an agricultural type building to provide a sheltered environment for the installation of electrical control equipment. The building will contain approximately four submersible type pumps, although the exact number will depend on the final flow requirements for the leaching process and will be confirmed at the FEED stage. Screens to remove any debris from the water that would be detrimental to the performance of the sea water and leaching pumps will also be included.

A second smaller enclosure will also be required to house the electrical transformer required to regulate the power supply to the intake pumps and other equipment.

This sump will be connected to the open sea by twin underground pipelines extending to a water depth of 4-5m at LAT. At present it is envisaged that these pipelines will be installed using HDD techniques in order to minimise any disturbance to the surrounding environment, however this is subject to ground conditions being suitable and will only be confirmed once ground investigations have been undertaken during the FEED stage of the project. The seaward end of the intake pipelines will protected by a seabed mounted pre-cast concrete structure incorporating coarse screens (circa 150-200mm) designed to prevent the entry of large items into the sea water system. The coarse screens will be sized such that flow velocities through the screens are low enough to reduce the potential for entrapment of fish and other marine organisms to acceptable levels.

It is envisaged that the construction works at Castle Robin will be undertaken using standard heavy construction plant i.e. tracked excavators, rubber-tyred dumpers and a HDD spread. The key environmental control issues arising during the construction period will principally relate to noise, dust and vibration, mostly associated with the excavation of the sump and installation of the intake pipelines. It is proposed to pump concrete from the top of the cliff to avoid the need to make significant changes to the steep access lane to make it suitable for use by concrete lorries, etc.

As with facilities elsewhere, as much use as possible will be made of off-site fabrication and assembly in order to limit the time on site and the number and frequency of vehicle movements to and from the site. However the local topography may limit the scope since it will be difficult to get heavy lifting equipment to the location of the proposed pumping station.

4.5.2 Operational Phase

During the operational phase the seawater pumping station will be largely un-manned, however regular visits will be required for routine inspection and maintenance, depending on the amount of debris removed on the screens, for the removal of debris skips. It is anticipated that much of the material trapped on the screens will be organic in nature, such as seaweed and it may be appropriate to return this to the strand line and hence back to the marine environment. However if necessary a licensed haulier will be contracted to remove the debris from the site and dispose of the contents in accordance with relevant legislation. A disposal plan for the debris captured trapped by the screens will be agreed with NIEA during the FEED stage of the project.

This facility will only be fully operational for 4 years, during the leaching phase of the caverns, after this time it will be mothballed to be available as required during future workovers which it is anticipated will be required at approximately 10-15 year intervals over the life of the project.

Noise is not anticipated to be an issue with the seawater pumping station since in addition to all plant being enclosed within buildings; the nearest residences are 170m away on top of the cliffs. Surrounding topography will tend to project any noise seawards.

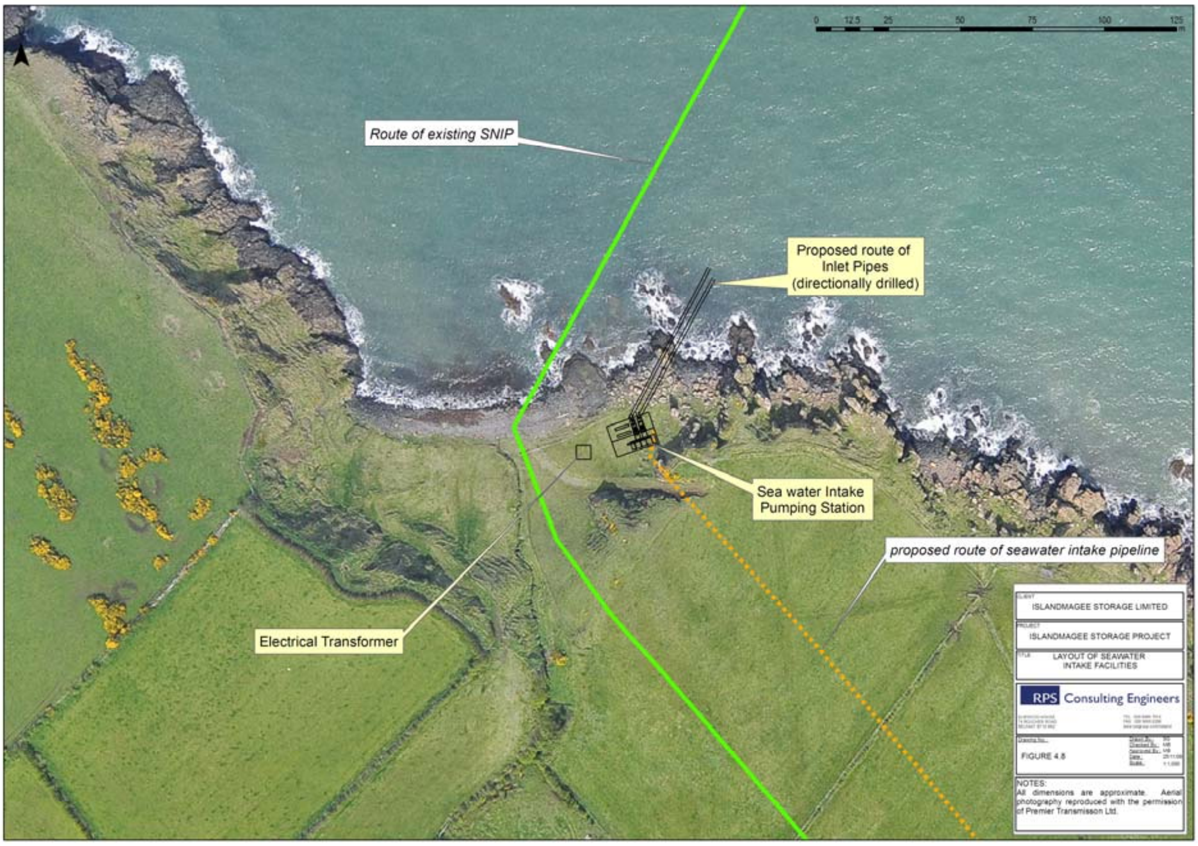

Figure 4.8 Seawater Intake Pumping Station

4.6 Provisional Construction Vehicles and Plant Equipment

This section provides an indication of the type and approximate number of vehicles that the construction contractor is likely to utilise in the construction of the various elements of the proposed gas storage facility. This outline is not exhaustive and may be subject to change following appointment of a construction contractor, however it provides a reasonable overview of what may be expected at the site.

4.6.1 Gas Plant Facility

4.6.1.1 Excavation / Filling / Drainage

- 40 to 50 tonne tracked 360 degree excavator: 3 No. (1 No. at gas plant site, 2 no. in borrow area)
- 25 tonne tracked 360 degree excavator: 2 No.
- 25 tonne articulated dumper: 4 No.
- Track mounted crusher/screener (diesel powered): 1 No. (in borrow area)
- Dozer (Cat D8 or similar): (1 No.)
- Vibrating roller: 1 No.

4.6.1.2 Piling

- Track mounted rotary/cfa piling rig, up to 90-100 tonne weight (e.g. Casagrande C600 / Llamada P-150) depending on diameter of piles required

4.6.1.3 Installation of pre-fabricated gas plant equipment

- 1 No. Crane
- Deliveries of pre-fabricated modules to site on articulated flat-bed lorry

4.6.2 Sea Water and Brine Pumping Facilities (Leaching Plant)

4.6.2.1 Excavation / Filling

- 40 to 50 tonne tracked 360 degree excavator with hydraulic breakers: 2 No.
- 25 tonne tracked 360 degree excavator: 2 No. (1 no trimming, 1 no. loading)
- 25 tonne articulated dumper: 2 No.
- Track mounted crusher/screener (diesel powered): 1 No.
- Vibrating roller: 1 No.

4.6.2.2 Inclined drains

- Rotary drill rig with rotary percussive drilling equipment: 1 No.
- 750cfm / 170psi compressor (diesel powered): 1 No.

4.6.2.3 Installation of brine leaching plant equipment

- 1 No. Crane
- Deliveries of pre-fabricated modules to site on articulated flat-bed lorry

4.6.3 Wellpad

4.6.3.1 Construction of wellpad:

- 2 No. 360degree excavators
- 1 No. Bulldozer or Grader
- 2 No. articulated dumper trucks
- 2 No. 'JCB' diggers (4CX or similar)
- 1 No Vibrating Roller
- 4 No 20 tonne stone lorries (on turn-around)
- 2 No portable site huts, including generators (part time use)
- Misc hand tools, (eg petrol powered cut-off saw)
- (also Barber Green for tarmac laying)

4.6.3.2 Drilling phase

- Drilling rig
- HGV (low loader flat-bed lorry) delivering well casings (est 1 per day).
- 1 No telehandler or similar to lift well casings off delivery lorry
- 3-4 HGV movements per day to remove drilling mud and cuttings

4.6.4 Sea Water Intake Pumping Station

(in addition to the general pipeline construction vehicles and plant listed below)

- 1 No. crawler crane positioned on foreshore
- 1 No. concrete pump (positioned at top of cliff)
- 2 No. tracked excavators with rock drilling/breaking equipment
- 1 No. Horizontal directional drill

Explosives may be required to excavate the drilling pit/sump into the rock

4.6.5 Connecting Pipelines

4.6.5.1 Conventional Trenching

- 3 No. Agricultural Tractor / Trailer (Fencing, general haulage along the working width & reinstatement)
- 2 No. Bulldozer (D6)(Top-soil reinstatement)
- 6 No. Tracked Excavator (Cat 350) (Top soil stripping, trench digging, backfill & general use)
- 1 No. Fuel bowser (Fuel filling of site-vehicles)
- 1 No. Water bowser (Water for construction activities)
- 1 No. Land drainage unit (Laying land drainage pipes during reinstatement)
- 4 No. Articulated flat-bed lorry (Delivery of pipe to storage & then to the working-width)
- 4 No. Articulated low-loader (Delivery of heavy plant to the working-width)

- 2 No. Welding Sets (inc. D4 Tour Tug Pipeline welding)
- 1 No. 8 wheel Wagon (Delivery of gravel for drainage purposes and sand for pipe trench packing – may also use tractors/trailers included above)
- 4 No. Pickup Trucks (Crew Cab) (General haulage use)
- 1 No. Minibus (Personnel Transport)
- 2 No. 4 wheel drive (Land Rover) (Personnel carriers)

4.6.5.2 Directional Drilling

(in addition to general pipe laying equipment above)

- 1 No. Sheet piler (to create walls of reception pit)
- 1 No. Horizontal Directional Drill
- 1 No. Dewatering pump

Approximately 35 vehicles and/or pieces of plant will be used during the construction of the pipelines, ranging from bulldozers to 4-wheel drive cars. Not all the heavy goods vehicles will be required at any one time nor will they require access to the working-width from only one entrance. Once the pipeline contractor has completed the works and demobilised from site then traffic levels will revert to original levels.

4.7 Well Drilling and Cavern Construction (Leaching)

The well site will comprise 7 wells directionally drilled into the Permian salt to a depth of approximately 1500m from a 0.5 hectare site close to the side of Larne Lough. From each well, a usable cavern volume of approximately 480,000m³ will be created.

The wellpad will be connected to the main gas plant facilities by a directionally drilled pipe string comprising a 450mm gas pipeline, a 450mm seawater pipeline and a 406mm brine pipeline, accompanied by control cables. The wellpad will be accessed via an upgraded entrance to an existing lane access from the Ballylumford Road.

Once constructed, the wellheads and all pipework will be located below ground with the header system also below ground level.

The preliminary drilling and leaching information presented in this section is derived from information gathered during the 3D seismic survey undertaken in October/November 2007 and information from the Larne-2 borehole and other information acquired during desktop studies of the geology of the site. The design is conceptual and is based on practical experience by the design team on comparable projects in the UK, France and Germany. Islandmagee Storage Limited will obtain the mechanical and physical properties of the salt beneath Islandmagee, from the first well drilled as part of the development. The information received from this borehole will be used to prepare a detailed design for the project.

The rig will therefore be present for approximately seven weeks in Year 1 (see Section 4.8 *"Phasing and Timescales"* whilst the first well is drilled. The rig will then leave the site whilst analysis of the borehole is undertaken and the detailed design of the caverns and leaching methodology is prepared. Assuming that the initial well confirms that the salt has the correct mechanical and physical properties, the rig will then return to drill the remaining 6 wells in Year 3.

4.7.1 Drilling

One well will be drilled per cavern. Due to the necessary horizontal step-out of the wells, their paths will be S-shaped (Figure 4.9). The maximum anticipated horizontal displacement is 700m.

The diameter and the setting depth of the last cemented casing shoe (LCCS) are the key parameters for cavern well design. The LCCS isolates the cavern from the rock formation above it and its quality is crucial for the tightness of the cavern.

Taking into consideration the desired leaching rates and a predefined gas production rate, a gas-tight 13 ⅜" last cemented casing is proposed for each of the cavern wells. A feasible casing scheme (also shown in Figure 4.9) is outlined below:

- 36" conductor casing pre-set (hammered) at approximately 10m below ground during preparation of the well pad areas and wellhead cellars.

- 26” surface casing set into the Glenstaghey Formation in the uppermost part of the Mercia Mudstone Group at approximately 200m TVD, and cemented to surface. This casing will isolate and protect any near-surface permeable formations that may be in communication with the local groundwater aquifer before using an inhibited drilling fluid for drilling subsequent well sections.
- 18 5/8” intermediate casing, set into the lowermost part of the Mercia Mudstone Group at approximately 900m TVD, and cemented to surface.
- 13 3/8” 'anchor casing', set in the upper Permian Marls at approximately 1500m TVD, and cemented to surface. In cavern wells this casing usually carries the first wellhead section. This casing will isolate the Sherwood Sandstone prior to increasing the drilling fluid density, which is required while drilling the upper part of the Permian Salt in the subsequent 12 ¼” well section.
- 9 5/8” last cemented casing will be set into the top of the Salt layer at 1,480m TVD, and cemented to surface. This casing may have a slightly larger diameter (e.g. 10 ¾”) in the top approximately 60m of the well in order to allow locating of the tubing retrievable sub-surface safety value (SSV) (see section “*Safety*” 13.5.1 in Chapter 13.) at approximately 50m, depending on the latter’s maximum outer diameter.

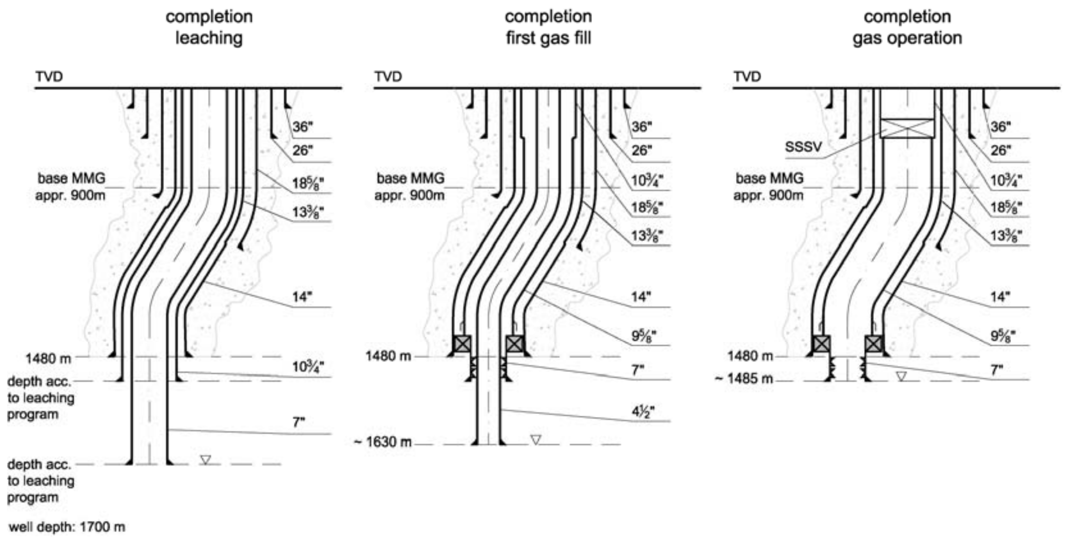

Figure 4.9 Schematic Drawing of Wells

(nb vertical and horizontal axes are not to scale)

The top of the Permian salt is expected at true vertical depths of between 1,400 and 1,500m and the wells will be drilled to a true vertical depth (TVD) of approximately 1,660m. Unlike in oil and gas production wells, the cavern wells must enter the later cavern interval very near vertically, at a maximum inclination of 1.5°, resulting in an 'lazy S' shaped well path being required (shown in Figure 4.9). The greater the reach, the higher the tangential inclination required. The maximum horizontal displacement of the cavern from the wellpad at Islandmagee will be in the order of 700m.

The maximum well deviation and the resulting maximum required tangential inclination of up to 34° poses few drilling related problems as there exists a wide range of experience with deviated wells in the oil and gas industry.

It is intended that the use of high precision and accurate measurement-while-drilling (MWD) and gyroscopic surveying techniques, and recently developed 'well twinning' directional drilling technology, will allow suitably tight tolerance to be established to control the well separation.

Whilst the well is being drilled the site would contain the drilling rig and ancillary equipment along with temporary office accommodation, essential 24-hour staff living accommodation and laboratories. The precise specification of the drilling equipment will not be known until a contractor has been selected, however, the maximum height of the rig mast is not expected to exceed more than 55m above ground level. Plate 4.17 shows a typical drilling rig in operation.

Plate 4.17 Typical Drilling Rig in operation

A fresh water supply will be required for the drilling fluids for the duration of drilling activities. If a mains connection is not available on site, water may be tankered to the site and stored in tanks.

Semi-dry drilling mud and rock cuttings will be collected in purpose built tanks which will be located on either a concrete pad or in skips and transported from the site by road by a licensed waste contractor for disposal at an approved licensed waste disposal site by agreement with NIEA. Domestic and general site waste will be discussed in more detail in Section 4.9.6

Under normal conditions approximately 12 site personnel would be on site at any one time during operations.

Drilling of the wells will be a 24hr operation and therefore, for safety reasons, the rig is required to be illuminated at night. Plate 4.18 below shows a typical rig in operation at night. All other site lighting would be minimal and at low-level sufficient to permit safety of operations.

Plate 4.18 Typical drilling rig in operation at night

The following deliveries, 3 or 4 of which would be assisted by police escort, would arise at the time of rig mobilization/demobilisation:

Derrick	1 load
Trailer with draw-works and rotary table	1 load
Sub-structure and ramp	1 load
Matting boards, Blow-out preventers & manifold	1 load
Mud pump buildings	2 loads
Mud tanks	2 loads
Light plant, accumulator & change house	1 load
Water tank and doghouse	1 load
Toolhouse and fuel tank	1 load
Catwalk, junk rack, V doors & stairs	1 load
Toolpush cabin	1 load
Forklift & washroom building	1 load
Cranes (for assembly)	2 loads
Total loads	**16 loads**

Additional deliveries would be required during mobilisation and demobilisation for ancillary services, as follows:

Mud logging cabin & equipment	2 loads
Wireline logging	1 load
Drilling Mud Solids control equipment	1 load
Operational control cabin	1 load
Materials & chemicals	4 loads
Drill pipe & tubulars	4 loads
Accommodation modules	3 loads
Total loads	**16 loads**

The total number of deliveries (32) equates to 64 HGV movements over each anticipated 3 day mobilisation/demobilisation periods in terms of in-going and out-going vehicle trips.

During drilling mode deliveries of equipment and removal of drilling mud and cuttings would generate 3-4 vehicle (6-8 trips) per day over a 4 week period. 20 light vehicle trips would be generated at 0800 and 2000 hrs at personnel shift changes.

All surface run-off within the site would fall to the surrounding ditch described. Spill kits designed for all materials and substances used on site would be available to deal with any emergencies that could arise. During testing any accidental spillage from the produced fluid storage tanks would be contained within purposely designed containment bunds.

There will be emissions from diesel exhausts from the generators powering the rig and vehicle exhausts. Such emissions would be negligible.

4 sources of waste would require to be removed from the site:

- drilling mud and cuttings located in the mud tanks,
- sanitary waste,
- site drainage collected in the ditch surround,
- general dry waste-paper, timber, scrap metal - collected in skips.

Mud cuttings, sanitary waste and produced fluids from drilling and testing operations will be removed by licensed operators and disposed of at authorised locations. Oil-based mud will be removed by its supply company for recycling. For most of the time water from site drainage is likely to be reused in drilling-mud and make-up but otherwise, when conditions dictate, it will be collected for disposal at an authorised licensed site. Skips for dry waste would be obtained from a local contractor and exchanged when necessary.

Site specific Emergency Response Procedures will be put in place in consultation with the emergency services. Drilling and any subsequent testing operations would be conducted in accordance with good practice and all relevant controlling bodies and British Standards. The geology has already been established from the Larne-2 borehole, where no hydrocarbons where encountered. An emergency is considered highly unlikely, but should any emergency situation occur the well would be instantaneously "closed in" by means of the fitted blow-out preventers.

Well operations will be undertaken as required by the Borehole Sites and Operations Regulations 1995, the Management of Health and Safety at Work Regulations (Northern Ireland) 2000, the Construction (Design & Management) Regulations 2007, the Offshore Installations & Wells (Design & Construction etc). Regulations 1996 and Sterling's Health & Safety Manual. All construction, drilling, possible testing and restoration activities will be carried out in accordance with the U.K.'s health & safety controlling bodies.

The wellsite has been designed so that all engineered features, including pipework and the 7 wellheads drilled from the wellsite platform will be placed underground. The design of the wellpad respects its rural situation and will result in a low-key development that minimizes potential landscape and visual impacts.

4.7.2 Cavern Construction

Cavern leaching can only commence once the leaching pump house and all associated seawater and brine piping systems including the seawater intake and outfall have been connected and the drilling of the first well has been completed.

The leaching process involves pumping seawater into the well at carefully controlled predetermined rates to leach out the salt layer some 1,500m below the surface. The subsequent brine is bought to the surface whereby it will pass into a holding tank for monitoring and temperature control, prior to discharge.

Each cavern will take approximately 22 months to be created. Accordingly several caverns will be "in leaching" at any one time, with the overall process for 7 caverns taking up to 4 years. Full technical details on cavern design and construction are supplied in Appendix 4.1.

The rock-mechanical desktop assessment has resulted in a cavern design with a net individual cavern volume of approximately 480,000m³. The maximum pressure depends on the overburden weight and the homogeneity of the storage horizon and will be approximately 250 bar.

The individual caverns will be arranged in a near hexagonal grid with a minimum distance of the cavern axes of 300m.

Prior to the completion of leaching, the mechanical integrity of the cementation at the shoe of the 9 5/8" last cemented casing will be tested by a hydraulic pressure test. Following the drilling operations for the first cavern, and after the wellhead completion and connection to the infrastructure, the leaching process will commence for this cavern.

Cavern construction is performed stepwise in a pre-defined three-stage leaching concept comprising the sump, main and roof leaching phases, respectively.

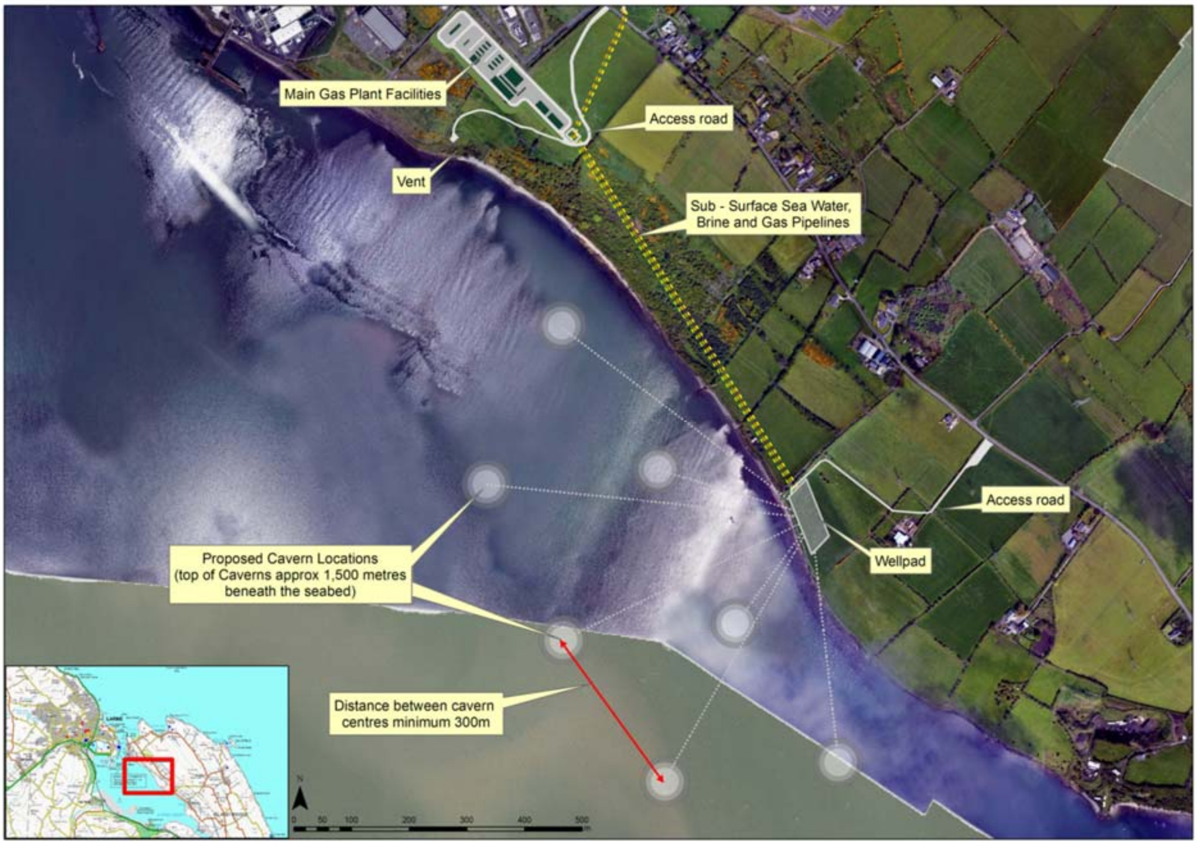

Figure 4.10 Cavern spacing and preliminary layout

The storage volume is created by circulating seawater through the leaching strings during the cavern leaching phase. Two different 'leaching modes' are applied:

- 'direct mode' or 'bottom injection' (injection through the inner leaching string), and
- 'reverse mode' or 'top injection' (injection through the annulus between inner and outer leaching string).

By switching between these leaching modes, the cavern will be shaped within the boundaries of the rock mechanical envelope. The leaching programme is adjusted to the present geology of the salt deposits as well as the desired and the feasible cavern shape. Further activities such as changing the setting depth of the leaching strings as well as moving the blanket level will continuously design the cavern shape and dimension development. The cavern roof will be protected by implementing a non-leachable blanket medium with a lower density compared to the brine that is produced in the cavern. At Islandmagee, nitrogen is planned to be used as blanket medium in this project. Acoustic surveys of the cavern are undertaken throughout the leaching phase to monitor its shape.

4.7.2.1 Sump phase

The outline cavern diameter of 80m has been based on the information gathered during the desktop geological study. This will be confirmed following recovery of salt cores from the confirmatory borehole however is unlikely to change significantly. The 80 metre cavern diameter is initially established during the sump leaching phase, which lasts approximately two months and uses the direct (bottom injection) leaching mode. The blanket level will remain fixed throughout sump leaching and brine flow rates of 100 to 200m³/h will be achieved. By the end of the sump leaching phase with an injection rate of approximately 200 m³/h the brine concentration will reach approximately 180g NaCl/l.

4.7.2.2 Main and Roof Leaching Phase

During the main leaching phase the leaching mode will be reverse (top injection) to achieve a good cavern shape development. The leaching rate will be around 300m³/h (nominal flow) for the remaining time of the leaching process. During the roof leaching phase, the blanket position is modified in small steps to facilitate the development of an ellipsoidal cavern roof. The brine concentration will gradually increase to a maximum of about 312g NaCl/l, close to saturation, towards the end of the process. By the end of the main and roof leaching phases, which will last approximately 16 months (see Figure 4.11), a geometrical cavern volume of about 480,000m³ will be achieved.

4.7.3 Brine Flow Rates

The leaching rate will be between 100 and 300 m³/h per cavern, but as the caverns are phased the overall process will result in a maximum total flow of 1,000m³/h for parallel operation of 4 caverns (Figure 4.11). The "fresh" water requirement for leaching the caverns will be seawater, which will be pumped though the intake pipeline from Castle Robin Bay discussed earlier in Section 4.1.5.1 (page 4-2). The sea-water becomes more saturated with halite salt as it is circulated to dissolve or leach the salt. The resultant brine is then dispersed into the sea via an outfall, located at approximately -27m Chart Datum around 450m off the eastern shore of Islandmagee.

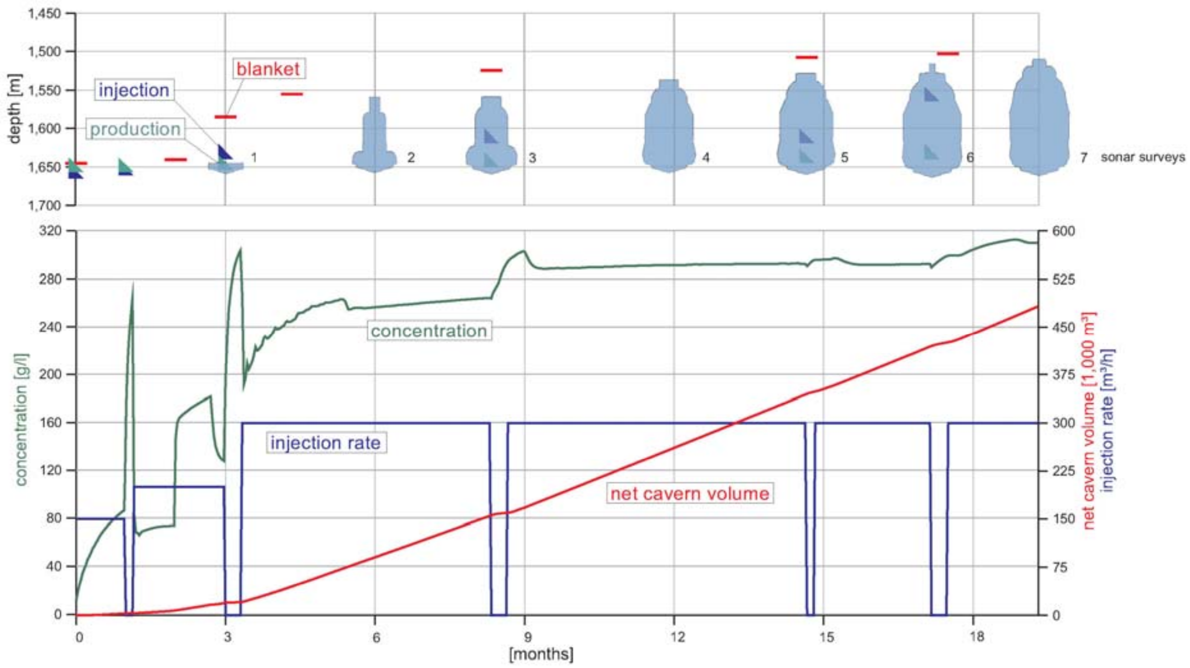

Figure 4.11 Leaching settings, brine saturation and geometrical volume through the cavern leaching process.

The site engineer and the operators will control the leaching procedure by means of a process control system specifically designed to the leaching operation. This system will visualise, collect and save relevant data, particularly pressures and flow rates.

The parallel leaching of caverns allows the switching of flow between individual caverns in case of workovers or other measures, so minimising any delay in the schedule of cavern construction. The total leaching time necessary to create all 7 caverns will be about 4 years (refer to phasing and timescales section 4.8). For an individual cavern, 10 % to 15 % downtime due to planned activities (workover, surveys etc.) or unexpected problems in the cavern development have been taken into account in the scheduling.

This operational concept requires a high flexibility of the pump equipment. Two 2MW leaching pumps are intended to be used, designed to inject the maximum flow of 450m³/h. The leaching pumps will be driven by variable speed electric motors.

One additional leaching pump of lesser capacity will be installed to provide low rates during the sump leaching phase of the first cavern. During this initial stage it will be necessary to produce a minimum total flow of 100m³/h. A header system is used and the flow for each cavern is adequately regulated by valves.

4.7.3.1 Power Supply

In order to provide power to the leaching pumps' transformers and switchboards, a new electrical substation will be constructed adjacent to the pump house. The power will be supplied to the plant from an existing 110kV feeder, by agreement with NIE. A transformer will supply a 11kV switchgear. This switchgear will supply the two transformers for the leaching pumps and the transformer for the 0.4kV supply of the leaching plant. In case of power failure of the public grid, the power supply for the control system and medium voltage system will be kept operational by a battery backup device.

4.7.3.2 Post Construction

After the construction of each cavern has been completed, an echometric (sonar) survey will be run in order to identify the cavern shape and volume.

Before commencing gas storage operations a pressure integrity or 'tightness' test will be performed on the last cemented casing seat in order to verify the gas tightness and confirm the suitability of the cavern for gas storage. The gas storage completion is then installed and pressure tested to confirm tightness. After the completion has been designated technically tight, the wellheads will be reconfigured and the cavern will be ready for storage operations.
During the lifetime of the project the caverns will be surveyed and intermittent leaching of the caverns may be required. The seawater intake and brine discharge infrastructure will therefore remain throughout the project life.

4.8 Phasing and Timescales

In total, the construction of the Islandmagee Gas Storage Facility is expected to take 7 years (Figure 4.12).

The construction will be phased, with construction of the wellpad, sea water intake, leaching plant, outfall and connecting pipelines taking place first. Leaching cannot commence until all these elements are completed and the first well has been drilled. It is anticipated that construction of the leaching infrastructure and wellpad and the subsequent reinstatement will take approximately 18 months.

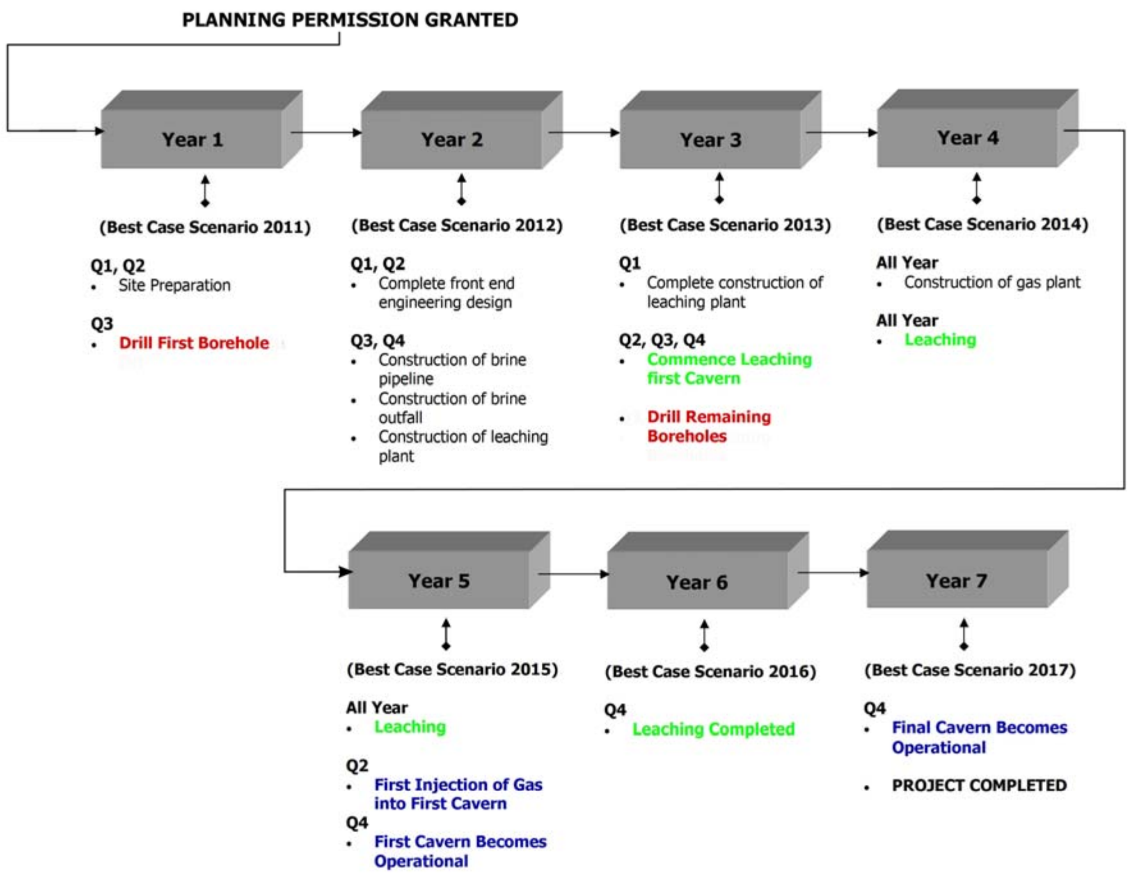

Figure 4.12 Schematic of Estimated Project Timeline

Each cavern is anticipated to take approximately 22 months to leach, with up to four caverns being leached concurrently. The total leaching time will be approximately four years (Years 3 to 6 inclusive).

Following completion of the leaching infrastructure in the middle of Year 3, works will commence on the main gas plant facilities. These facilities will take approximately one year to construct and are expected to be complete by the end of Year 4 in time for testing the first cavern, which should be completed its leaching phase by the end of Year 4.

Once the gas facilities have been completed at the end of Year 4, all remaining construction and operational activities will be entirely sub-surface.

Following testing and commissioning the first cavern should become operational for gas storage in the middle of Year 5, with the final cavern becoming operational by the end of Year 7.

4.9 Waste Management

4.9.1 Introduction

In this section, all forms of solid and liquid emissions, that may arise, from the construction, commissioning and operational phases of the pipeline are considered. Air emissions are discussed in Chapter 7; the disposal of uncontaminated site drainage water is discussed in Chapter 12.

4.9.2 Key Legislation

A list of the key pieces of legislation relating to waste and emissions is listed below:

- European Union (EU) Framework Directive on Waste (91/156/EEC)
- Pollution Control and Local Government (NI) Order, 1978;
- Waste and Contaminated Land (NI) Order, 1997;
- Special Waste Regulations, 1998;
- Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations, 1999;
- The Environmental Protection (Duty of Care) Regulations (NI) 2002;
- Controlled Waste Regulations (NI) 2002;
- The Water (Northern Ireland) Order 1999;
- The Water Quality Regulations (Northern Ireland) 1994;
- The Water and Sewerage Services (Northern Ireland), 1973 (and as amended 1993);
- The Groundwater Regulations (Northern Ireland) 1998;
- The Pollution of Groundwater by Dangerous Substances Regulations (Northern Ireland) 1994;
- Health and Safety at Work Act 1974;
- The Control of Substances Hazardous to Health Regulations, 1999;
- Construction (Design & Management) Regulations 2007 - CDM Regulations

4.9.3 Construction Phase

4.9.4 Liquid Effluent and Spillages

<u>4.9.4.1 Control of Surface Water Run-off</u>

Along the proposed pipeline routes, where there is a slope from the pipeline route down to a watercourse or road, bunds, grips, barriers or straw filled ditches will be constructed adjacent to the banks of the watercourse or road. The purpose of this will be to prevent, as far as possible, sediment laden run-off from the working width flowing directly into the watercourse or on to the road.

At the proposed sites of the brine leaching plant, gas facilities and wellpad, careful consideration has been given to drainage design and implementation from the initial phases of site clearance. More detail on site drainage is given in Chapter 12, Geology and

Hydrogeology. Interceptors to treat surface water to remove oils, silt and other contaminants during the construction phase will be installed and monitored appropriately.

4.9.4.2 Fuel and Oils

Fuel quantities used will be registered at the site offices and will be stored in designated areas. Fuel tanks will be either double skinned and/or imperviously bunded to contain 110% capacity of the combined capacities of the containers. If the fuel tanks are double skinned only the connections and delivery hoses will need to be within a bunded area.

Bunds will be constructed in accordance with the PPG 2, Above Ground Oil Storage Tanks. Accumulated rainwater will be routinely emptied. If contaminated, it will be disposed of at a suitably licensed waste disposal facility. Storage of fuels and oils along the pipeline route working width will be avoided so far as is practicable. Where unavoidable, all fuel and oil drums or containers will be stored in bunded areas or lipped temporary stores. Fuel and oil storage will be banned in the flood plains of all rivers and/or within 30m of watercourses and ditches and 50m from boreholes or springs.

All plant will be inspected for fuel and oil leaks before being accepted for delivery onto the working width. Thereafter, regular maintenance inspections will be carried out to minimise the risk of ground contamination from leaking machinery. When available, generators and pumps with integral drip tray will be used; when not available, drip trays will be placed under standing generators and pumps. All drip trays will be emptied of rain water as required.

Machinery used on the working width will be refuelled using portable bowsers with integral secondary containment. Bowser use on the working width will be regularly monitored and appropriate measures will be taken, such as the use of funnels, drip trays or oil absorbent pads, to prevent ground contamination. No re-fuelling of mobile plant or fuel storage will be allowed within 30m of any watercourse or in the flood plains of rivers. The bowsers will be returned to the construction base overnight and stood on a hard impervious standing with lip containment.

If a spillage occurs it will be contained, and subsequently recovered in order to prevent it reaching the groundwater or entering the drainage system. Appropriate clean-up techniques will be employed. Oil absorbent pads and grab packs will be available on vehicles and further materials, including booms, will be carried by fuel bowsers and designated emergency teams. Suitable stocks will also be maintained at the main construction site base. All workforce members will receive training in the use of spill kits during induction. Any contaminated soil and absorbents will be disposed of as special waste to an appropriate licenced site.

All spillages will be reported and recorded as part of construction procedures. Prior to the start of construction, the main contractor will prepare pollution control and emergency response plans, which will be discussed and agreed with the appropriate authorities, e.g. EHS.

4.9.5 Sewage

Portable toilets will be provided on the working width, at each of the above ground facility construction sites and at the site offices within the temporary construction set down area. They will be emptied regularly by a specialist contractor and disposed off-site in accordance with The Environmental Protection (Duty of Care) Regulation (NI) 2002.

4.9.6 Solid Wastes

The Contractor will produce a Waste Management Plan as part of the detailed design (see Chapter 18), having due regard to the legislation listed in 13.2 and the 'Waste Management – Duty of Care – a Code of Practice' issued under Article 5 of the Waste and Contaminated Land (NI) Order, 1997. This will identify likely waste arisings, approximate quantities and appropriate handling and disposal methods.

An important aspect of the Waste Management Plan will be to collect and control waste on site. Waste will be regularly collected from the working strip and construction sites and either placed in covered skips or similar containers at designated access points or removed from the site daily.

The likely wastes generated by the construction of the facilities, pipelines and associated infrastructure and the most appropriate methods of disposal are listed in Table 4.2.

Special Wastes will be segregated and kept secure, then disposed of in accordance with the Special Waste Regulations (NI), 1998. Typical Special Wastes generated during pipeline construction are listed in Table 4.3. Where there are alternative 'fit for purpose' materials (e.g. welding rods and shot blast) these will be used in preference to those that form Special Wastes on disposal.

Burning of waste on the spread will not be permitted.

4.9.6.1 Mixed Waste

Site facilities such as welfare units and office facilities will be provided at the drilling site. These facilities will produce mixed municipal waste in the form of food and office waste. This waste is classified as non-hazardous in its mixed form, however it is best practice to send this waste for treatment and recovery of recyclables before sending to landfill. The most viable option for disposal of this waste stream would be to contract a waste operator that will conduct collection, treatment of the waste and disposal of the residual waste. This waste treatment process could be a material recovery facility (MRF) were recyclable waste streams can be recovered. The table below identifies potential waste contractors that can supply skips for the collection of the waste as well as undertake the treatment and disposal of the waste.

Site Name	Licence Number	Waste Type
Waste Beater	WML07/20	Non-Hazardous
SITA	WML07/17	Non-Hazardous
Wilson Waste Management	WML07/27	Non-Hazardous

4.9.7 Drilling Waste

A review of the disposal options that exist in Northern Ireland for the predicted drilling waste (based on geological information from the Larne-2 borehole, 2007 seismic survey data and other available geological information) was undertaken for this EIS.

The following waste quantities are predicted to arise from the drilling activities for each of the 7 wells which will be drilled into the Permian salt beneath Larne Lough.

- Approximately 200 MT/95m³ of fresh water wet drilling cuttings from the top well section, which has to be drilled using water based mud while the aquifer is exposed. These will be small rock cuttings, predominately of basalt, chalk and claystones, and will be wet, covered in fresh water mud.
- Approximately total of 250 MT/120m³ of cuttings wetted in oil based mud from drilling the lower 12-1/4" and 8-1/2" well sections (which will be drilled using oil based mud). These will be small rock cuttings, predominately claystone, sandstone & salt, will be wet, covered in oil based mud and fresh water.
- Approximately 50 MT/40m³ of 'dirty oil based drilling fluid, mixed with water. This relatively small volume of 'oil based slops' waste fluid will be generated when cleaning the mud tanks of the rig after rig is released, prior to moving off the location. The main volume of oil based mud used in the well will be returned to the supplier by tanker for restocking.
- 10 x 12 cubic metre skips of domestic waste from site facilities

4.9.7.1 Fresh water drill cuttings

During drilling activities using a water based mud, wet chippings of predominately basalt, chalk and claystone will be produced. These cuttings will most likely be coated in the fresh water mud. It is considered that the most appropriate disposal option for these chippings would be to an inert landfill site. It is recommended that if an inert landfill site is utilised for the disposal of these chippings that the site holds a Pollution Prevention and Control (PPC) Permit. The table below identifies two potential PPC Permitted Landfill Sites for the disposal of the fresh water drill cuttings.

Site Name	Permit Number	Waste Type
Blackmountain	P0259/07A	Inert
Quarry Landfill Service	P0162/07A	Inert

It should be noted that before waste can be sent to the above sites laboratory testing of the waste for a Waste Acceptance Criteria suite would have to be conducted to confirm to the landfill operator that the waste is inert.

4.9.7.2 Oil coated drill cuttings

It is considered that under current NI legislation, these cuttings would be classified as hazardous waste. There are currently no hazardous waste landfill sites in Northern Ireland. Therefore it is likely that the oil coated chippings will have to be transported to mainland UK for disposal in a hazardous waste landfill site. It is considered that the most appropriate method of disposal would be to contract a registered waste carrier, registered under the Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations (Northern Ireland), 1999 to transport the waste cuttings to an appropriate site on mainland GB. The table below identifies two potential registered carriers that are licensed to transport hazardous waste to mainland GB.

Name	Permit Number	Waste Type
Enva	146	Hazardous
Irish Waste Services	210	Hazardous

Following conversations between Islandmagee Storage Limited and drilling engineering companies in GB it is understood that similar drilling operations in England have resulted in the oil coated drill cuttings being composted. Following research into the regulation of composting facilities in Northern Ireland it is considered that this would not be a viable option as the waste will be classified in Northern Ireland as hazardous. However, the potential exists for the waste to be transported to the facilities in England that are currently composting this waste stream. If this route is chosen then it should be noted that a registered waste carried should be contracted to transport the waste to the appropriately licensed facility.

4.9.7.3 Oil based drilling fluid

Oil based drilling fluid is considered hazardous under the European Waste Catalogue, code 01 05 05*. This waste will have to be disposed of at a hazardous waste treatment facility. It should be noted that the facility should have the appropriate waste management licences. The table below identifies two potential waste treatment facilities that can accept waste oil based drilling fluid.

Site Name	Licence Number	Waste Type
Enva	WML09/16	Hazardous
Irish Waste Services	WML07/32	Hazardous

4.9.8 Emissions during Pipeline Testing, Commissioning and Operation

4.9.8.1 Liquid Effluent

During pressure testing the pipelines will be filled with water that will need to be abstracted and discharged safely. Preferred abstraction and discharge locations will be agreed with the Rivers Agency, NIEA and other relevant authorities and the appropriate licences/consents obtained. The water will be tested for non-approved contaminants prior to and after testing and the rate of discharge controlled in accordance with consent requirements.

4.9.8.2 Solid Wastes

Typical solid wastes from the pigging operation will be mill scale, weld splatter, rust and other such debris. Arrangements will be made at the test locations to contain and collect this waste for subsequent disposal to an appropriately licensed facility.

Table 4.2 Typical wastes generated by Construction

Activity	Waste Generated	Disposal Recommendations
Site Preparation	Likely to be negligible.	
Operation	Office rubbish, paper, packaging, canteen refuse etc. Rubbish from the yard and site. Scrap metal.	Paper re-cycling. Collection of waste in covered skips or bins for disposal to a licensed waste facility. Sold as scrap.
Demobilisation of site	Workshop wastes, paints, oils, grease etc.	Collection in covered skips for disposal to a licensed waste facility.
Working Width Preparation	Hedge vegetation, wire, fence posts, brash and timber.	Use of chippers on site to reduce bulk of vegetable waste. Disposal at a licensed waste facility. Timber remains the property of the landowner.
Pipe Stringing and Bending	Rubber pipe bands and plastic end caps.	Collected in covered skips for disposal to a licensed waste facility.
Welding and Coating	Welding rod stubs, grinding wheels and shot blast.	Collected in covered skips for disposal to a licensed waste facility.
Lower and Lay	Pack pads. Water collection in excavation.	Collected in covered skips for disposal to a licensed waste facility. Pump on to land or into adjacent ditch using suitable filtration/ settlement techniques in accordance with NIEA requirements.
Backfilling and Grading	Surplus spoil and rock.	Offer to landowner or if re-use not possible removed from site to a licensed disposal facility.
Micro-tunnelling and Auger Boring	Slurry/spoil and rock cuttings	Pass through desander, slurry recycled and ultimately disposed of using road truck tankers to licensed waste disposal facility.
Reinstatement	Hardcore used for temporary roads and hard standings. Temporary fencing material and gates.	Re-used within the land holding if possible subject to the agreement of the landowner.
General Activity	Canteen refuse from site	Collected in covered skips for disposal

on Site	mess huts, grease cartridges etc.	to a licensed waste facility.
Temporary Site Toilets	Sewage.	Emptied under contract for disposal at an appropriate facility.

Table 4.3 Potential Special Wastes generated by Construction

Category	Description/Examples
Oils and Solvents	Empty containers, oily rags, thinners solvents, degreasers, hydraulic fluids, lube oils, used oil spill clean up/absorbent materials and associated contaminated soil.
Paint	Primers, paints and empty cans
Epoxy Coatings	Used for coating joints or repairing damaged factory applied coatings
Biocides	Disinfectant, corrosion inhibitors (if used), herbicides
Batteries	Lead acid
Fluorescent tubes	Lighting used for site offices
Drilling Muds	Oil based and water based (see 4.9.7 above)
Pigging Debris	Water/contaminated debris
Welding Rods	Dependant on the composition of the materials used in their manufacture
Shot blast	Dependant on the composition of the materials used

4.10 Operations

The diagram below sets out the principal components of the facility used for operations, following completion of the construction phase.

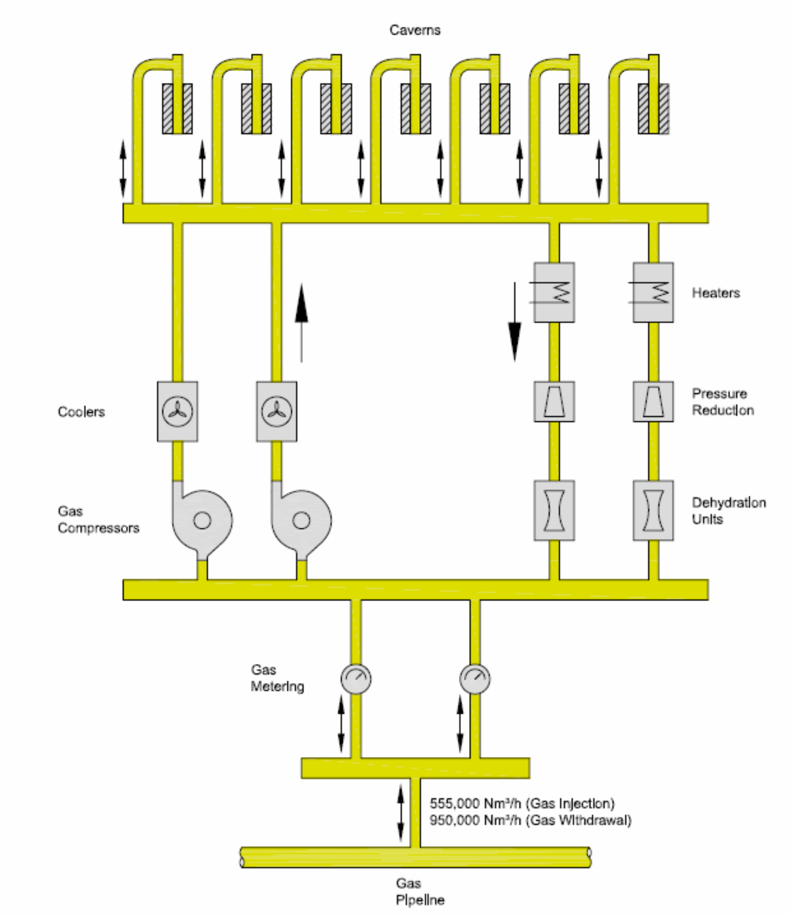

Figure 4.13 Flow diagram for gas operations

Gas will enter the facility from Premier Transmission Limited's above-ground-facilities adjacent to the main gas storage facilities. The gas will be metered on site and then be compressed by electrically driven compressors. Compression results in heating of the gas, so it passes through air coolers before entering the caverns.

On leaving the caverns the gas will be heated before the pressure is reduced. The gas will pick up a little moisture in the caverns and needs to pass through dehydration units prior to being metered to record the volume of gas leaving the gas storage facility.

The proposed 7 caverns will commence gas operations one at a time over an interval of approximately 2 years following injection of gas into the first cavern. The caverns are first filled with "cushion gas"; this gas remains in each cavern at all times during operations to maintain a minimum operating pressure. Each cavern will be able to store approximately 71 million cubic metres of "working gas" resulting in a maximum stored volume of approximately 500 million cubic metres.

The gas storage facility will be largely filled (gas compressed and injected into the caverns) during the summer months and gas withdrawn from the caverns during the high demand winter months. However, throughout the year there will be flows in and out of the facility (injection and withdrawal) to meet demand spikes (commonly referred to as “peak shavings”). The chart below in Figure 4.14 shows a simulated utilisation of the facility over the course of a year.

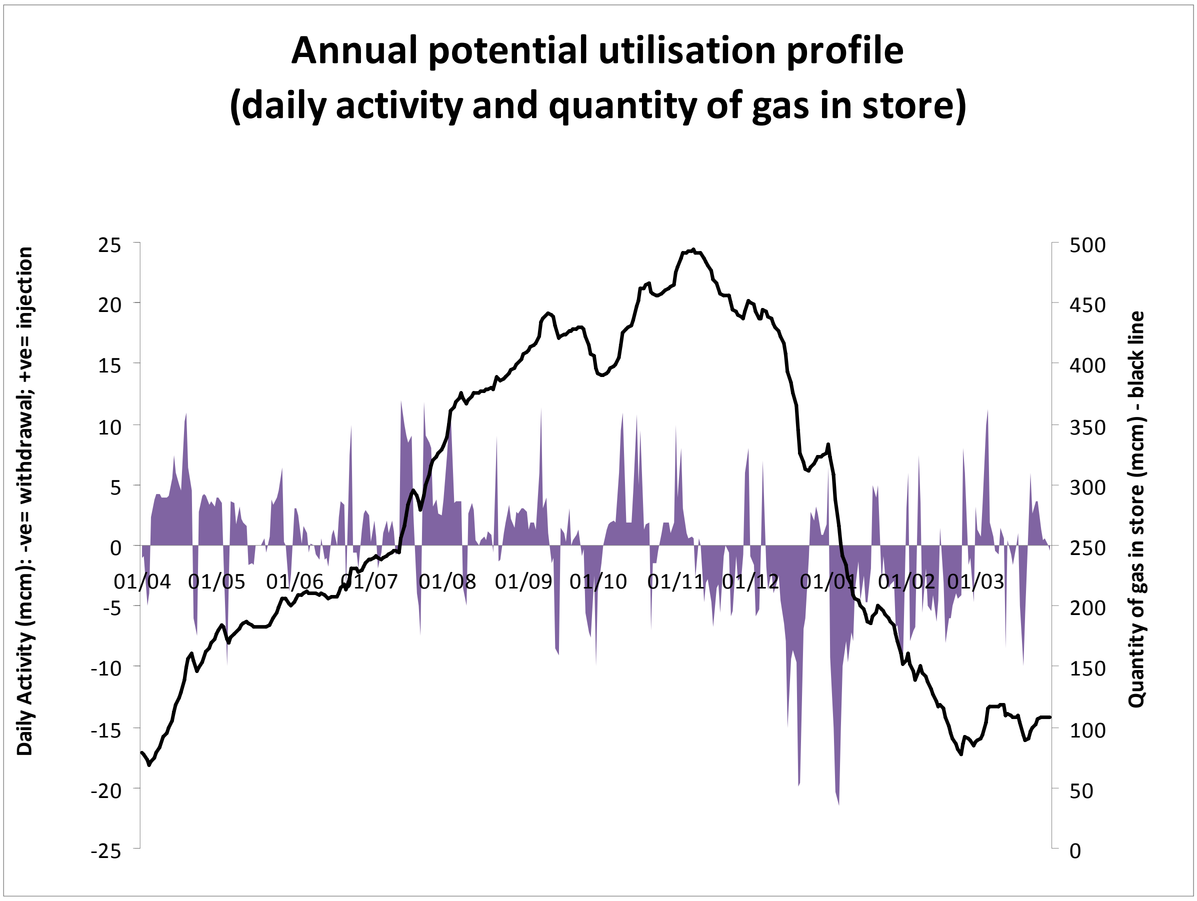

Figure 4.14 Annual potential utilisation profile

4.11 Decommissioning

4.11.1 Pipeline and Above Ground Facilities Decommissioning

The pipelines will be decommissioned when they reach the end of their useful life, in accordance with legislation at the time of de-commissioning. At that time detailed decommissioning procedures will be produced. The above ground installations can also be disassembled and removed from the site at the end of their working life.

4.11.2 Decommissioning of Caverns

When a gas storage cavern reaches the end of its life, it must be decommissioned in a way that does not allow for any later hazard or environmental degradation. Some effects influencing the long-term abandonment of caverns (increase / decrease in pressure) are:

- Initial undersaturation of the brine fill,
- thermal expansion of the brine fill,
- convergence of the cavern (due to salt creep),
- long-term permeation into the salt,
- fluid permeation through the sealing plug/casing cement, and
- chemical processes (e. g. re-crystallisation).

A basic cavern sealing and abandonment concept (CSA) has been prepared for the Islandmagee Storage Project. Technical procedures have been set out on how to realise the post operational (abandonment) phase.

Up to now, worldwide, there are only a handful gas storage caverns that have been abandoned or are currently in the preparation for abandonment. However, during recent years, extensive research has been undertaken to study the various aspects of cavern abandonment. A substantial portion of this work has been done under the aegis of the Solution Mining Research Institute (SMRI) in a special 'Cavern Sealing and Abandonment (CS&A) Project' worked out by an international board of experts from the salt industry and relevant authorities (Ratigan, 2003). In 2006, a 'Cavern Well Abandonment Techniques Guidelines Manual' was prepared by KBB Underground Technologies (KBB UT) for SMRI (Crotogino & Kepplinger, 2006). To summarise the results of these studies, it can be stated that reliable and internationally accepted procedures for cavern abandonment have been developed, which must be adapted to the specific situation of every single cavern.

4.11.2.1 CSA (Cavern Sealing and Abandonment) Requirements

A CSA (Cavern Sealing and Abandonment) concept needs to meet the following requirements:

- Long-term protection from contamination of drinking water aquifers and the escape of brine and/or flammable and/or environmentally hazardous storage product residues at the surface,
- long-term stability of rock mass surrounding the cavern,
- free of (or low in) maintenance,

- application of tried-and-tested methods and materials as far as possible,
- affordability, and
- acceptable by the authorities.

After a successful plugging, the field lines and the well head as well as other installations on the cavern pad have to be dismantled and the cavern pad and the access roads restored.

4.11.2.2 Preparations for Cavern Sealing

First of all, the gas cavern to be abandoned needs to be depressurised down to permissible minimum pressure, at which the stability of the cavern can still be guaranteed. To replace the remaining cushion gas with (sea-) water, the subsurface safety valve is removed or sleeved before a (sea-) water injection string can be snubbed in under gas pressure. As soon as the cavern is filled with (sea-) water, the injection string and gas completion can be removed. Before the plugging, a waiting period will be given to allow for thermal equilibrium to be achieved between the brine fill and formation. After this waiting time, the installation of the plug can commence.

4.11.2.3 Cavern Sealing

The objective for the abandonment of a cavern is to guarantee the long-term stability of the formation around the cavern and the integrity of the cavern seal. In a plugged and fluid-filled cavern, the internal cavern pressure will increase over time due to salt creep resulting in cavern convergence and thermal expansion of the enclosed brine approaching the formation temperature once prevailing prior to leaching and gas operations. The increase of internal cavern pressure is counteracted by further salt dissolution (inducing a decrease of the brine temperature) and brine slowly permeating into the salt matrix. Theoretically, the pressure increase will stop as soon as the internal cavern pressure is equal to the formation pressure of the surrounding rock salt.

Since the thermal expansion of the brine has a major effect, it is recommended, that prior to cavern sealing, all caverns should be kept open as long as possible and practical (i. e. in shut-in and bleed-off periods) to minimise the temperature difference between the salt formation and the brine (Ratigan, 2003).

Following the end of operations and a period of time to reach thermal equilibrium, the work on the plugging can be conducted. There are basically three possible alternatives for plugging cavern boreholes prior to abandonment:

- plug within cemented casing,
- plug within cavern neck (open hole) below cemented casing, and
- plug within milled casing section.

The option of plugging depends on the local cavern conditions (e. g. geometry of the cavern neck) as well as on the cavern history.

4.11.2.4 Monitoring

A long-term equilibrium will be reached, if thoroughly prepared abandonment schemes are adhered to. In a preparation phase prior to cavern abandonment, some site-specific investigations will have to be carried out and the following features will have to be monitored or tested:

- cavern compressibility,
- in-situ creep behaviour of the surrounding rock mass, and
- temperature development with time during the brine fill (temperature logs in the brine-filled cavern).

These tests and observations together with the geology, cavern, well data, rock mechanics, salt permeability and operational history of the cavern will provide specific data for numerical simulations of the pressure development in the cavern during abandonment. These data will provide indications whether critical values may be reached in the future of the abandoned cavern.

A pressure control may be necessary in case of insufficient data and parameters listed above. In homogenous salt formations, in which long-term stability and integrity of the cavern and seal is proven and a complete data set is available, the monitoring in the post-abandonment phase can be reduced to periodic measurements of subsidence (Crotogino & Kepplinger, 2006).