BORD GÁIS

Limerick Gasworks
Dock Road, Limerick

Site Investigation Factual Report
Volume 1A

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Parkman Environment,
Parkman House, Lloyd Drive
Ellesmere Port, South Wirral
CH65 9HQ

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0.0 EXECUTIVE SUMMARY

Appointment	Parkman Environment were appointed by Bord Gais Eireann in a letter dated 30th May 2000 to provide Engineering Consultancy Services for the decontamination / remediation of the former gasworks sites at Limerick and Waterford. This document comprises Volume 1 (factual information) of the Phase II (intrusive investigation) report for the Limerick Gasworks site.
Location	The site lies to the south-east of the Dock Road in the City of Limerick, approximately 100m from the River Shannon; the approximate National Grid Co-ordinates are E 157600 N 157200.
Site History	A limestone quarry extended over most of the eastern quadrant of the site prior to 1840. The gasworks was established to the north-west of the quarry in the 1830's. Several generations of gasworks producing 'town' gas occupied the site until gas manufacture was converted to oil - gas production in the late 1960's / early 1970's. The arrival of natural gas to Limerick in 1986 made the generating process redundant and most above ground structures were demolished by 1988.
Geology & Hydrogeology	The site is underlain by various thickness of Made Ground, overlying Lower Carboniferous Limestone (Visean Limestone); thin layers of Alluvium deposits have been identified in some locations overlying the bedrock. The Limestone is considered to be a locally important aquifer and due to limited drift cover could be considered vulnerable. The nearest recorded abstraction is 6 km to the south-east of the site.
Previous Site Investigations & Results	Two previous site investigations have been carried out on site in 1990 and 1995 comprising a total of 27 trial pits and 12 boreholes. Visual and olfactory evidence of organic contaminations was noted in a large number of exploratory holes, particularly over the south-western part of the site. Tarry staining was identified in the bedrock joints in four boreholes. Groundwater was contaminated with heavy oils and oozing tarry liquid particularly on the western side of the site. The results of leachate testing showed that the potential for leaching was low.
Recent Site Investigation	A total of 17 trial pits and 4 rotary boreholes were excavated between 26 February and 6 March 2001. Samples of soil and water were selected and sent to City Analytical Services plc (CAS) in Coventry, UK for subsequent chemical analysis. Samples were also taken for geotechnical analysis. Gas/water monitoring standpipes with taps were fitted to all 4 boreholes.
Services	All main services are present in Dock Road, St. Alphonsus Street and O'Curry Street; some gas services enter the site along the north-west boundary of the site and an electricity cable is shown running into the electricity sub-station from O'Curry Street. Private services may also exist on the site.
Development Issues	Three development options have been indicated for the site namely light commercial, residential (excluding townhouses with gardens), or car parking.

1.0 INTRODUCTION

1.1 Terms of Reference

Parkman Environment were appointed by Bord Gáis Éireann in a letter dated 30 May 2000 (ref. No. 00/004) to provide engineering consultancy services for the decontamination/remediation of the former gasworks sites at Limerick and Waterford. These services include the preparation of Phase 1 (Document Review) and Phase II (Intrusive Investigation) reports. This document comprises Volume 1 (factual report) of the the Phase II report for the Limerick gasworks site. Interpretation of the factual information is presented in Volume 2.

Bord Gáis propose to either dispose of the sites in their current condition or alternatively, remediate them ready for development.

The site reviewed in this report is based on the boundaries as defined by Bord Gáis Éireann at the time of the review. Parkman Environment prepared this Report based on the available information obtained during the study period. Every reasonable effort has been made to obtain all relevant information. Sources examined are listed in section 1.2 and particular references are listed at the end of this report.

Further details of statutory consultees, service companies etc can be found in the Phase I Desk Study Report No.25837/OR/01B.

This Report has been prepared and written for the exclusive benefit of Bord Gáis for the purpose of providing environmental information relevant to the existing potential environmental liabilities associated with the site in accordance with the Brief. The Report contents should not be used out of that context. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the Report after the date of its submission.

1.2 Methodology

The preparation of the Phase II report involves a review of all current available site information, a review of the information collected during the recent site investigation and discussion of available remediation techniques.

In undertaking the study, the following sources have been consulted: -

Limerick Corporation - Environment, Community & Sport Department
- City Engineer's Department
Environmental Protection Agency
The National Library of Ireland
Geological Survey of Ireland
The Map Library, Trinity College, Dublin
Eircom Ireland
ESB
Bord Gais Eireann
GVA Donal O'Buachalla (Estate Agents)

Other references used in completing this report are provided in Section 4.0.

A walkover survey was undertaken on 13 July 2000 and Mr Michael Shouldice, the Site Manager for Bord Gais was interviewed by Parkman.

Site investigation works were carried out between 26 February 2001 and 6 March 2001.

GVA Donal O' Buachalla (Estate Agents) were also consulted with respect to potential future uses for the site.

1.3 Report Format

This Report (Volume 1) is sub divided into three sections. Following this Introduction [Section 1], the findings of the Phase I Desk Study are reviewed in detail [Section 2]. The information gathered during the recent site investigation is then presented [Section 3]. Finally, any relevant references are collated [Section 4]. All of these sections are summarised in tabular form in the Executive Summary [Section 0].

2.0 DESK STUDY ASSESSMENT

2.1 Site Location and Description

Limerick gasworks lies to the south-east of the Dock Road in the City of Limerick, approximately 100m from the River Shannon. The Shannon Bridge lies approximately 400m to the south-east of the site. The approximate National grid co-ordinates of the site are E157600 N157200.

Access to the site is either from Dock Road, which forms the north-western site boundary, or from O'Curry Street forming the north-eastern boundary.

The site is approximately rectangular, 130m x 110m, and covers an area of 1.4 hectares (3.5 acres), including the "house pound" area in the northern corner, adjacent to the junction of Dock Road and O'Curry Street. Part of the site was a former limestone quarry and rock faces are evident in the north-eastern and south-eastern boundaries.

The main area of the site is generally level at about 5.00m OD [Malin Head Datum] but it rises to approximately 8.00m OD towards the site boundaries to the south and east.

The site is used as a depot for Bord Gais, and includes a two-storey office adjacent to the south-west boundary. Other buildings on site include a derelict former store building constructed of stone in the eastern corner and various other smaller brick buildings including the former No.'s 3 & 4 Store, the former Naphtha Process Control building (two-storey), ESB sub-station and the former Governor House.

In addition, high stone walls remain around the location of the former gasholder No 2 (T12) whilst the concrete bund walls and slab are present around the former Tank No 1 (T31). An above ground installation [AGI] remains towards the north west corner of the site adjacent to the site access from Dock Road.

The north-eastern boundary along O'Curry Street comprises a 2m high limestone block wall that becomes higher (3.5m) halfway along the boundary towards the south-east. The south-eastern boundary comprises a 6m high limestone block wall that retains the adjacent Garda training centre, at a level some 2m above the Bord Gais site level. This wall becomes a 3m high brick retaining wall (which retains limestone fill on the site side) in its south-western end adjacent to residential properties. The south-western boundary comprises a 2.5m high brick wall, which retains fill to 2.5m on the site side. The north-western boundary along Dock Road comprises a 2.5m high limestone block wall.

A recent survey of the boundary walls was undertaken by Parkman in March 2001; the findings are presented in report no.25837/OR/02 (see section 2.6.4).

2.2 Statutory Authorities/Services

Limerick Corporation report that they are not aware of any other substantial sources of contamination within 500m of the gasworks site.

There are no known landfills or cases of statutory nuisance within 500m of the site. Limerick Corporation sewers presently discharge into the River Shannon although a new main drainage scheme is currently being constructed and will subsequently collect all such discharges and route them to a new sewage treatment facility. No other discharges are made into the river. Correspondence with Limerick Corporation is included in Appendix F.

All main services are provided along the Dock Road, St. Alphonsus Street and O'Curry Street. Electricity cables are shown running into the electricity sub-station from O'Curry Street. Bord Gais pipelines are shown entering the AGI in the western corner of the site. Low pressure 180mm PE gas pipes also exist in the site along the eastern end of the Dock Road boundary. Private services may also exist on the site.

Figures 3a-e show the layout of services in relation to the site at a scale of 1:1000

2.3 Geology, Hydrology and Hydrogeology

The Geological Survey of Ireland, Sheet 17, Limerick, 1:100,000 Scale (ref. 7), the "Geology of the Shannon Estuary" (ref. 8) and the local geological memoir were consulted and indicated that the bedrock beneath the site comprises the Visean Limestones of the Lower Carboniferous Period. These limestones are 'oolitic' (small (≤1mm diameter) carbonaceous accretionary bodies cemented together, resembling fish eggs) in places, representing a shallow marine carbonaceous shelf depositional environment. These deposits occasionally contain clay 'wayboards' which formed when the limestone was periodically exposed above sea level. The limestone often contains chert nodules (siliceous concretions) and thin interbedded shales. The Visean Limestone is also known as 'Clean Shelf Limestone'. It is over 800m thick and lies conformably on the Waulsartion Limestone, described as a massive unbedded lime mudstone representing a deeper marine depositional environment.

Beneath the site, the beds dip 8° to the north. The site is located on the southern limb of an east-west trending syncline.

The rockhead is close to the surface with little or no drift cover. Should any be present, it is likely to comprise very recent fill [made ground used as backfill in the construction of the gasworks and infilling of the quarry] or Recent alluvium associated with the River Shannon flood plain.

Previous site investigations (section 2.5) and the recent investigation (section 3.0) identify that Alluvial material is present although its thickness does not exceed 4.4m.

The site is situated on the southern bank of the Shannon River, which flows westwards towards the Atlantic Ocean. The Shannon River will be tidally affected at this point.

The site comprises approximately 60% hard cover and 40% free draining material (with many underground structures that may impinge on the flow of water through

the made ground). There is a slight fall in the site level from the south-east (3m OD) to the north-west (5m OD), and so any surface infiltration that does not enter the surface drainage system will tend to flow in the fill materials towards the north-west corner, i.e. towards the River Shannon. The River Shannon water level is typically 3m OD near the site.

Drainage of the site is to the city's sewers, which discharge directly into the river. The 'Site Investigation Report - Limerick Gasworks Site' (ref 2) records that storm water flooding has occurred in the past along the Dock Road at its junctions with O'Curry Street and Alphonsus Street, i.e. close to the site.

The maximum recorded flood level for the City is reported as 4.25m OD. (Malin Head)

The Groundwater Protection Maps for County Limerick (Maps 1-6) (ref. 6) indicate that the Clean Shelf Limestone is a 'Locally Important Aquifer' that is generally Moderately Productive (40-100m^3/d). The aquifer is controlled by fissure flow and well-developed karst features have been observed in the area. The nearest abstraction well is 6 km to the south-east of the site. The oolitic limestones of the Limerick Syncline are known to have relatively high permeabilities. The aquifer is considered 'Vulnerable' due to the lack of impermeable cover.

The majority of the ground water is hard, containing calcium bicarbonate ($Ca(HCO_3)_2$). Iron and manganese have been found in elevated concentrations west of Limerick. Elevated nitrates have been encountered in some locations due to agricultural activities. Groundwater quality of smaller, shallower sources is generally poorer than the larger, deeper sources.

There are no recorded active wells or boreholes in the vicinity of the site although the historical site plan dated 1977 shows a well 5m to the north west of Gasholder No3 (T11).

It is likely that hydraulic continuity exists between the Made Ground/Alluvial deposits and the bedrock.

The recent investigation has identified that there is a shallow hydraulic gradient to the north west towards the River Shannon.

The proximity of the site to the tidal inlet of the River Shannon would suggest the potential for groundwater on site to be tidally affected. The recent investigation has found little evidence of tidal influence.

2.4 Site History

An extract from the Autumn 1987 Limerick Journal entitled "150 Years of Limerick Gas" (ref.10) provided a background history to the site.

The article states "In 1826, the London-based United General Gas Company took over the Hibernian Gas Company in Dublin and soon began to spread its operations to the large urban areas throughout the country. It set up businesses in Limerick in the 1830's and became the sole manufacturer of gas in the city. But the service

was very poor and the people's patience became so exhausted that in the year 1837 a public protest meeting was convened in the City Courthouse.... shortly afterwards, the newly reformed Corporation purchased premises in Watergate for the manufacture of gas, with the aid of a loan of £24,000. In 1878 following a Parliamentary enquiry and the passing of the Corporation Gas Act, the Local Authority took over the private firm and in 1884 moved from Watergate to the more spacious premises at the Dock Road."

Coal based gas manufacture is reported to have continued on site until the early 1970's and the article also states that "it was only in 1974 that the new catalytic oil-gas plant was finally completed in the city.....in 1986, natural gas was piped to Limerick on a spur line from the main Dublin-Cork pipeline. In early 1987, new natural gas pipelines were laid throughout the city and the change over from 'town' gas was complete. The old manufacturing process has been rendered obsolete and the plant at the Dock Road is nothing more that a relic of industrial archaeology."

The following table overleaf summarises the history of the site:

Table 2.4 - Summary of Historical Site Features

Date of Historical Map

Feature	1840	1844	1872	1902	1919	1938	1943	1954	1977	1982	1988	1991	1995
Lime Stone Quarry	■	■	■	■									
Tank T13	■	■	■										
Tanks T14-T19	■	■											
Tank T23			■	■	■	■	■						
Tank T28			■	■	■	■	■	■	■	■	■		
Lime Kilns (2 no.)			■	■									
Tanks T29 & T30				■	■	■	■	■					
Tank T11				■	■	■	■	■	■	■	■		
Cattle Pens				■	■	■	■	■					
Electricity Station					■	■	■						
Tanks T20-T22				■									
Tank T7					■								
Tank T25						■	■	■					
Tanks T1 & T2									■	■	■		
Tank 31									■	■	■		
Tank T24, T26, T27, T32, T33, T3-T6, T8-T10, (associated with oil-gas plant)									■				
Tank 12 *										■	■		
Bord Gais Offices											■	■	■

- Tank T12 is known to have been constructed in 1978 although it is not shown on the 1982 map.

■ Feature Present

Feature Not Present

2.5 Assessment of Previous Site Investigations

2.5.1 Description of Works Undertaken

Two site investigations have been carried out previously to assess the level of contamination on site.

The first was carried out in 1990 by Gibb Environmental (environmental sampling) and Irish Geotechnical Services Limited (trial pitting and borehole excavation) under the direction of O'Connor Sutton Cronin and Associates Limited (ref.1) and comprised ten trial pits to between 1.4m and 2.3m deep and six boreholes to between 4m and 7.6m depth; the latter to prove rock.

Twenty-one soil samples were analysed for pH, sulphate, sulphide, cyanide (total & free), phenols, and toluene extractable material, with four also analysed for speciated PAH's and calorific value. Four water samples were analysed for pH, ammoniacal nitrogen, sulphate, total organic carbon (T.O.C), total cyanide and total phenols as tar acids. One sample of water and one sludge sample were analysed for speciated PAH's.

The second investigation was carried out by K T Cullen and Company and Glover Site Investigations Limited under the direction of Ove Arup & Partners in 1995 (ref.2) and comprised 17 trial pits to between 0.15 m and 3.7m deep and 6 boreholes to between 5m and 11.8m deep and 5 surface (scraped) samples.

Fifty-five soil samples were analysed for pH, sulphates, total cyanide, toluene extractable material and total phenols. Based on the results obtained, selected samples were then subjected to analysis for dependant options comprising PAH'S, BTEX, free & complex cyanide, thiocyanate and water soluble sulphate.

In addition, selected samples were also analysed in respect of metals, mineral oils and total VOC's and a further two were the subject of a leachability test.

Twenty-three water samples were taken and analysed for a suite comprising total phenols, sulphide, ammoniacal nitrogen, total cyanide, speciated PAH's, pH, temperature and conductivity. Eleven samples were also subjected to a suite of tests including organic and inorganic determinands.

Monitoring was carried out subsequently on two occasions in respect of groundwater levels and gas levels.

The results of both investigations are reported and discussed in Ove Arup's April 1996 Site Investigation Report on Limerick Gasworks Site (ref. 3).

2.5.2 *Details of Ground Conditions*

The following succession of strata was identified from the two previous investigations: -

Table 2.5.2 Summary of ground conditions

Stratum	Thickness (m)	
	Range	Average
Made Ground	0.2 - 7.3	2.6
Alluvium	0.0 - 4.4	1.8
Limestone	4.2m proven	

The Made Ground was found to be variable in nature and consistency. The exploratory holes describe the made ground as variable but predominately granular.

The Made Ground contains sand, gravels, cobbles, clays, brick rubble, spent oxides, ash, concrete etc. and was often contaminated with tarry liquid and occasionally has a strong phenolic odour. The deepest thicknesses of made ground are associated with either the old quarry or former tanks that extended underground.

The Alluvial deposits were found in at least three excavations (BH11, TP7 and TP27) towards the northern end of the site beneath the Made Ground, and were described as soft to firm brown plastic silty clays. Some materials encountered in other excavations, may have also been Alluvial deposits although it was unclear from the descriptions provided.

The top 0.5m to 1.0m of the bedrock was generally weathered and comprised of gravel to boulder size fragments of angular limestone. Below this level the bedrock comprises strong dark to medium grey coarse grained fresh, bedded Limestone. Total Core Recoveries (TCR) were in the range 14% to 100% with an average of 76%. Rock Quality Designation (RQD) values were also in range 14% to 100% with an average of 64%. The rockhead was often described as "stained with black tar" over a depth of upto 3m.

The bedrock surface was found to be very uneven due to previous quarrying activities and excavation for underground tanks and tank foundations. The natural slope of the bedrock is from approximately 7m OD at the southern boundary to 3m OD at the northern boundary.

Groundwater was encountered in all of the trial pits and boreholes at depths between 0.3m and 2.8m in the Made Ground. The general direction of groundwater flow was found to be north/north-west towards the River Shannon from a level of approximately 7m OD on the southern side of the site to approximately 4m OD on the northern side of the site (The River Shannon water level is typically 3m OD near the site).

2.5.3 *Details of Analysis*

Initial screening of the site investigation data has been undertaken using the UK ICRCL Threshold Trigger Values (least sensitive end use), for soils (where available), with the Dutch Intervention Values considered for soil contaminants not covered by the ICRCL list. The only exception to this is in the case of PAH where screening assessment criteria has been set at the Acton Trigger Level for the most sensitive end use.

This screening provides a basic assessment of the areas of site requiring remedial action, although it is recommended that a site specific quantitative risk assessment be carried out to establish remedial action values.

In general, the most significant soil contamination at Limerick gasworks was organic, with evidence of heavy staining by tars and tarry liquid with a phenolic odour being encountered in most of exploratory holes, particularly over the south western part of the site. Tarry staining penetrated into the bedrock joints in BH's 7, 8, 10 and 11. Elevated levels of organic contaminants were encountered in TP's1, 2, 8, 15, 19, 22, 23 and 24, mostly in the vicinity of former tanks. The contamination is most likely due to spillages and leaks from the tanks. Visual evidence of spent oxide ("blue billy") was encountered in the central area of the site (old quarry area).

Elevated sulphate levels occurred throughout the site except in the western part of the site where cleaner fill had been placed in recent years. Elevated cyanide levels occurred mostly along the central strip of the site. Elevated sulphur and sulphide levels occurred randomly but mostly around the central part of the site.

Generally there were no significantly elevated metal levels found at the site with the exception of the area around the chimney of the original gasworks (in the vicinity of T12), the elevated levels apparently being associated with ash from burning.

The groundwater encountered in the trial pits on the western side of the site were contaminated with heavy oils and oozing tarry liquid. Floating product with globules of tarry material was detected in three of sixteen trial pits, these are associated with buried structures (e.g. tar tanks). Tarry liquid was discovered to have penetrated downwards into the joints of the bedrock across the central area of the site.

Elevated levels of contaminants in groundwater occurred in generally the same areas as elevated levels of soil contamination, possibly suggesting that the groundwater is not very mobile. Generally, no significantly high metal concentrations were detected in the ground water except in trial pits in the area of the old gasworks (near T12).

The results of chemical testing on the surface samples scraped from the masonry walls around the site showed elevated levels of sulphates and various organics.

The results of leachate testing showed that the potential for leaching was low, the

measured concentrations being less than 0.1% of the original value. The exception was that 28% of the phenol in TP15 was extractable following leaching.

A second set of groundwater samples were taken about six weeks after the initial sampling. There was no significant difference in the results, one possible exception was BH8, where there was a significant increase in the concentration of phenol and a decrease in the concentration of PAH's. These results were associated with a significant decrease in temperature of the sample.

Elevated levels of methane (>1%) were recorded within borehole monitoring installations during a total of seven visits in BH's 7, 8 and 10 although the most significant levels (upto 90%) were recorded in BH12. The levels of methane recorded were generally significantly higher than the explosive limit (5 - 15%). The velocity of the gas flow was measured and found to be negligible. A tube sample of gas was taken from BH12 and analysed using GCMS. Traces of Kinsale Natural Gas were detected, suggesting that the elevated methane levels may have been due to a leak in a nearby gas main. During the recent site investigation BH33 was drilled approximately 30m from the location of BH12. A methane level of 0.3% was recorded at BH33 during the first monitoring visit.

Levels of carbon dioxide ranged between 1.7 - 3.2% in BH's 7, 8, 10 and 12. Levels of oxygen were reduced significantly in all boreholes and were accompanied by elevated levels of carbon dioxide and methane. No hydrogen sulphide was found in any of the standpipes.

Please refer to Figure 6 in the Desk Study Phase I Report (Report No. 25837/OR/01B) for previous exploratory hole locations.

2.6 Development

2.6.1 Development Options

GVA Donal O'Buachalla have indicated in correspondence that the site may be suitable for three potential uses as listed below: -

i. Commercial offices, retail, leisure, car sales etc.

ii. Residential, but excluding townhouses with gardens.

iii. Car park, either a surface or multi-storey.

It is noted that storm water flooding has occurred in the past along the Dock Road at its junctions with O'Curry Street and Alphonsus Street and consequently Limerick Corporation require a minimum floor level of 4.7m OD for any new development. The maximum recorded flood level for the City is reported as 4.25m OD (Malin Head).

It is likely that the No. 5 Stores building in the eastern corner of the site will remain as a part of any proposed development.

2.6.2 *Access*

Current site access is either via Dock Road, which forms the north-western site boundary, or from O'Curry Street forming the north-eastern boundary. The site access from O'Curry Street was not secured, at the time of the site visit and does not appear to be generally locked. The access gate off Dock Road is the main access to the site for Bord Gais personnel and is kept locked and secure when the site is not in use.

The current site access off Dock Road would be considered most suitable with respect to the proposed uses of the site although the access from O'Curry Street may be appropriate for small vehicles such as cars.

2.6.3 *Services*

All main services (gas, electricity, telecommunications, water and sewerage) are present in the Dock Road and O'Curry Street. Electricity cables are shown running into the electricity sub-station from O'Curry Street. Bord Gais pipelines are shown entering the AGI located in the western corner of the site. Low pressure 180mm PE gas pipes also exist in the site along the eastern end of the Dock Road boundary.

In view of the above and further to initial discussions with the statutory utilities, there should be no problems in providing these services at the site. However, detailed discussions will be required to determine the most appropriate connections to existing services, once the precise requirements of the development are known.

2.6.4 *Boundary Conditions*

Existing site boundaries comprise a 2m high limestone block wall (which becomes higher (3.5m) halfway along the boundary towards the south-east) along the north-eastern boundary along O'Curry Street. The south-eastern boundary comprises a 6m high limestone block wall that retains the adjacent Garda training centre at a level some 2m above the Bord Gais site level. This wall becomes a 3m high brick retaining wall (which retains limestone fill on the site side) along its south-western end, adjacent to residential properties. The south-western boundary comprises a 2.5m high brick wall, which retains fill to 2.5m on the site side. The north-western boundary along Dock Road comprises a 2.5m high limestone block wall. The boundaries are considered generally secure at present, although trespassers can gain access over a low wall along O'Curry Street or via the gates on O'Curry Street which do not appear to be generally locked.

A survey of the boundary walls has been carried out by Parkman (report No. 25837/OR/02) on the 6th and 7th March 2001. The report concludes that in places the walls are in a poor state of repair and it is recommended that they are demolished prior to remediation, especially in areas when excavation is required close to the walls.

3.0 SITE INVESTIGATION

3.1 Field and Laboratory Work

The recent site investigation was planned and supervised full-time by Parkman Environment who also scheduled the analysis of soil, water and leachate samples. The ground investigation was carried out by Geotech Specialists Limited. A total of 17 trial pits and 4 rotary boreholes were excavated between 26 February and 6 March 2001. Trial pitting was conducted using a JCB 3CX excavator. Rotary holes were drilled using a Soil Mech 215 rig. These exploratory holes were set out to identify the location of underground structures associated with building foundations, various former tanks, the depth and nature of made ground and the underlying natural strata and to allow construction of gas/water monitoring installations. The locations of the exploratory holes are shown on Drawing No. 25837/OB/01.

Samples of soil and water were selected and sent to City Analytical Services plc (CAS) in Coventry, UK for subsequent analysis. Analyses were carried out in accordance with British Gas Property "Guidance for Assessing the Potential Contamination on Gasworks Sites" Version 2.4. The results of contamination analyses are included in Appendix A; trial pit and borehole logs are presented in Appendix B, and photographs taken during the investigation are included in Appendix G. Bulk samples were taken for geotechnical analysis. The results of the geotechnical testing carried out are included in Appendix D.

Gas monitoring standpipes with taps were fitted to all four boreholes. These took the form of slotted pipes surrounded with gravel, sealed at the surface with bentonite clay and covered with vandal proof covers.

Monitoring of water levels within all installations (including boreholes from previous investigations that still remain) has been undertaken on one occasion to date, on 5 April 2001.

On-site monitoring of gas by GA-90 infrared detector from the recent installations has been undertaken on one occasion to date, on 2 April 2001.

Groundwater samples were also taken from the gas/water monitoring installations. Samples were sent to CAS plc for analysis.

Details of the water and gas monitoring are included in Appendix C.

Samples were obtained from two local quarries and sent to CAS for analysis. The samples were taken to provide information on potential sources of backfill during any future remediation works. The results of the chemical analysis are included in Appendix A.

3.2 Health and Safety Aspects

With respect to the Ground Investigation Works the site was classified as "Red" in accordance with "Guidelines for the Safe Investigation by Drilling of Landfills and Contaminated Land", published by Thomas Telford. A Health and Safety Hazard

Assessment was prepared by Parkman Environment as part of a Pre-Tender Stage Health and Safety Plan (Report No. 25837/OU/01 dated December 2000) in connection with the site investigation works. The Health and Safety Hazard Assessment is included in Appendix E.

With respect to the planned Site Remediation works, a Safety Plan should be produced including a hazard assessment of the site, a consideration of the management of safety on the site and specific measures to be observed during the works including the following:

* Site development personnel, especially those in direct contact with fills, should observe a reasonable standard of personal hygiene, washing facilities being made available.

* Boots, overalls and gloves should be worn by persons working in close proximity to fill materials (Excavation, trenches etc). In addition to these protective measures, full filter masks should be worn and monitoring of volatile organic compounds should take place wherever tar, ammoniacal liquor etc. is encountered.

* To eliminate any risk of hand to mouth transfer of potentially harmful material, smoking, eating and drinking should be prohibited for on-site personnel.

* It is important that dust should be minimised by utilising appropriate suppression measures. If dust should arise, the wearing of simple dust masks is recommended.

* As with any site containing contaminated fills, no matter how thorough the investigation, there is a finite risk of encountering previously unidentified hot spots of highly contaminated material. Site development personnel should be made aware of this, and any suspect material, tanks, etc be treated with some circumspection. If necessary, the advice of a senior environmental chemist should be sought.

A Project Supervisor (Design) must also be appointed for the Remediation Works in accordance with the Safety Health and Welfare at Work Regulations 1995. It is the responsibility of the Project Supervisor (Design) to co-ordinate Health and Safety aspects of the design and planning phase and for the early stages of both the Safety Plan and Safety and Health File.

3.3 Quality Assurance

3.3.1 General

All site work was specified and carried out in accordance with "Guidance for the Safe Investigation by Drilling on Landfills and Contaminated Land" published by Thomas Telford (Site Designation - Red).

3.3.2 *Chemical Testing*

Samples were taken during the excavation of exploratory holes for chemical analysis. Samples were given identification codes and submitted to the laboratory operated by City Analytical Services (CAS) plc, UK for chemical analysis in accordance with British Gas Property "Guidance for Assessing the Potential Contamination on Gasworks Sites" Version 2.4. CAS is a NAMAS accredited laboratory and is approved by British Gas Property. The following quality assurance procedures were implemented in the laboratory for the analysis of the samples from the Limerick Gasworks site.

i. One in every twenty samples were duplicated.
ii. A reagent blank is included in each batch of samples.
iii. Laboratory standards are run with each batch. If the lab standard fails, all samples in that batch are re-analysed.
iv. Quality control charts are maintained for all parameters.
v. External certified reference materials are analysed at regular intervals, one being from the 'Community Bureau of Reference' (BCR 144), the other from the 'Laboratory of the Government Chemist' (LGC 6138).
vi. The lab participates in the following external proficiency schemes -
    a) CONTEST-soils
    b) LEAP-waters
    c) WASP-filters

3.3.3 *Geotechnical Testing*

Samples were taken during the excavation of the exploratory holes for geotechnical analysis. All samples were taken in accordance with British Standard 5930. Samples were analysed by Geotech Specialists Limited's laboratory in Castlemartyr, Co. Cork. Geotechnical tests included Undrained Multistage 106mm Triaxials, Permeability in Triaxial Cells, Moisture Content, Atterberg Limits, and Particle Size Distribution on soil samples. Testing was conducted in accordance with British Standard 1377.

PARKMAN

4.0 REFERENCES

1. O' Connor Sutton Cronin (1995), "Summary Report on Limerick Site", ref. B87, August 1995.

2. Ove Arup &Partners (1996), "Site Investigation Report - Limerick Gasworks Site", ref. D1078/3, Volumes 1 (Report) and Volume 2 (Factual Site Investigation Data). April 1996.

3. Ove Arup & Partners (1996), "Report on Site Remediation Options", ref. D1078, April 1996.

4. Ove Arup & Partners (1996), "Report on Contamination Guidelines", ref. D1078, April 1996.

5. Charles J.O' Sullivan (1987), The Gasmakers - Historical Perspectives on the Irish Gas Industry", Irish Gas Association.

6. Groundwater Protection Maps For County Limerick (Maps 1-6)

7. Geological Survey of Ireland, Sheet 17, Limerick, 1:100,000 Scale.

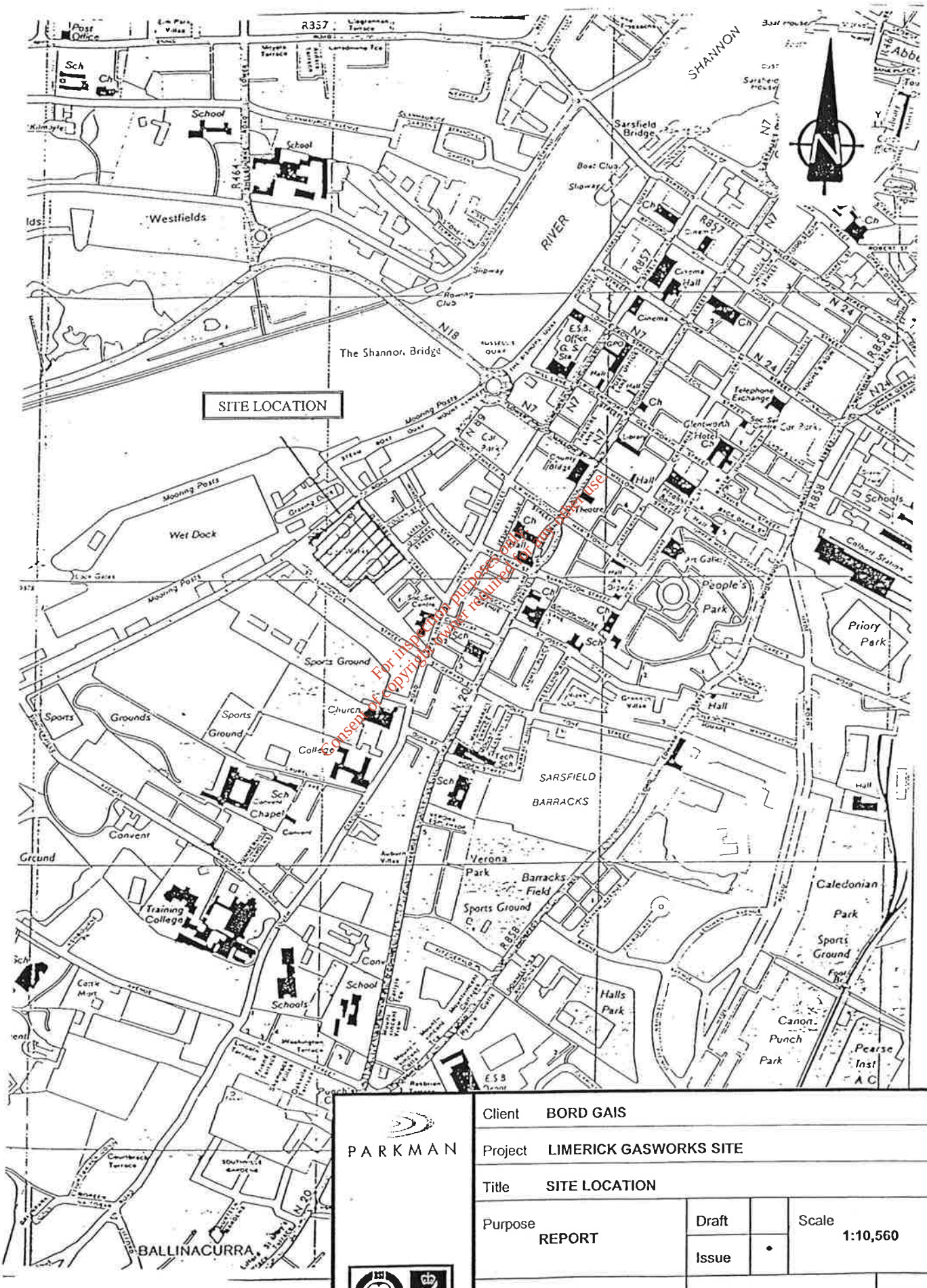
8. Geological Survey of Ireland, "Geology of the Shannon Estuary"

9. British Gas Property Holdings Ltd, "Guidance for Assessing and Managing Potential Contamination on Former Gasworks and Associated Sites (Version 2.5)" (May 2000)

10. Extract from Limerick Journal, Autumn 1987, "150 Years of Limerick Gas".

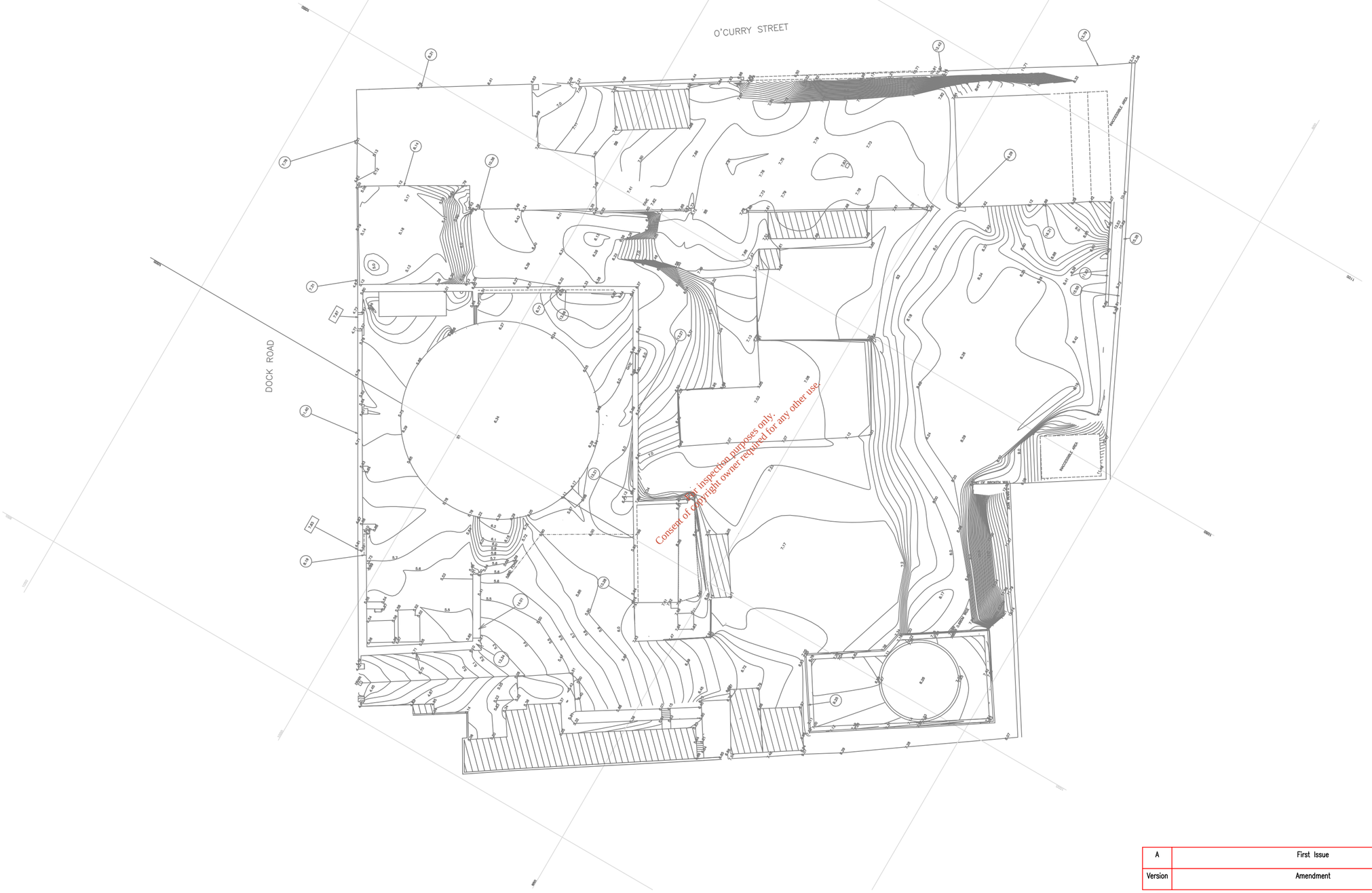
11. Parkman Environment (2000), Limerick Gasworks, Dock Road, Limerick, Preliminary Safety and Health Plan

12. Parkman Environment (2000), Limerick Gasworks, Dock Road, Limerick, Desk Study-Phase I Report



PARKMAN

Client	BORD GAIS		
Project	LIMERICK GASWORKS SITE		
Title	SITE LOCATION		
Purpose REPORT	Draft		Scale 1:10,560
	Issue	•	
Issuing Office CHESTER	Drawing number FIGURE 1		Version A
Telephone 0151 3565555			



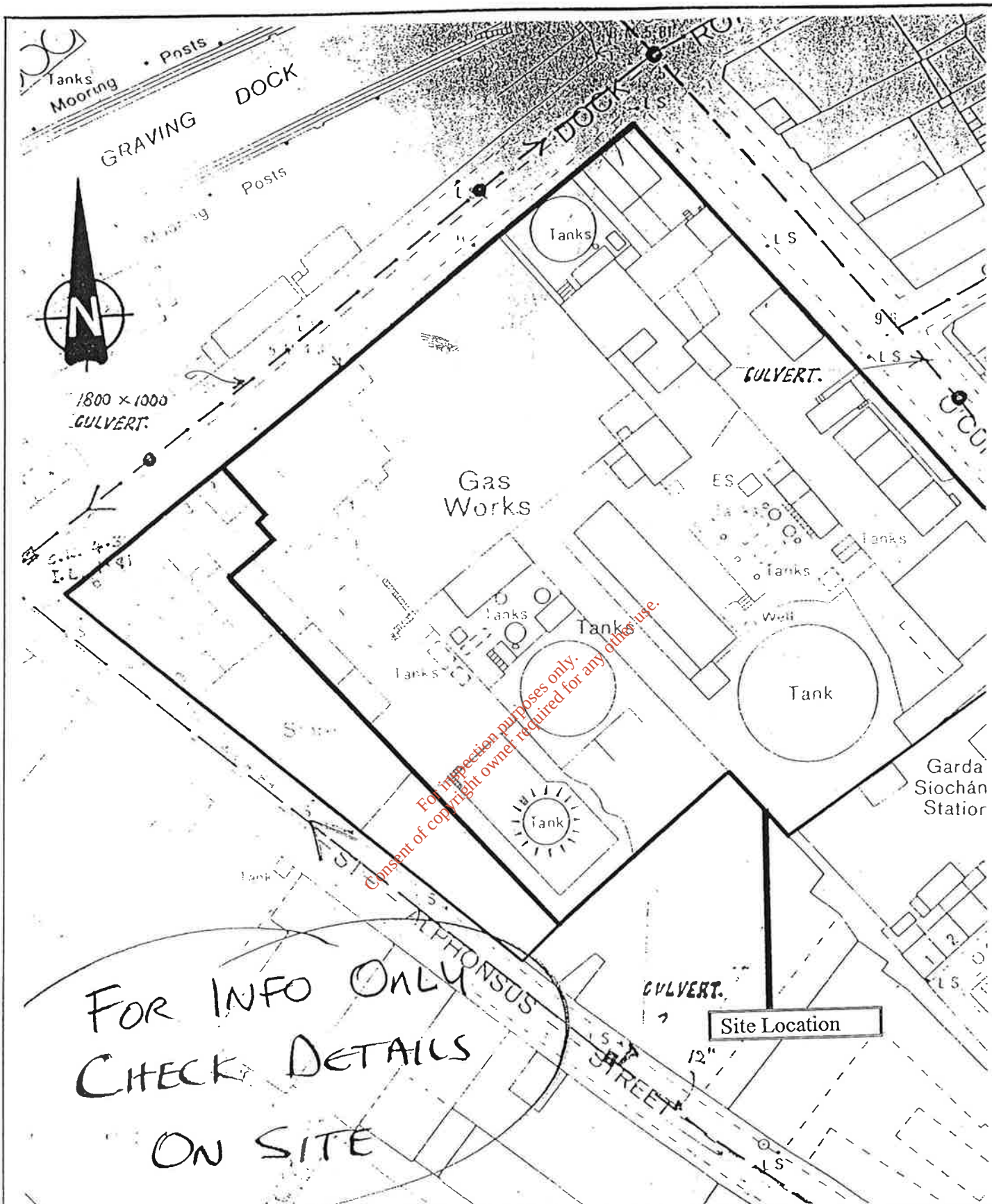
Version	Amendment	Originated by and date	Checked by and date	Approved by and date
A	First Issue	15.10.01	D.H. 15.10.01	T.B. 15.10.01

PARKMAN

BSI REGISTERED FIRM — Certificate no. FS 15024

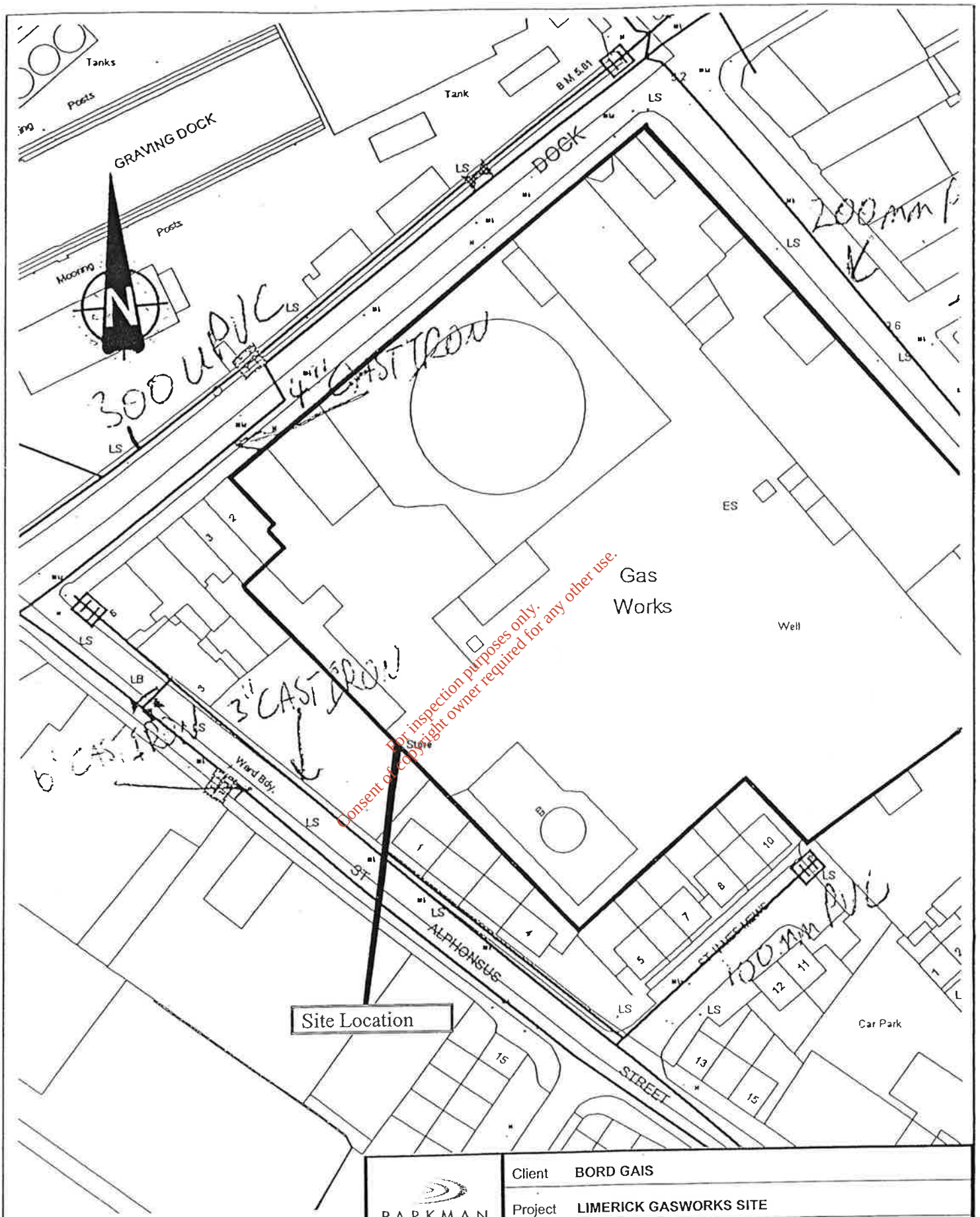
NATIONAL ACCREDITATION OF CERTIFICATION BODIES

Client	Bord Gas
Project	Limerick Gasworks
Drawing Title	Topographical Survey
Purpose	Information
Draft	
Issue	●
Scale	1:500(A2)
Issuing Office	Cheshire
Telephone	0151 356 1666
Drawing Number	Figure 2
Version	A



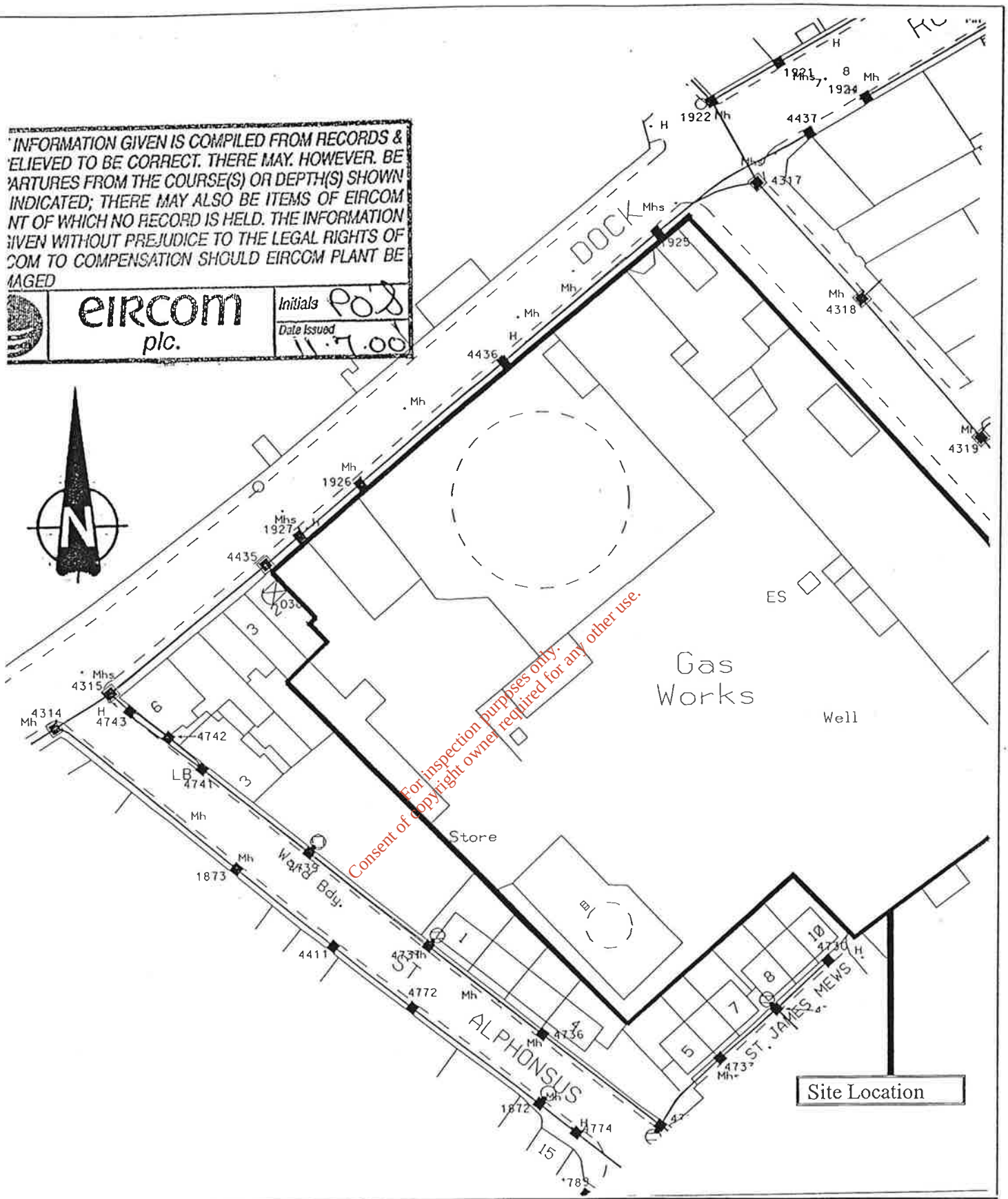
PARKMAN

Client	BORD GAIS		
Project	LIMERICK GASWORKS SITE		
Title	SERVICE LOCATION PLAN (SEWERAGE)		
Purpose: REPORT	Draft		Scale: 1:1,000
	Issue	•	
Issuing Office: CHESTER	Drawing number: FIGURE 3A		Version: A
Telephone: 0151 3565555			



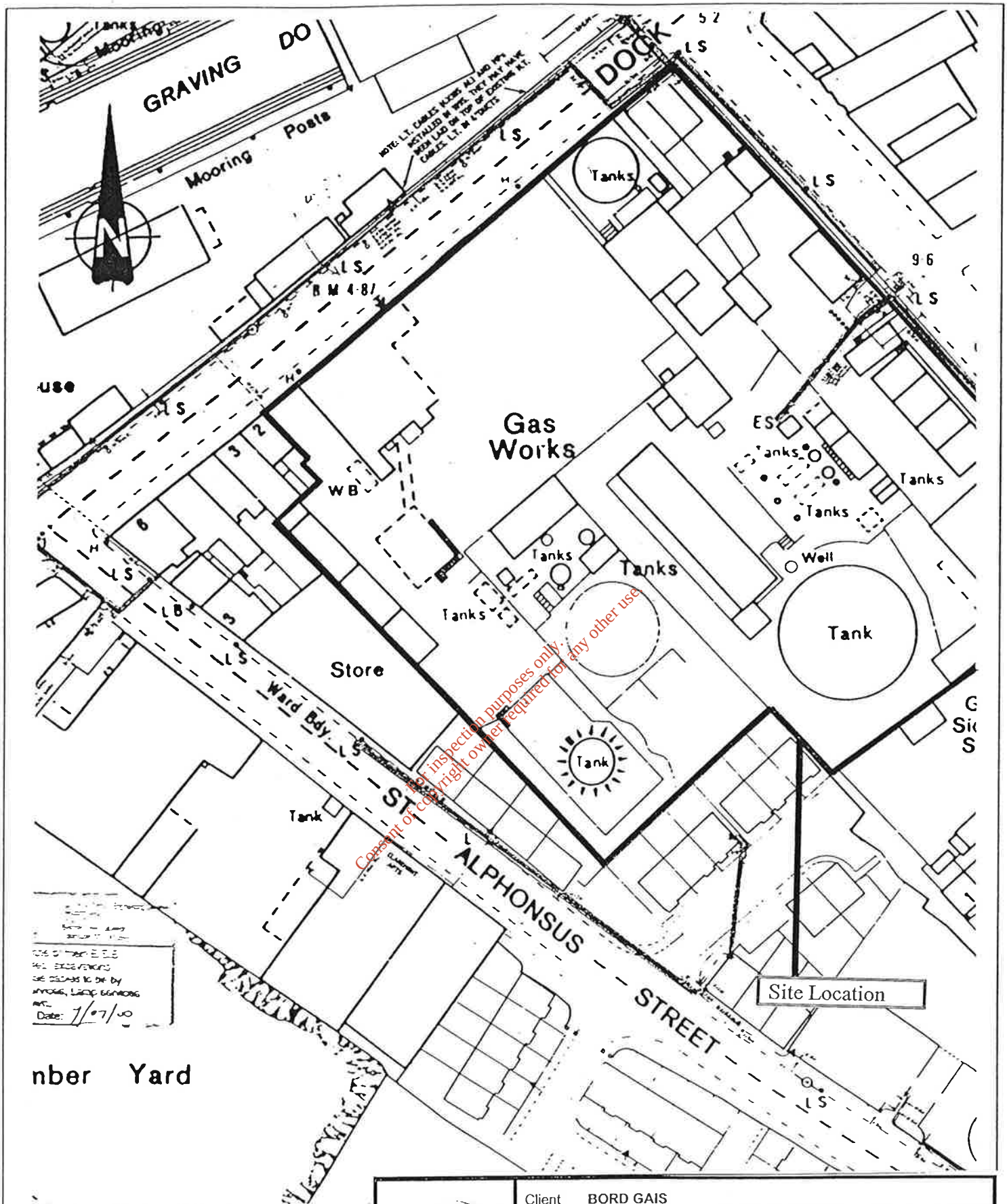
PARKMAN

Client	BORD GAIS		
Project	LIMERICK GASWORKS SITE		
Title	SERVICE LOCATION PLAN (WATER MAINS)		
Purpose REPORT	Draft		Scale 1:1,000
	Issue	•	
Issuing Office CHESTER	Drawing number FIGURE 3B		Version A
Telephone 0151 3565555			

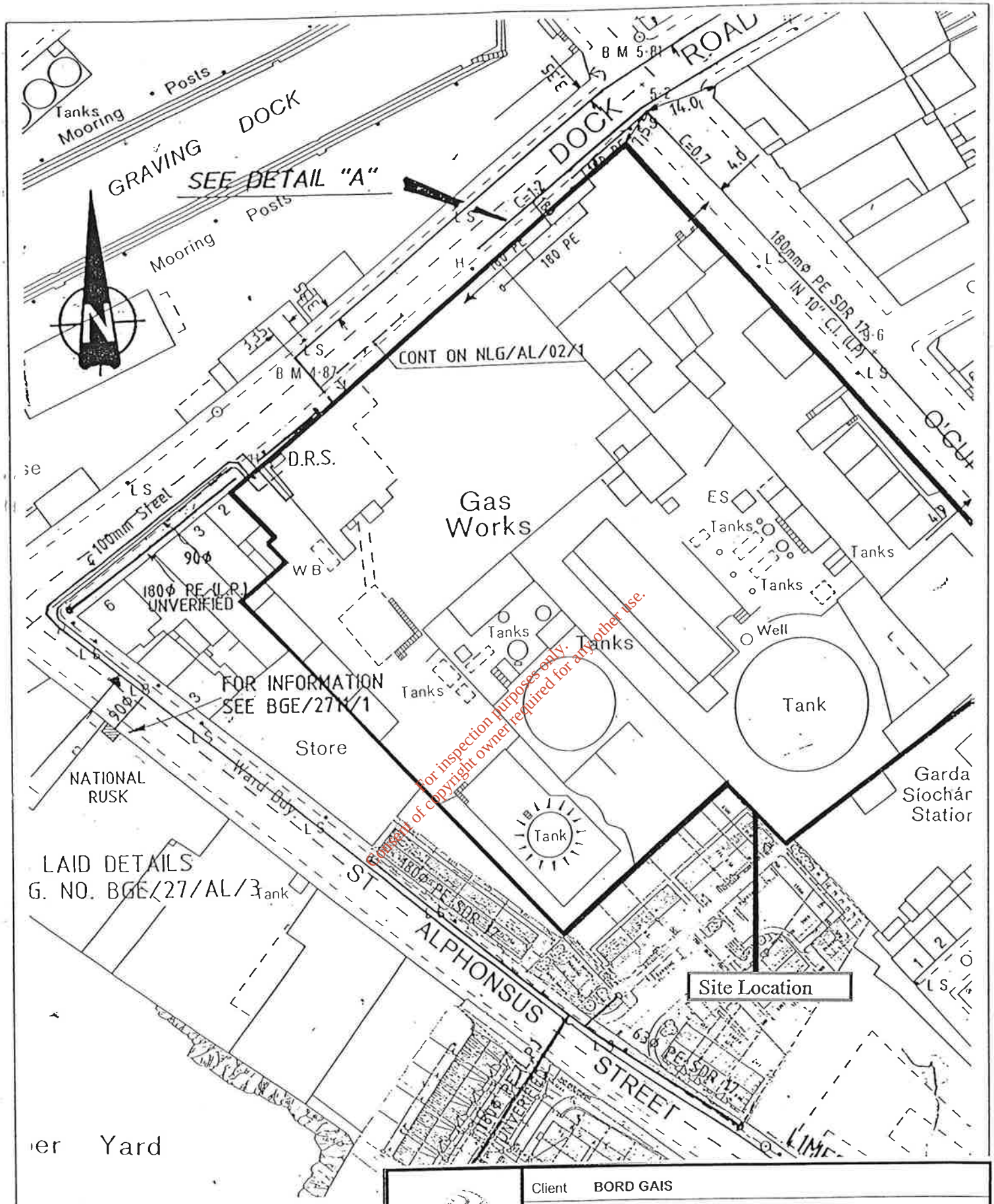


PARKMAN

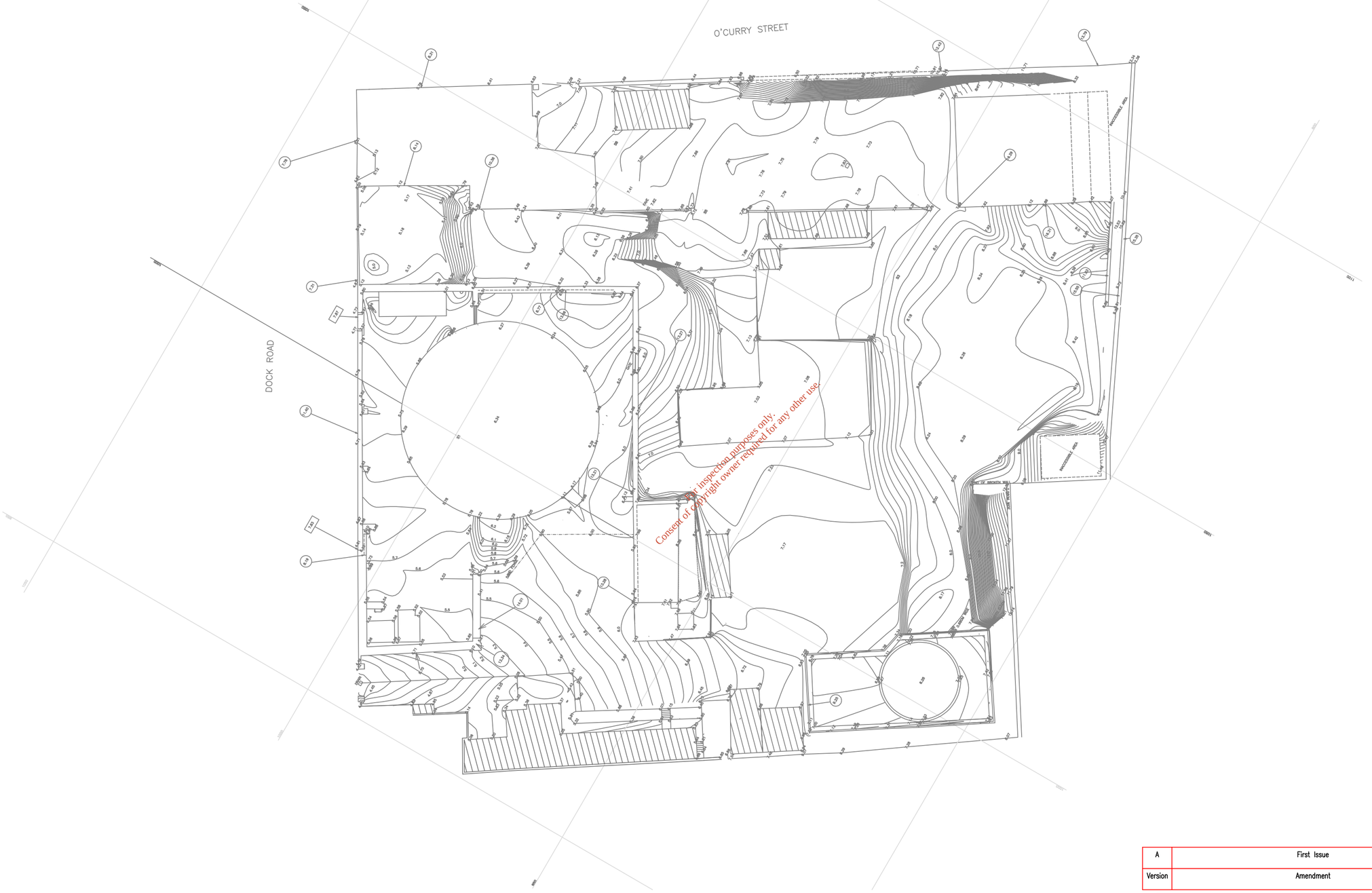
Client	BORD GAIS		
Project	LIMERICK GASWORKS SITE		
Title	SERVICE LOCATION PLAN (TELECOMMUNICATIONS)		
Purpose: REPORT	Draft / Issue •	Scale: 1:1,000	
Issuing Office: CHESTER	Drawing number: FIGURE 3C	Version: A	
Telephone: 0151 3565555			



PARKMAN	Client	BORD GAIS		
	Project	LIMERICK GASWORKS SITE		
	Title	SERVICE LOCATION PLAN (ELECTRICITY CABLES)		
	Purpose: REPORT	Draft		Scale: 1:1,000
		Issue	•	
	Issuing Office: CHESTER	Drawing number: FIGURE 3D		Version: A
	Telephone: 0151 3565555			



PARKMAN	Client BORD GAIS			
	Project LIMERICK GASWORKS SITE			
	Title SERVICE LOCATION PLAN (GAS MAINS)			
	Purpose REPORT	Draft		Scale 1:1,000
		Issue	•	
	Issuing Office CHESTER	Drawing number FIGURE 3E		Version A
	Telephone 0151 3565555			



Version	Amendment	Originated by and date	Checked by and date	Approved by and date
A	First Issue	15.10.01	D.H. 15.10.01	T.B. 15.10.01

PARKMAN

BSI REGISTERED FIRM — Certificate no. FS 15024

NATIONAL ACCREDITATION OF CERTIFICATION BODIES

Client	Bord Gas
Project	Limerick Gasworks
Drawing Title	Topographical Survey
Purpose	Information
Draft	
Issue	●
Scale	1:500(A2)
Issuing Office	Cheshire
Telephone	0151 356 1666
Drawing Number	Figure 2
Version	A

PARKMAN

Soil

SOIL RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as mg/kg ONLY

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number	BH32	BH32	TP31	TP31	TP31	TP32	TP32	TP32	TP33	TP33	TP33	TP34	TP34
Depth	0.50m	1.20m	0.60m	1.10m	2.20m	0.20m	2.40m	3.40m	0.60m	1.50m	2.40m	0.30m	1.20m
pH	7.2	7.3	7.4	7.4	7.2	6.7	7.2	7.0	7.3	7.2	7.5	6.8	7.1
% Loss on Ignition	3.5	1.7	1.5	2.4	4.2	5.7	7.1	2.1	11	4.0	3.0	9.4	12
% Moisture	9.1	12	9.9	12	11	8.4	13	20	15	13	14	25	18
% Stones	49	54	57	35	44	38	46	38	17	23	21	25	31
Cresols	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10	< 0.10	< 0.10	0.93	< 0.10	< 0.10	< 0.10	< 0.10
Xylenols & Ethylphenols	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.87	< 0.10	< 0.10	< 0.10	< 0.10
Naphthols													
Phenol	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.32	< 0.10	< 0.10	< 0.10	< 0.10
Trimethylphenol	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.35	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	2.5	< 0.50	< 0.50	< 0.50	< 0.50
Napthalene	14	1.6	4.1	2.4	18	34	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5.8	62
Acenaphthylene	5	0.86	0.55	0.61	4.6	76	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	3.4	31
Acenaphthene	4.6	0.82	0.48	0.91	13	12	< 1.0	< 1.0	< 1.0	< 1.0	0.91	1.2	11
Fluorene	1.4	0.47	0.59	0.79	8	70	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1	10
Phenanthrene	22	1.3	6.6	3.5	6.5	370	< 1.0	< 1.0	5.8	< 1.0	2.1	2.2	33
Anthracene	7.8	0.51	1.5	0.73	2.2	180	< 1.0	< 1.0	2.4	< 1.0	< 1.0	3.2	18
Fluoranthene	50	2	9.2	9.1	3.1	560	< 1.0	< 1.0	19	< 1.0	4.8	6.2	75
Pyrene	45	1.7	8.5	6.7	3.1	480	< 1.0	< 1.0	21	< 1.0	2.3	5.7	62
Benzo(a)anthracene	31	0.9	4.8	3.2	0.85	260	< 1.0	< 1.0	15	< 1.0	1.7	2.4	36
Chrysene	28	1.8	5.9	3.9	2	330	< 1.0	< 1.0	17	< 1.0	1.6	3.2	40
Benzo(b)fluoranthene	21	1.7	4.1	2.6	0.6	250	< 1.0	< 1.0	16	< 1.0	< 1.0	3.8	49
Benzo(k)fluoranthene	22	1.4	4.1	1.7	0.9	150	< 1.0	< 1.0	21	< 1.0	< 1.0	3.3	35
Benzo(a)pyrene	20	1.4	4.1	2.4	0.6	240	< 1.0	< 1.0	16	< 1.0	2.4	4.1	42
Indeno(1,2,3-cd)pyrene	13	< 1.0	3.3	< 1.0	< 1.0	280	< 1.0	< 1.0	16	< 1.0	< 1.0	6.7	31
Di-benz(a,h,)anthracene	1.3	< 1.0	0.85	< 1.0	< 1.0	47	< 1.0	< 1.0	4.6	< 1.0	< 1.0	2.5	12
Benzo(g,h,i)perylene	13	< 1.0	3.5	< 1.0	< 1.0	200	< 1.0	< 1.0	13	< 1.0	< 1.0	5.3	16
Anthanthrene	1.1	< 1.0	< 1.0	< 1.0	< 1.0	27	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Benzo(e)pyrene	15	1.4	4.1	1.3	0.7	190	< 1.0	< 1.0	14	< 1.0	< 1.0	3.9	35
Cyclopenta(cd)pyrene	18	< 1.0	0.96	1.7	< 1.0	9.3	< 1.0	< 1.0	1.4	< 1.0	< 1.0	<1.0	16
Total PAH	330	18	66	42	65	3800	< 10	< 10	180	< 10	18	65	620
Easily-liberatable Cyanide	0.56	0.53	0.48	1.5	0.63	< 1.0	1.2	<1.0	<1.0	< 1.0	< 1.0	3.0	<1.0
Complex Cyanide	1.1	3.7	1.4	3	2.5	11	1.9	14	120	410	23	10	120
Total Cyanide	1.7	4.2	1.9	4.5	3.1	11	3.1	15	120	410	23	13	120
Thiocyanate													
Elemental Sulphur	< 100	< 100	< 100	100	85	640	150	< 100	< 100	< 100	640	<100	190
Water Soluble Sulphate as SO4	< 25	38	240	27	270	760	89	69	3100	240	55	940	1600
Water Soluble Chloride	0.55	6.6	9.1	10	12	7.6	31	4.0	13	15	11	7.4	9.4
Exchangeable Ammonium	17	6.9	30	34	33	6.5	9.9	<5.0	13	16	21	< 5.0	25
Arsenic	6.9	5.1	9.5	6.7	3.8	8.7	5.2	9.5	6.5	3.2	2.5	26	24
Cadmium	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	<0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chromium	6.4	5.1	3.7	5.2	4	6.4	6.6	6.9	8.8	5.1	6.2	18	11
Lead	55	8.8	41	91	47	93	8.5	21	34	61	46	180	1100
Mercury	0.55	0.21	0.1	0.21	0.1	0.25	< 0.10	< 0.10	< 0.10	0.42	0.99	0.57	0.39
Selenium	0.26	0.086	< 0.10	0.073	0.085	0.23	<0.10	<0.10	< 0.10	0.20	< 0.10	0.61	0.81
Copper	16	11	13	59	55	19	4.7	13	27	8.1	9.1	94	81
Nickel	13	9	6.3	7.3	6.5	23	7.5	15	11	4.6	6.2	30	17
Zinc	34	22	21	60	41	40	19	27	18	19	17	38	160
Boron	0.13	0.1	< 0.10	< 0.10	0.085	0.44	0.47	0.24	0.47	0.48	0.50	< 0.10	0.26
Analytes below to be determined if their presence on site is suspected.													
Cobalt													
Vanadium													
Molybdenum													
Germanium													
Hex Cr													
Silver													
Antimony													
Beryllium													
Benzene	< 0.10			< 0.10	< 0.10	< 0.10		< 0.10			< 0.10		
Toluene	< 0.10			< 0.10	< 0.10	< 0.10		< 0.10			< 0.10		
Ethylbenzene	< 0.10			< 0.10	< 0.10	< 0.10		< 0.10			< 0.10		
Xylene's	< 0.10			< 0.10	< 0.10	< 0.10		< 0.10			< 0.10		
Mineral Oil													
Asbestos				ND								ND	
ADDITIONAL ANALYTES													
Coal Tar													
Sulphide													
Toluene Extractable Matter													
TPH by GC (C_{10} to C_{20})	< 50			97	300	220		< 50			< 50		
TPH by GC (C_{20} to C_{39})	38			34	50	440		< 50			< 50		
TPH by GC (C_{10} to C_{39})	38			130	350	640		< 50			< 50		
Organic Matter													
Total Sulphate as SO4													

SOIL RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as mg/kg ONLY

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number	TP34	TP34	TP35	TP35	TP35	TP36	TP36	TP37	TP37	TP38	TP38	TP39	TP39
Depth	2.00m	3.00m	1.00m	2.00m	3.00m	0.50m	2.30m	0.20m	1.10m	0.50m	1.50m	0.50m	1.50m
pH	7.4	7.7	8.2	7.3	7.7	8.1	7.8	7.9	7.8	7.2	7.6	6.3	12.0
% Loss on Ignition	3.8	1.6	8.5	6.6	4.9	0.14	0.050	1.0	0.081	9.0	3.1	28	3.8
% Moisture	23	15	12	19	15	3.6	3.5	5.0	2.9	11	11	17	23
% Stones	34	36	41	27	22	82	87	66	87	27	43	32	22
Cresols	0.11	< 0.10	210	< 0.10	0.16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	12	< 0.10
Xylenols & Ethylphenols	0.20	0.50	250	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	46	< 0.10
Naphthols													
Phenol	< 0.10	< 0.10	60	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	2.8	< 0.10
Trimethylphenol	0.20	0.23	110	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	24	< 0.10
Total Phenols	0.56	0.76	620	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	90	< 0.50
Napthalene	15	<1.0	1400	5.5	8.8	< 1.0	< 1.0	< 1.0	< 1.0	12	4.9	370	3.9
Acenaphthylene	5.6	< 1.0	490	6.1	2.4	< 1.0	< 1.0	< 1.0	< 1.0	23	3.2	140	2.0
Acenaphthene	5.1	< 1.0	130	1.8	1.3	< 1.0	< 1.0	< 1.0	< 1.0	6.0	< 1.0	48	< 1.0
Fluorene	8.5	< 1.0	430	2.9	1.9	< 1.0	< 1.0	< 1.0	< 1.0	11	1.1	100	< 1.0
Phenanthrene	9.6	< 1.0	960	9.3	7.4	< 1.0	< 1.0	< 1.0	< 1.0	40	7.3	620	3.6
Anthracene	5.6	< 1.0	370	4.1	1.9	< 1.0	< 1.0	< 1.0	< 1.0	14	2.4	150	1.1
Fluoranthene	16	< 1.0	690	28	5.2	0.22	0.11	< 1.0	< 1.0	61	15	510	5.7
Pyrene	13	< 1.0	530	24	5.2	< 1.0	< 1.0	< 1.0	< 1.0	50	13	360	4.9
Benzo(a)anthracene	6.2	< 1.0	300	15	2.9	< 1.0	< 1.0	< 1.0	< 1.0	27	7.8	150	2.6
Chrysene	6.8	< 1.0	290	19	4.7	< 1.0	< 1.0	< 1.0	< 1.0	36	9.3	200	4.1
Benzo(b)fluoranthene	5.4	< 1.0	150	17	1.8	< 1.0	< 1.0	< 1.0	< 1.0	41	7.3	92	5.6
Benzo(k)fluoranthene	5.6	< 1.0	140	16	2.0	< 1.0	< 1.0	< 1.0	< 1.0	30	7.8	100	4.4
Benzo(a)pyrene	6.8	< 1.0	180	13	2.7	< 1.0	< 1.0	< 1.0	< 1.0	29	6.7	74	5.7
Indeno(1,2,3-cd)pyrene	9.6	< 1.0	210	11	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	35	4.1	49	6.4
Di-benz(a,h,)anthracene	2.0	< 1.0	35	2.4	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	4.8	1.3	13	1.6
Benzo(g,h,i)perylene	6.8	< 1.0	170	10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	25	3.4	36	7.0
Anthanthrene	< 1.0	< 1.0	19	1.5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.5	< 1.0	< 1.0	< 1.0
Benzo(e)pyrene	6.2	< 1.0	130	12	2.7	< 1.0	< 1.0	< 1.0	< 1.0	32	5.2	62	6.0
Cyclopenta(cd)pyrene	1.0	< 1.0	15	<1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	12	< 1.0	6.0	1.9
Total PAH	140	< 10	6900	200	52	< 10	< 10	< 10	< 10	500	99	3100	68
Easily-liberatable Cyanide	<1.0	<1.0	1.3	7.3	1.8	0.19	0.14	< 1.0	0.14	0.82	0.64	470	2.0
Complex Cyanide	6.9	1.5	45	170	3.7	0.56	0.42	2.5	0.14	51	45	15000	200
Total Cyanide	7.7	2.3	46	180	5.5	0.74	0.56	2.5	0.27	52	45	15000	200
Thiocyanate													
Elemental Sulphur	1500	120	1300	540	640	< 100	< 100	< 100	< 100	690	160	2200	79
Water Soluble Sulphate as SO4	150	25	2000	4100	170	< 25	6.3	< 25	5.5	1700	830	31	1200
Water Soluble Chloride	4.3	5.2	13	9.3	27	2.5	5.9	3.6	4.1	9.0	6.2	28	26
Exchangeable Ammonium	24	67	25	33	43	2.2	3.8	3.3	3.8	5.2	7.7	140	41
Arsenic	8.5	3.6	8.0	13	2.8	0.9	0.55	2.7	0.32	11	5.1	21	12
Cadmium	<0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.16	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chromium	7.9	20	8.0	11	<5.0	< 5.0	< 5.0	3.6	< 5.0	25	36	5.1	7.2
Lead	96	81	130	160	38	3.4	0.84	26	1	110	38	260	34
Mercury	0.12	0.46	0.64	0.50	0.18	< 0.10	< 0.10	0.054	< 0.10	0.39	0.078	1.0	< 0.10
Selenium	0.35	< 0.10	0.20	0.49	0.11	< 0.10	< 0.10	< 0.10	< 0.10	0.39	< 0.10	0.61	0.27
Copper	15	16	18	18	5.5	0.86	0.44	5.7	0.34	41	27	1.2	21
Nickel	11	23	12	6.4	5.6	1.8	1	7.8	0.73	29	25	< 1.0	13
Zinc	23	33	49	64	23	7.8	2.4	30	1.6	76	47	74	47
Boron	0.14	0.26	0.16	<0.10	0.16	< 0.10	< 0.10	< 0.10	< 0.10	0.32	0.16	< 0.10	< 0.10
Analytes below to be determined if their presence on site is suspected.													
Cobalt													
Vanadium													
Molybdenum													
Germanium													
Hex Cr													
Silver													
Antimony													
Beryllium													
Benzene	0.46	"	62	"	0.24	"	< 0.10	"	< 0.10			"	"
Toluene	0.25	"	110	"	< 0.10	"	< 0.10	"	< 0.10			"	"
Ethylbenzene	0.65	"	23	"	< 0.10	"	< 0.10	"	< 0.10			"	"
Xylene's	0.95	"	260	"	0.26	"	< 0.10	"	< 0.10			"	"
Mineral Oil	"	"	"	"	"	ND	"	"	"			ND	"
Asbestos													
ADDITIONAL ANALYTES													
Coal Tar													
Sulphide													
Toluene Extractable Matter													
TPH by GC (C_{10} to C_{20})	960	"	12000	"	49	"	38	"	< 50			"	"
TPH by GC (C_{20} to C_{39})	230	"	4000	"	< 50	"	15	"	< 50			"	"
TPH by GC (C_{10} to C_{39})	1200	"	16000	"	49	"	54	"	< 50			"	"
Organic Matter													
Total Sulphate as SO4													

SOIL RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as mg/kg ONLY

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number	TP39	TP40	TP40	TP41	TP41	TP42	TP43	TP47	TP47	TP48	TP48	TP49	TP49
Depth	2.80m	0.70m	2.20m	0.50m	0.80m	0.30m	0.40m	1.00m	2.00m	1.50m	2.50m	0.30m	1.50m
pH	8.9	7.0	6.9	8.6	7.0	7.5	7.5	7.6	6.8	7.2	8.3	6.9	7.5
% Loss on Ignition	8.0	1.6	1.2	4.5	2.9	0.63	1.0	4.3	1.7	3.4	37	3.3	3.6
% Moisture	31	9.0	8.8	17	22	6.3	11	8.6	11	14	13	20	19
% Stones	32	44	52	38	49	76	36	45	43	42	0	34	43
Cresols	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	140	< 0.10	67	590	< 0.10	< 0.10
Xylenols & Ethylphenols	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.22	170	< 0.10	170	790	< 0.10	< 0.10
Naphthols													
Phenol	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	41	< 0.10	12	230	< 0.10	< 0.10
Trimethylphenol	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	52	< 0.10	120	290	< 0.10	< 0.10
Total Phenols	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	400	< 0.50	370	1800	< 0.50	< 0.50
Napthalene	37	0.78	2.2	< 1.0	1.4	0.8	1.7	660	17	280	7600	5.0	6.6
Acenaphthylene	53	< 1.0	1.8	< 1.0	1.5	1.4	1.4	240	8.8	110	1900	2.8	6.1
Acenaphthene	45	< 1.0	0.69	1.6	1.3	0.19	< 1.0	43	4.1	21	280	0.92	1.1
Fluorene	86	< 1.0	0.78	1.5	2.2	0.53	2.4	170	7.2	81	1400	0.69	0.85
Phenanthrene	170	< 1.0	1.7	6	4.7	1.7	7.7	380	18	190	3300	2.5	2.7
Anthracene	59	< 1.0	1.3	1.9	1.2	0.78	1.6	150	5.7	76	1200	1.1	1.9
Fluoranthene	130	0.57	9.9	4.6	6.6	4.2	5.2	280	16	140	2500	6.9	14
Pyrene	97	< 1.0	9.0	4.3	6.9	3.8	4.3	210	14	120	1800	7.4	14
Benzo(a)anthracene	50	< 1.0	3.7	2.4	3.3	2.3	1.6	120	6.2	27	1000	5.1	12
Chrysene	43	< 1.0	4.7	2.1	3.5	2.1	3.6	130	7.8	41	940	6.3	14
Benzo(b)fluoranthene	31	< 1.0	3.7	1.5	2.5	2.7	1.1	61	4.7	14	610	9.2	19
Benzo(k)fluoranthene	24	< 1.0	3.3	0.92	1.9	1.9	1	56	4.6	16	630	8.0	17
Benzo(a)pyrene	30	< 1.0	3.8	1.2	3.5	2.7	0.77	71	4.6	15	770	11	21
Indeno(1,2,3-cd)pyrene	11	< 1.0	2.6	< 1.0	2.3	1.3	< 1.0	61	2.3	9.1	800	4.6	14
Dl-benz(a,h,)anthracene	3.8	< 1.0	0.60	< 1.0	< 1.0	0.32	< 1.0	20	< 1.0	1.9	270	1.0	5.7
Benzo(g,h,l)perylene	11	< 1.0	2.8	< 1.0	2.5	1.4	< 1.0	49	1.8	9.7	700	4.2	18
Anthanthrene	2.3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	7.1	< 1.0	1.8	130	0.63	3.3
Benzo(e)pyrene	19	< 1.0	3.0	0.76	2.1	1.7	1	56	3.5	11	570	9.7	17
Cyclopenta(cd)pyrene	8.6	< 1.0	< 1.0	< 1.0	1.2	0.84	< 1.0	9.6	0.67	0.56	210	2.6	5.7
Total PAH	910	< 10	56	30	51	31	34	2700	130	1200	27000	92	190
Easily-liberatable Cyanide	0.98	< 1.0	0.53	< 1.0	0.65	< 1.0	0.72	0.60	< 1.0	< 1.0	1.2	1.6	5.6
Complex Cyanide	120	4.9	2.6	1.5	3.9	0.77	2.2	4.8	5.1	1.3	38	150	390
Total Cyanide	120	4.9	3.2	1.5	4.6	0.77	2.9	5.4	5.1	1.3	39	150	400
Thiocyanate													
Elemental Sulphur	340	< 100	< 100	54	290	< 100	< 100	< 100	< 100	< 100	340	< 100	130
Water Soluble Sulphate as SO4	250	88	210	87	51	6.3	65	61	47	86	110	740	300
Water Soluble Chloride	5.9	8.3	17	8.7	4.4	2.9	14	15	14	42	110	6.9	5.7
Exchangeable Ammonium	38	21	70	11	14	4.9	72	19	7.7	15	210	4.8	18
Arsenic	5.9	4.8	9.2	3.9	2.7	1.8	6.5	4.8	4.8	6.6	25	7.4	10
Cadmium	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.32	< 0.50	< 0.50	0.35	< 0.50	< 0.50	0.27
Chromium	4.8	5.2	4.7	7.6	2.9	1.1	5.8	6.6	6.2	7.1	8.4	9.2	14
Lead	48	12	26	41	40	9.9	11	30	26	37	1100	92	280
Mercury	0.19	< 0.10	0.056	< 0.10	0.04	0.025	< 0.10	0.14	0.072	0.24	1.3	0.18	0.46
Selenium	0.54	< 0.10	0.047	< 0.10	0.051	< 0.10	< 0.10	0.056	0.19	0.15	0.73	0.20	0.31
Copper	11	5.7	5.6	12	6.2	2.5	8.3	8.6	10	18	49	17	29
Nickel	9.1	9.3	7.8	15	5.1	1.9	13	10	10	13	19	13	26
Zinc	14	22	29	26	12	5	19	22	33	29	160	32	71
Boron	< 0.10	< 0.10	0.22	0.12	0.047	< 0.10	< 0.10	0.24	0.19	0.18	0.22	0.19	0.25
Analytes below to be determined if their presence on site is suspected.													
Cobalt													
Vanadium													
Molybdenum													
Germanium													
Hex Cr													
Silver													
Antimony													
Beryllium													
Benzene	0.25		< 0.10		< 0.10			23		11	200		
Toluene	0.33		< 0.10		< 0.10			50		23	240		
Ethylbenzene	0.37		< 0.10		< 0.10			11		4.4	37		
Xylene's	3.5		< 0.10		< 0.10			130		50	450		
Mineral Oil													
Asbestos		ND		ND		ND				ND		ND	
ADDITIONAL ANALYTES													
Coal Tar													
Sulphide													
Toluene Extractable Matter													
TPH by GC (C_{10} to C_{20})	1400		130		110			11000		110	80000	97	
TPH by GC (C_{20} to C_{39})	350		170		340			4500		130	38000	300	
TPH by GC (C_{10} to C_{39})	1700		300		440			16000		240	120000	390	
Organic Matter													
Total Sulphate as SO4													

SOIL RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as mg/kg ONLY

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number	TP49	TP49WELL	TP51	TP51	Barrigone	Ballyneety
Depth	2.60m	0.50m	0.30m	1.00m	Quarry	Quarry
pH	7.3	8.3	8.2	9.3	7.1	7.2
% Loss on Ignition	14	10	45	4.7	0.17	0.25
% Moisture	36	19	8.2	16	2.9	1.9
% Stones	21	54	0	51	69	59
Cresols	0.17	68	900	4.6	< 0.10	< 0.10
Xylenols & Ethylphenols	< 0.10	57	1500	9.8	< 0.10	< 0.10
Naphthols						
Phenol	0.21	25	160	1.2	< 0.10	< 0.10
Trimethylphenol	< 0.10	27	1000	7.5	< 0.10	< 0.10
Total Phenols	< 0.50	180	3700	23	< 0.50	< 0.50
Napthalene	1.9	310	380	90	< 1.0	< 1.0
Acenaphthylene	2.7	68	140	31	< 1.0	< 1.0
Acenaphthene	2.5	51	32	12	< 1.0	< 1.0
Fluorene	4.1	68	110	29	< 1.0	< 1.0
Phenanthrene	3.4	140	210	58	< 1.0	0.64
Anthracene	1.1	47	86	23	< 1.0	< 1.0
Fluoranthene	22	98	150	43	< 1.0	0.89
Pyrene	22	81	120	33	< 1.0	0.52
Benzo(a)anthracene	20	37	66	18	< 1.0	0.44
Chrysene	26	34	74	19	< 1.0	0.48
Benzo(b)fluoranthene	19	20	31	12	< 1.0	< 1.0
Benzo(k)fluoranthene	17	16	30	11	< 1.0	< 1.0
Benzo(a)pyrene	20	20	29	14	< 1.0	< 1.0
Indeno(1,2,3-cd)pyrene	< 1.0	10	18	15	< 1.0	< 1.0
Di-benz(a,h,)anthracene	< 1.0	1.7	4.4	1.9	< 1.0	< 1.0
Benzo(g,h,i)perylene	< 1.0	11	17	13	< 1.0	< 1.0
Anthanthrene	< 1.0	0.78	4.7	1.3	< 1.0	< 1.0
Benzo(e)pyrene	11	11	19	10	< 1.0	< 1.0
Cyclopenta(cd)pyrene	8.8	16	4.9	3.3	< 1.0	< 1.0
Total PAH	180	1000	1500	430	< 10	< 10
Easily-liberatable Cyanide	3.7	5.7	1.1	0.58	0.64	0.84
Complex Cyanide	640	25	11	9.3	0.64	0.84
Total Cyanide	640	31	12	9.8	1.3	1.7
Thiocyanate						
Elemental Sulphur	140	20000	< 100	430	< 100	< 100
Water Soluble Sulphate as SO4	430	1300	31	46	87	< 25
Water Soluble Chloride	6.6	16	66	23	4.4	6.0
Exchangeable Ammonium	26	19	23	13	10	5.5
Arsenic	16	4.4	16	4.3	0.82	1.7
Cadmium	< 0.50	0.25	< 0.50	< 0.50	< 0.50	< 0.50
Chromium	20	5.7	8.9	5.1	< 5.0	< 5.0
Lead	390	21	48	30	< 5.0	13
Mercury	0.52	1.4	0.86	0.082	< 0.10	< 0.10
Selenium	0.32	0.57	0.46	0.078	< 0.10	< 0.10
Copper	41	9.8	60	9.7	0.35	2.1
Nickel	32	6.1	27	7.4	0.96	3.5
Zinc	110	27	59	21	1.2	6.8
Boron	0.35	0.041	0.64	0.16	< 0.10	< 0.10
Analytes below to be determined if their presence on site is suspected.						
Cobalt						
Vanadium						
Molybdenum						
Germanium						
Hex Cr						
Silver						
Antimony						
Beryllium						
Benzene	.	15	150	1.9	< 0.10	< 0.10
Toluene	.	19	200	4.6	< 0.10	< 0.10
Ethylbenzene	.	3.5	38	1.7	< 0.10	< 0.10
Xylene's	.	37	410	16	< 0.10	< 0.10
Mineral Oil						
Asbestos	.	.	.	ND	.	.
ADDITIONAL ANALYTES						
Coal Tar						
Sulphide						
Toluene Extractable Matter						
TPH by GC (C_{10} to C_{20})	.	20000	87000	1200	< 50	< 50
TPH by GC (C_{20} to C_{39})	.	6400	48000	350	< 50	< 50
TPH by GC (C_{10} to C_{39})	.	26000	140000	1500	< 50	< 50
Organic Matter						
Total Sulphate as SO4						

PARKMAN

Water

WATER RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as stated units.

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number		**BH 7**	**BH10**	**TP33**	**TP34**	**TP35**	**TP35**	**TP36**	**TP37**	**TP38**	**TP39**	**TP42**	**TP47**
Depth		**1.00m**	**2.00m**	**2.50m**	**2.05m**	**1.50m**	**3.00m**	**2.20m**	**1.00m**	**1.55m**	**2.60m**	**0.40m**	**2.75m**
Hardstanding at surface (Y/N)													
	Units												
pH	pH Units	11	9.5	7.8	7.2	9.9	6.7	7.6	7.9	7.5	8	7.7	8.9
Suspended Solids	mg/l	240	6900	20000	620	530	280	20000	2600	3900	790	160000	14000
Conductivity (µs/cm)	µs/cm	530	2300	1300	1700	1100	2400	1200	680	1500	1600	380	5100
Cresols	µg/l	11000	130000	63	24	380000	11	15000	35	< 0.50	3600	3.1	550000
Xylenols & Ethylphenols	µg/l	8200	66000	31	520	200000	89	520	370	< 0.50	13000	580	270000
Catechol	µg/l	620	7900	< 0.50	< 0.50	13000	< 0.50	270	< 0.50	< 0.50	110	5.4	27000
Phenol	µg/l	3300	110000	31	23	190000	12	1500	4.1	< 0.50	950	4.1	360000
Trimethylphenol	µg/l	7600	38000	< 0.50	730	71000	77	1800	220	< 0.50	5100	540	67000
Total Phenols	µg/l	31000	350000	120	1300	850000	190	19000	620	< 2.5	22000	1100	130000
Napthalene	ng/l	330000	360000	190	40000	360000	3400	140000	99000	2000	470000	89000	340000
Acenaphthylene	ng/l												
Acenaphthene	ng/l	22000	< 20	160	12000	2900	460	1900	5200	470	16000	12000	7400
Fluorene	ng/l	6900	3400	59	5100	4300	230	18000	3800	2200	43000	3800	3700
Phenanthrene	ng/l	6600	7300	62	6300	8400	730	59000	4100	6500	140000	4600	6000
Anthracene	ng/l	1300	25	23	2000	73	300	1400	1200	510	860	1200	260
Fluoranthene	ng/l	1200	570	67	6500	500	340	11000	1300	5200	22000	1300	230
Pyrene	ng/l	1100	2000	71	5400	1300	350	36000	1300	17000	54000	1100	670
Benzo(a)anthracene	ng/l	210	450	30	1600	250	110	8700	340	27000	1700	180	80
Chrysene	ng/l	230	470	31	1900	290	130	9500	390	27000	16000	240	71
Benzo(b)fluoranthene	ng/l	150	370	40	1500	140	140	10000	280	30000	11000	220	66
Benzo(k)fluoranthene	ng/l	91	270	23	780	130	77	7200	160	19000	10000	100	51
Benzo(a)pyrene	ng/l	< 20	630	26	1500	330	110	13000	620	32000	23000	390	69
Indeno(1,2,3-cd)pyrene	ng/l	200	280	76	2200	340	250	6400	< 20	23000	11000	330	< 20
DI-benz(a,h,)anthracene	ng/l	43	47	< 20	550	26	45	< 20	130	< 20	1900	65	< 20
Benzo(g,h,i)perylene	ng/l	94	340	24	880	240	74	5600	240	21000	11000	130	< 20
Anthanthrene	ng/l	62	< 20	< 20	250	< 20	< 20	5100	< 20	13000	13000	57	< 20
Benzo(e)pyrene	ng/l	410	340	52	2000	< 20	250	5400	480	22000	15000	440	< 20
Cyclopenta(cd)pyrene	ng/l												
Total PAH	ng/l	370000	370000	950	90000	380000	7000	330000	120000	250000	870000	120000	350000
Easily-liberatable Cyanide	mg/l	0.4	0.2	< 0.10	0.20	0.80	0.10	0.1	< 0.10	0.20	< 0.10	0.1	0.10
Complex Cyanide	mg/l	0.9	1	0.70	0.60	270	1.8	0.2	0.2	5.3	4.7	0.5	2.9
Total Cyanide	mg/l	1.3	1.2	0.70	0.80	270	1.9	0.3	0.2	5.5	4.7	0.6	3.0
Thiocyanate	mg/l												
Sulphate	mg/l	1000	280	480	400	1100	1000	110	61	840	390	8.2	1300
Sulphide	µg/l			< 50	< 50		< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chloride	mg/l												
Total Ammonium	mg/l	32	150	9.6	23	13	9.6	7.5	2.1	< 0.64	3.9	2.6	490
Arsenic	mg/l	< 0.01	0.02	0.020	0.020	0.050	0.020	< 0.01	< 0.01	0.020	< 0.01	< 0.01	0.090
Cadmium	mg/l	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Chromium	mg/l	< 0.01	0.08	0.030	0.010	0.060	0.010	< 0.01	< 0.01	< 0.01	0.020	< 0.01	0.050
Lead	mg/l	< 0.01	0.03	< 0.01	0.19	0.90	0.12	< 0.01	< 0.01	< 0.01	0.020	< 0.01	0.020
Mercury	mg/l	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Selenium	mg/l	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	0.027
Copper	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	mg/l	< 0.01	0.06	0.020	0.030	0.13	0.040	0.28	0.07	0.030	0.030	0.04	0.10
Zinc	mg/l	< 0.01	0.78	0.060	0.070	0.30	0.21	< 0.01	< 0.01	0.19	0.030	< 0.01	0.15
Iron	mg/l	5.7	40	21	16	70	64	0.29	0.07	2.0	21	0.09	68
Analytes below to be determined if their presence on site is suspected.													
Cobalt	mg/l												
Vanadium	mg/l												
Molybdenum	mg/l												
Germanium	mg/l												
Hex Cr	mg/l												
Benzene	µg/l	1600	17000	< 10	1600	13000	13	490	310	< 10	1100	330	18000
Toluene	µg/l	360	7500	< 10	81	4400	< 10	120	150	< 10	250	320	5200
Ethylbenzene	µg/l	24	320	< 10	93	210	< 10	15	18	< 10	54	36	210
Xylene's	µg/l	300	3800	< 10	230	2100	< 10	140	220	< 10	420	410	2500
TPH by GC (C_{10} to C_{28})	µg/l	7000	13000	< 100	4500	22000	250	63000	1800	< 100	6300	4000	27000
TPH by GC (C_{28} to C_{39})	µg/l	250	730	< 100	530	240	< 100	14000	< 100	< 100	890	670	260
TPH by GC (C_{10} to C_{39})	µg/l	7200	14000	< 100	5100	22000	250	77000	1800	< 100	7200	4700	27000
ADDITIONAL ANALYTES													
BOD	mg/l												
COD (filtered	mg/l												
Boron (B)	mg/l												
Total Organic Carbon	mg/l	74	570	25	100	2600	100	87	53	110	61	75	2000
Toluene Extractable Matter	mg/l												

WATER RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as stated units.

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number		TP48	TP49	TP49	TP51
Depth		3.50m	2.40m	WELLW	1.25m
Hardstanding at surface (Y/N)					
	Units				
pH	pH Units	9.8	7.5	11	> 12.0
Suspended Solids	mg/l	1800	140000	36000	30000
Conductivity (µs/cm)	µs/cm	4200	960	1300	1800
Cresols	µg/l	170000	4500	1200000	18000
Xylenols & Ethylphenols	µg/l	100000	3000	670000	26000
Catechol	µg/l	31000	87	33000	3500
Phenol	µg/l	87000	2600	440000	9800
Trimethylphenol	µg/l	34000	820	120000	27000
Total Phenols	µg/l	420000	11000	2400000	84000
Napthalene	ng/l	340000	5800	690000	620000
Acenaphthylene	ng/l				
Acenaphthene	ng/l	3500	3300	< 20	6300
Fluorene	ng/l	4300	2000	110000	13000
Phenanthrene	ng/l	7000	5400	210000	35000
Anthracene	ng/l	41	2900	1200	710
Fluoranthene	ng/l	290	20000	81000	11000
Pyrene	ng/l	920	19000	160000	11000
Benzo(a)anthracene	ng/l	130	6700	50000	3400
Chrysene	ng/l	120	7400	50000	4300
Benzo(b)fluoranthene	ng/l	69	3700	38000	2600
Benzo(k)fluoranthene	ng/l	66	360	33000	1300
Benzo(a)pyrene	ng/l	150	< 20	74000	110
Indeno(1,2,3-cd)pyrene	ng/l	59	27000	43000	2000
Di-benz(a,h,)anthracene	ng/l	< 20	< 20	6200	96
Benzo(g,h,i)perylene	ng/l	59	8300	39000	1100
Anthanthrene	ng/l	< 20	1400	40000	570
Benzo(e)pyrene	ng/l	< 20	4600	63000	5100
Cyclopenta(cd)pyrene	ng/l				
Total PAH	ng/l	350000	120000	1700000	710000
Easily-liberatable Cyanide	mg/l	0.1	0.20	0.20	< 0.10
Complex Cyanide	mg/l	2.9	540	15	7
Total Cyanide	mg/l	3	540	15	7
Thiocyanate	mg/l				
Sulphate	mg/l	340	740	690	58
Sulphide	µg/l	.	< 50	.	.
Chloride	mg/l				
Total Ammonium	mg/l	140	7.1	220	15
Arsenic	mg/l	0.04	< 0.01	0.42	< 0.01
Cadmium	mg/l	< 0.0050	< 0.0050	0.0054	< 0.0050
Chromium	mg/l	0.01	< 0.01	< 0.01	< 0.01
Lead	mg/l	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/l	< 0.0010	< 0.0010	0.0020	< 0.0010
Selenium	mg/l	0.006	0.0030	0.0020	< 0.0020
Copper	mg/l	0.03	< 0.01	0.020	< 0.01
Nickel	mg/l	0.02	0.070	0.030	0.02
Zinc	mg/l	0.08	< 0.01	< 0.01	< 0.01
Iron	mg/l	12	1.3	29	0.45
Analytes below to be determined if their presence on site is suspected.					
Cobalt	mg/l				
Vanadium	mg/l				
Molybdenum	mg/l				
Germanium	mg/l				
Hex Cr	mg/l				
Benzene	µg/l	7300	66	30000	1600
Toluene	µg/l	3100	23	7800	1800
Ethylbenzene	µg/l	190	< 10	300	240
Xylene's	µg/l	2100	18	3000	2200
TPH by GC (C_{10} to C_{20})	µg/l	16000	1000	410000	71000
TPH by GC (C_{20} to C_{39})	µg/l	160	330	36000	15000
TPH by GC (C_{10} to C_{39})	µg/l	16000	1300	440000	86000
ADDITIONAL ANALYTES					
BOD	mg/l				
COD (filtered	mg/l				
Boron (B)	mg/l				
Total Organic Carbon	mg/l	480	95	1200	170
Toluene Extractable Matter	mg/l				

PARKMAN

Leachate

LEACHATE RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as stated units.

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number		BH32	TP31	TP31	TP32	TP32	TP34	TP34	TP35	TP35	TP36	TP37
Depth		0.50m	1.10m	2.20m	0.20m	3.40m	0.30m	2.00m	2.00m	3.00m	2.30m	1.10m
	Units											
pH	pH Units	9.2	8.9	8.7	7.1	8	7.5	8.3	7.8	8.8	9.5	9.6
Suspended Solids	mg/l	.	.	.			.	.	.	.	.	.
Conductivity	µs/cm	130	42	50	320	85	3100	500	1100	76	40	31
Cresols	µg/l	< 0.50	< 0.50	1.5	< 0.50	< 0.50	< 0.50	2.5	< 0.50	< 0.50	3	1.2
Xylenols & Ethylphenols	µg/l	< 0.50	< 0.50	3.1	< 0.50	< 0.50	< 0.50	11	< 0.50	< 0.50	5.2	< 0.50
Catechol	µg/l	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Phenol	µg/l	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.82	< 0.50	< 0.50	1.7	< 0.50
Trimethylphenol	µg/l	< 0.50	< 0.50	11	< 0.50	< 0.50	< 0.50	36	< 0.50	< 0.50	40	< 0.50
Total Phenols	µg/l	< 2.5	< 2.5	16	< 2.5	< 2.5	< 2.5	51	< 2.5	< 2.5	49	< 2.5
Napthalene	ng/l	130	43	280	20000	210	150	350	260	39	1300	180
Acenaphthylene	ng/l											
Acenaphthene	ng/l	< 20	< 20	< 20	1900	28	< 20	250	< 20	< 20	< 20	26
Fluorene	ng/l	< 20	< 20	< 20	1600	30	26	150	< 20	< 20	130	36
Phenanthrene	ng/l	< 20	57	< 20	1600	52	< 20	58	< 20	< 20	49	58
Anthracene	ng/l	< 20	< 20	21	280	< 20	28	59	< 20	< 20	120	< 20
Fluoranthene	ng/l	< 20	54	77	400	31	130	280	74	30	350	58
Pyrene	ng/l	100	180	420	300	41	530	530	210	< 20	580	78
Benzo(a)anthracene	ng/l	< 20	37	30	< 20	< 20	< 20	69	< 20	< 20	33	< 20
Chrysene	ng/l	< 20	44	38	< 20	< 20	27	71	< 20	< 20	32	< 20
Benzo(b)fluoranthene	ng/l	< 20	26	< 20	< 20	< 20	< 20	74	< 20	< 20	< 20	< 20
Benzo(k)fluoranthene	ng/l	< 20	< 20	< 20	< 20	< 20	< 20	31	< 20	< 20	< 20	< 20
Benzo(a)pyrene	ng/l	< 20	22	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Indeno(1,2,3-cd)pyrene	ng/l	< 20	< 20	54	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-benz(a,h,)anthracene	ng/l	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Benzo(g,h,i)perylene	ng/l	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Anthanthrene	ng/l	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Benzo(e)pyrene	ng/l	< 20	59	57	< 20	< 20	25	99	< 20	< 20	42	< 20
Cyclopenta(cd)pyrene	ng/l											
Total PAH	ng/l	280	580	1100	26000	420	950	2000	560	< 200	2700	480
Easily-liberatable Cyanide	mg/l	0.2	0.2	0.1	0.20	0.30	0.20	0.20	0.10	0.10	0.1	0.3
Complex Cyanide	mg/l	0.2	0.2	0.3	0.60	0.60	0.40	0.50	1.2	0.40	0.3	0.3
Total Cyanide	mg/l	0.4	0.4	0.4	0.80	0.90	0.60	0.70	1.3	0.50	0.4	0.6
Sulphate	mg/l	.	.	.			.	.	.	.	.	.
Total Ammonium	mg/l	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64	< 0.71	1.9	< 0.64	1.3	< 0.64	< 0.64
Arsenic	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	mg/l	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Chromium	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/l	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Selenium	mg/l	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Copper	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.010	< 0.01	0.020	0.010	< 0.01	< 0.01
Iron	mg/l	< 0.01	< 0.01	< 0.01	0.030	0.10	0.13	0.040	0.80	< 0.01	< 0.01	< 0.01
Analytes below to be determined if their presence on site is suspected.												
Cobalt	mg/l											
Vanadium	mg/l											
Molybdenum	mg/l											
Germanium	mg/l											
Uranium	mg/l											
Benzene	µg/l	.	.	.			.	.	.	.	.	.
Toluene	µg/l	.	.	.			.	.	.	.	.	.
Ethylbenzene	µg/l	.	.	.			.	.	.	.	.	.
Xylene's	µg/l	.	.	.			.	.	.	.	.	.
TPH by GC (C_{10} to C_{20})	µg/l	.	.	.			.	.	.	.	.	.
TPH by GC (C_{20} to C_{39})	µg/l	.	.	.			.	.	.	.	.	.
TPH by GC (C_{10} to C_{39})	µg/l	.	.	.			.	.	.	.	.	.
ADDITIONAL ANALYTES												
BOD	mg/l											
COD (filtered	mg/l											
Boron (B)	mg/l											
Total Organic Carbon	mg/l	6.6	4.3	8.1	3.9	6.0	9.0	8.6	9.9	8.6	5.1	2.4
Toluene Extractable Matter	mg/l											
Thiocyanate	mg/l											
Sulphide	µg/l	.	.	.			.	.	.	.	.	.
Chloride	mg/l											

LEACHATE RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as stated units.

Laboratory: City Analytical Services Plc

Borehole / Trial Pit Number		TP39	TP39	TP40	TP41	TP47	TP47	TP48	TP51	TP51
Depth		0.50m	2.80m	2.20m	0.80m	1.00m	3.00m	2.50m	0.30m	1.00m
	Units									
pH	pH Units	7.5	8.4	8.6	9.2	8.9	8.4	8.9	9.6	11
Suspended Solids	mg/l	-	-	-	-			-	-	-
Conductivity	µs/cm	730	120	120	62	94	130	210	87	130
Cresols	µg/l	110	< 0.50	< 0.50	< 0.50	53000	16000	85000	92000	3000
Xylenols & Ethylphenols	µg/l	310	< 0.50	< 0.50	< 0.50	44000	8300	68000	87000	2700
Catechol	µg/l	24	< 0.50	< 0.50	< 0.50	2800	< 0.50	13000	1900	150
Phenol	µg/l	20	< 0.50	< 0.50	< 0.50	20000	4600	46000	20000	1200
Trimethylphenol	µg/l	210	< 0.50	< 0.50	< 0.50	23000	5800	41000	40000	7600
Total Phenols	µg/l	680	< 2.5	< 2.5	< 2.5	140000	34000	250000	240000	15000
Napthalene	ng/l	97	6300	80	350	650000	52000	550000	260000	10000
Acenaphthylene	ng/l									
Acenaphthene	ng/l	2200	13000	65	310	2400	< 20	10000	2100	11000
Fluorene	ng/l	170	8500	45	72	15000	8900	14000	4200	4400
Phenanthrene	ng/l	3200	2400	46	23	16000	13000	19000	5300	5900
Anthracene	ng/l	99	2400	< 20	32	460	340	73	28	1100
Fluoranthene	ng/l	310	2300	110	160	450	430	690	270	780
Pyrene	ng/l	< 20	1600	110	270	< 20	< 20	2200	470	690
Benzo(a)anthracene	ng/l	44	120	< 20	22	100	88	210	34	51
Chrysene	ng/l	< 20	140	< 20	20	78	73	210	30	64
Benzo(b)fluoranthene	ng/l	< 20	51	< 20	< 20	57	27	56	< 20	< 20
Benzo(k)fluoranthene	ng/l	< 20	33	< 20	< 20	28	< 20	46	< 20	< 20
Benzo(a)pyrene	ng/l	< 20	< 20	< 20	< 20	59	33	120	< 20	20
Indeno(1,2,3-cd)pyrene	ng/l	< 20	< 20	< 20	< 20	41	< 20	44	28	< 20
Di-benz(a,h,)anthracene	ng/l	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Benzo(g,h,i)perylene	ng/l	< 20	< 20	< 20	< 20	30	< 20	< 20	22	< 20
Anthanthrene	ng/l	< 20	< 20	< 20	< 20	62	< 20	< 20	< 20	< 20
Benzo(e)pyrene	ng/l	22	120	< 20	< 20	74	30	< 20	32	52
Cyclopenta(cd)pyrene	ng/l									
Total PAH	ng/l	6200	37000	480	1300	690000	75000	600000	270000	34000
Easily-liberatable Cyanide	mg/l	0.20	0.30	< 0.10	0.2	0.10	0.10	0.3	0.3	0.2
Complex Cyanide	mg/l	3.6	2.5	0.30	0.2	1.3	0.70	0.3	0.3	0.8
Total Cyanide	mg/l	3.8	0.5	0.30	0.4	1.4	0.80	0.6	0.6	1
Sulphate	mg/l	-	-	-	-			-	-	-
Total Ammonium	mg/l	< 0.64	< 0.64	< 0.64	< 0.64	3.2	3.1	14	2.4	2.6
Arsenic	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	mg/l	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Chromium	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/l	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Selenium	mg/l	< 0.0020	< 0.0020	< 0.0020	0.003	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Copper	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/l	0.020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	mg/l	2.7	0.71	0.030	0.05	0.040	0.040	0.17	< 0.01	0.28
Analytes below to be determined if their presence on site is suspected.										
Cobalt	mg/l									
Vanadium	mg/l									
Molybdenum	mg/l									
Germanium	mg/l									
Uranium	mg/l									
Benzene	µg/l	-	-	-	-			-	-	-
Toluene	µg/l	-	-	-	-			-	-	-
Ethylbenzene	µg/l	-	-	-	-			-	-	-
Xylene's	µg/l	-	-	-	-			-	-	-
TPH by GC (C_{10} to C_{20})	µg/l	-	-	-	-			-	-	-
TPH by GC (C_{20} to C_{39})	µg/l	-	-	-	-			-	-	-
TPH by GC (C_{10} to C_{39})	µg/l	-	-	-	-			-	-	-
ADDITIONAL ANALYTES										
BOD	mg/l									
COD (filtered	mg/l									
Boron (B)	mg/l									
Total Organic Carbon	mg/l	44	12	5.5	4.5	200	70	320	270	38
Toluene Extractable Matter	mg/l									
Thiocyanate	mg/l									
Sulphide	µg/l	-	-	-	-			-	-	-
Chloride	mg/l									

PARKMAN

Water Monitoring

WATER MONITORING RESULTS
LIMERICK GASWORKS
Apr-01

All analytical results to be reported as stated units.

Laboratory: City Analytical Services Plc

Laboratory Sample Reference		133041	133042	133043	133044	133045
Sample ID		BH31	BH32	BH33	BH34	BH 7
Other ID	Units					
pH	pH Units	6.7	7	7.3	7.2	9.8
Suspended Solids	mg/l	210	340	62	130	37
Conductivity (µs/cm)	µs/cm	780	400	820	900	1500
Cresols	µg/l	< 0.50	< 0.50	31000	18	12000
Xylenols & Ethylphenols	µg/l	< 0.50	< 0.50	31000	79	8200
Catechol	µg/l	< 0.50	< 0.50	< 0.50	< 0.50	510
Phenol	µg/l	< 0.50	1.5	20000	2.4	3900
Trimethylphenol	µg/l	< 0.50	< 0.50	25000	43	6500
Total Phenols	µg/l	< 2.5	< 2.5	110000	140	31000
Napthalene	ng/l	530	5300	760000	780	390000
Acenaphthylene	ng/l					
Acenaphthene	ng/l	< 20	5700	19000	2100	18000
Fluorene	ng/l	77	1800	7800	980	7300
Phenanthrene	ng/l	630	730	8200	200	21000
Anthracene	ng/l	120	390	1400	37	4700
Fluoranthene	ng/l	200	800	490	69	6300
Pyrene	ng/l	410	830	570	100	8100
Benzo(a)anthracene	ng/l	170	120	55	33	2900
Chrysene	ng/l	150	130	50	35	33000
Benzo(b)fluoranthene	ng/l	130	87	32	39	2800
Benzo(k)fluoranthene	ng/l	71	44	< 20	< 20	1200
Benzo(a)pyrene	ng/l	300	210	70	74	1200
Indeno(1,2,3-cd)pyrene	ng/l	270	94	26	95	2400
Di-benz(a,h,)anthracene	ng/l	21	21	< 20	< 20	300
Benzo(g,h,i)perylene	ng/l	100	43	< 20	32	1100
Anthanthrene	ng/l	43	< 20	< 20	< 20	590
Benzo(e)pyrene	ng/l	300	190	73	67	5500
Cyclopenta(cd)pyrene	ng/l					
Total PAH	ng/l	3500	17000	750000	4700	400000
Easily-liberatable Cyanide	mg/l	0.10	0.10	0.10	0.10	0.30
Complex Cyanide	mg/l	0.40	0.20	0.40	0.20	4.1
Total Cyanide	mg/l	0.50	0.30	0.50	0.30	4.4
Thiocyanate	mg/l	0.26	0.15	15	0.98	46
Sulphate	mg/l	550	51	130	510	1100
Sulphide	µg/l	< 50	< 50	< 50	< 50	< 50
Chloride	mg/l					
Total Ammonium	mg/l	2.1	1.4	57	42	33
Arsenic	mg/l	0.020	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	mg/l	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Chromium	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead	mg/l	0.19	0.11	0.040	0.090	< 0.01
Mercury	mg/l	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Selenium	mg/l	0.0050	< 0.0020	0.010	< 0.0020	0.0040
Copper	mg/l	0.030	0.020	0.020	0.010	< 0.01
Nickel	mg/l	0.020	0.020	0.010	0.020	0.010
Zinc	mg/l	0.15	0.19	0.10	0.10	0.13
Iron	mg/l	3.5	3.3	1.3	2.4	5.7
Analytes below to be determined if their presence on site is suspected.						
Cobalt	mg/l					
Vanadium	mg/l					
Molybdenum	mg/l					
Germanium	mg/l					
Hex Cr	mg/l					
Benzene	µg/l	< 10	< 10	16000	18	2700
Toluene	µg/l	< 10	< 10	5500	11	1000
Ethylbenzene	µg/l	< 10	< 10	250	< 10	99
Xylene's	µg/l	< 10	< 10	3000	21	1100
TPH by GC (C_{10} to C_{20})	µg/l	< 100	440	8900	540	12000
TPH by GC (C_{20} to C_{39})	µg/l	< 100	< 100	120	< 100	440
TPH by GC (C_{10} to C_{39})	µg/l	< 100	440	9000	540	13000
ADDITIONAL ANALYTES						
BOD	mg/l					
COD (filtered	mg/l					
Boron (B)	mg/l					
Total Organic Carbon	mg/l	14	5.4	15	15	110
Toluene Extractable Matter	mg/l					

Borehole Log

GEOTECH

Drilled by TB Logged by Checked by	Equipment and Methods Rotary Open Hole 115 mm diameter from 0.00m to 1.85m. Rotary Cored 110 mm diameter from 1.85m to 5.25m.	Ground Level National Grid Coordinates

Samples and Tests

Strata

Depth	TCR SCR RQD	If	Records	Date Casing	Time Water	Description	Depth,Level (Thickness)	Legend
				08/03/2001		MADE GROUND**	(1.85)	
1.85 - 3.65m	0						1.85	
						LIMESTONE**	(3.40pen)	
3.65 - 5.25m								
				08/03/2001		EXPLORATORY HOLE ENDS AT 5.25 m.	5.25	

Groundwater

No.	Struck	Behaviour
1	1.85m	

Remarks

Hole backfill : 0.00m to 0.50m Concrete (c), 0.50m to 1.85m Bentonite (b). Surface protection : Stop Cock Cover Standpipe installed, 50mm diameter, response zone from 1.85m to 5.25m.

Notes : For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.
Scale 1 : 50

Project: LIMERICK GAS WORKS
Project no.: 171016/2
Carried out for: Messrs. Parkman Environmental

Borehole
BH31
Sheet 1 of 1

14/03/2001 15:14:05 ESGLog v2.04

Borehole Log

GEOTECH

Drilled by TB **Logged by** **Checked by**	**Equipment and Methods** Inspection Pit from 0.00m to 1.20m. Rotary Open Hole 110 mm diameter from 1.40m to 4.85m.	**Ground Level** **National Grid Coordinates**

Samples and Tests

Depth	Type & No.	Records	Date Casing	Time Water
			04/03/2001	
			04/03/2001	

Strata

Description	Depth,Level (Thickness)	Legend
MADE GROUND**	(1.65)	
	1.65	
LIMESTONE**	(3.20pen)	
EXPLORATORY HOLE ENDS AT 4.85 m.	4.85	

Depth	TCR SCR RQD	If	Records	Date Casing	Time Water

Groundwater

No.	Struck	Behaviour
1	1.75m	

Remarks

Hole backfill : 0.00m to 0.85m Concrete (c), 0.85m to 1.85m Bentonite (b). Surface protection : Stop Cock Cover Standpipe installed, 50mm diameter, response zone from 1.85m to 4.85m.

Notes : For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.
Scale 1 : 50

Project LIMERICK GAS WORKS
Project no. 171016/2
Carried out for Messrs. Parkman Environmental

Borehole BH32
Sheet 1 of 1

14/03/2001 15:14:13 ESGLog v2.04

Borehole Log

GEOTECH

Drilled by TB **Logged by** **Checked by**	**Equipment and Methods** Rotary Open Hole 115 mm diameter from 0.00m to 2.85m. Rotary Cored 110 mm diameter from 2.85m to 8.45m.	**Ground Level** **National Grid Coordinates**

Samples and Tests

Strata

Depth	TCR SCR RQD	If	Records	Date Casing	Time Water	Description	Depth,Level (Thickness)	Legend
				04/03/2001				c b
2.85 - 4.00m	***							
						LIMESTONE**	(8.45pen)	
4.00 - 5.80m								
5.80 - 7.40m								
7.40 - 8.45m								
				06/03/2001		EXPLORATORY HOLE ENDS AT 8.45 m	8.45	

Groundwater
No. Struck Behaviour

Remarks
Hole backfill : 0.00m to 0.50m Concrete (c), 0.50m to 1.45m Bentonite (b). Surface protection : Stop Cock Cover
Standpipe installed, 50mm diameter, response zone from 1.45m to 8.45m.

Notes : For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.
Scale 1 : 50

Project LIMERICK GAS WORKS
Project no. 171016/2
Carried out for Messrs. Parkman Environmental

Borehole BH33
Sheet 1 of 1

Borehole Log

GEOTECH

Drilled by TB **Logged by** **Checked by**	**Equipment and Methods** Rotary Open Hole 115 mm diameter from 0.00m to 7.20m. Rotary Cored 110 mm diameter from 7.20m to 10.25m.	**Ground Level** **National Grid Coordinates**

Samples and Tests

Depth	TCR SCR RQD	If	Records	Date Casing	Time Water
				06/03/2001	

Strata

Description	Depth,Level (Thickness)	Legend
MADE GROUND**	(7.15)	c, b, 1
	7.15	
LIMESTONE**	(3.10)	

Groundwater

No.	Struck	Behaviour
1	7.20m	

Remarks

Hole backfill : 0.00m to 0.50m Concrete (c), 0.50m to 7.15m Bentonite (b). Surface protection : Stop Cock Cover
Standpipe installed, 50mm diameter, response zone from 7.15m to 10.25m.

Notes : For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.
Scale 1 : 50

Project LIMERICK GAS WORKS
Project no. 171016/2
Carried out for Messrs. Parkman Environmental

Borehole BH34
Sheet 1 of 2

14/03/2001 15:14:33 ESGLog v2.04

Borehole Log

GEOTECH

Drilled by	TB	Equipment and Methods	Ground Level
Logged by		See sheet 1	National Grid Coordinates
Checked by			

Samples and Tests

Depth	TCR SCR RQD	If	Records	Date Casing	Time Water
				06/03/2001	

Strata

Description	Depth,Level (Thickness)	Legend
As sheet 1		
EXPLORATORY HOLE ENDS AT 10.25 m.	10.25	

Groundwater
No. Struck Behaviour

Remarks

Notes : For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.
Scale 1 : 50

Project	LIMERICK GAS WORKS
Project no.	171016/2
Carried out for	Messrs. Parkman Environmental

Borehole **BH34**

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP31
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	01/03/2001	NW-SE	3 x 3 x 2.9m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.05m - Layer of vegetation (grass and roots with topsoil).			
			0.15m - MADE GROUND - Compact layer of bricks and sand and concrete flooring		0.5m	
0.6	1		0.75m - MADE GROUND - Soft brown sandy gravelly clay with occasional brick debris, slight hydrocarbon odour.			
1.1	2		1.35m - MADE GROUND - Soft dark brown sandy gravelly clay with occasional brick debris and some sub angular to rounded limestone cobbles, hydrocarbon or chemical odour, in particles very sandy and very gravelly.		1.0m	
			MADE GROUND - Soft grey very sandy gravelly clay with many angular sub-rounded cobbles of limestone (in places clayey and gravelly fine to coarse sand), strong hydrocarbon or chemical odour.		1.5m	
2.2	3				2.0m	
					2.5m	
			Trial pit abandoned at 2.9m due to pit collapse.		3.0m	
					3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:

Orientation

REMARKS (pit stability / water encountered)
Very unstable below 0.75m / water flowing in at 2m in NW end - not enough to sample, pit collapsing constantly.

SAMPLE DESCRIPTION:

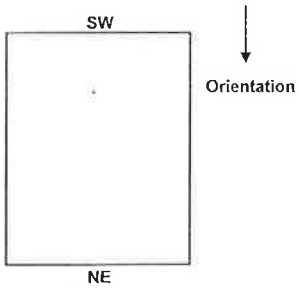
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP 32
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	27/02/2001	SW - NE	1.2 x 2.3 x 3.5m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.2m	1		0.1m - MADE GROUND. Loose grey medium to coarse angular to sub rounded gravel hardcore with some fine angular to rounded gravel of limestone. 0.5m - MADE GROUND. Loose brown/black stained sandy fine to coarse angular to rounded gravel of brick clinker, slate, limestone with a hydrocarbon odour. 0.9m MADE GROUND. Loose light brown/grey medium to coarse lime sand with some fine to coarse angular to rounded gravel of lime.		0.5m	
			1.9m MADE GROUND. Compact dark brown clayey slightly sandy fine to coarse angular to rounded gravel of brick with some angular cobbles of brick (demolition rubble).		1.0m 1.5m	
2.4	2		2.6m MADE GROUND. Soft grey/mottled black silty sandy very gravelly clay with much fine to coarse angular to rounded gravel of brick and limestone.		2.0m 2.5m	
3.4	3		DISTURBED GROUND. Soft grey/mottled black silty gravelly CLAY with slight organic odour and some whole and fragmented shells (disturbed natural ground).		3.0m 3.5m	
			Trial pit ended @ 3.5m		4.0m 4.5m 5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)

Slightly unstable between 0.9 - 1.9m / small amount of water in base of hole.

SAMPLE DESCRIPTION:

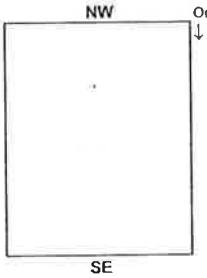
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP 33
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB - 3CX	27/02/2001	NW - SE	1.4 x 2.8 x 2.7m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.1m - MADE GROUND. Mass Concrete.			
			0.3m - MADE GROUND - Loose brown sandy fine to coarse angular gravel of brick fragments.			
0.6	1		1.8m - MADE GROUND - Loose light brown/grey with some minty green patches medium to coarse lime sand with some fine to coarse angular to rounded gravel of lime interbedded with soft to firm slightly clayey silt layers with occasional fine angular to rounded gravel of brick, limestone and lime fragments between 0.5 - 0.65m and 1.4 - 1.6m.		0.5m 1.0m	
1.5	2				1.5m	
2.4 2.5	3	4	Soft grey mottled black clayey SILT with some fine to coarse angular to rounded gravel of limestone, some wood debris at top of layers below 2.6m, limestone boulders hindering excavation.	▼	2.0m 2.5m	
			Trial pit ended @ 2.7m due to difficult excavation with boulders - possible rockhead?		3.0m 3.5m 4.0m 4.5m 5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)

Sides unstable below 2m/ grey water filling in pit from 2.5m in west wall; filled to 2.5m in 10 minutes.

SAMPLE DESCRIPTION:

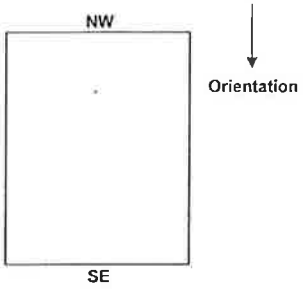
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP 34
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	27-28/02/01	NW - SE	1.1 x 3.1 x 3.1m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.3m	1		0.5m MADE GROUND. Loose brown fine to coarse angular to sub angular gravel of ash, clinker and brick.		0.5m	
			0.75m MADE GROUND. Mass Concrete.			
1.2m	2		1.3m MADE GROUND. Loose brown/dark brown medium to coarse sand with much fine to coarse angular to rounded gravel of brick, limestone and some ash and clinker; occasional large metal pieces and whole bricks, slight hydrocarbon odour in places.		1.0m	
2.0m 2.05m	3	4	2.7m MADE GROUND. Compact dark grey/black fine to coarse angular to sub rounded gravel of clinker ash, and brick with many clay and silt rich patches; tarry odour and appearance.	▼	1.5m 2.0m 2.5m	
3.0m	5		Soft grey clayey slightly sandy SILT with occasional shells, some egg shells found; in places very sandy.		3.0m	
			Trial pit ended @ 3.1m		3.5m 4.0m 4.5m 5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)

Stable/black water with hydrocarbon sheen and odour entering @ 2.05m; settled to 2.65m after 10 mins.

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

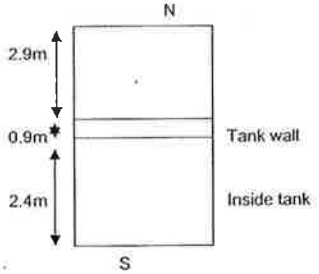
Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP35
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	28/02/2001	N-S	1.4 x 6.2 x 3.1m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.5m -MADE GROUND- Loose brown slightly clayey sandy fine to coarse, angular to rounded gravel of brick, ash, tarmac, grass at top of layer.		0.5m	
			2.8m - MADE GROUND - Compact to very compact brown/red m-c a sub a gravel of ash, clinks and brick with iron oxide staining.			
1.0m	1*		MADE GROUND - Loose light brown/grey m-c lime sand with some fine to coarse, angular to rounded gravel of lime. Below 2.6m water contaminating fill.		1.0m	
1.5m		2*	INSIDE TANK: MADE GROUND - Loose to compact dark brown slightly clayey very gravelly medium to coarse sand with many angular cobbles of limestone, strong tarry odour, black tarry water standing at 1.5m - excavation ended at 1.8m within tank.		1.5m	
2.0m	3				2.0m	
					2.5m	
3.0m	4		Soft dark grey clayey slightly sandy SILT with strong hydrogen sulphide odour	▼	3.0m	
			Trial pit ended at 3.1m		3.5m	
					4.0m	
					4.5m	
					5.0m	

* Samples within tank

ELEVATION:



Orientation ↓

REMARKS (pit stability / water encountered)
Unstable/brown water standing @ 3.0m outside tank.

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

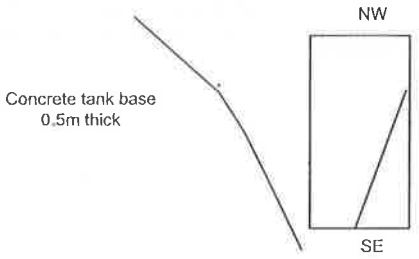
Trial Pit Log

CLIENT:	CONSULTANT:	PROJECT:	TRIAL PIT:
Bord Gàis	Parkman Environment	Limerick Gasworks	TP36

LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	02/03/2001	NW-SE	1.5 x 3.5 x 2.4m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.2m - MADE GROUND - Loose slightly clayey gravelly fine to medium sand with occasional brick fragments and plastic, many rootlets and grass at top of layer.			
0.5m	1		MADE GROUND - Loose to compact light brown/grey sandy medium to coarse angular to sub angular gravel of limestone		0.5m	
					1.0m	
					1.5m	
2.2m		2			2.0m	
2.3m	3		below water line gravel becomes grey with slight hydrocarbon odour	▼		
			Trial pit ended at 2.4m		2.5m	
					3.0m	
					3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)
Unstable below 0.2m/grey water with h/c odour standing @ 2.2m

SAMPLE DESCRIPTION:

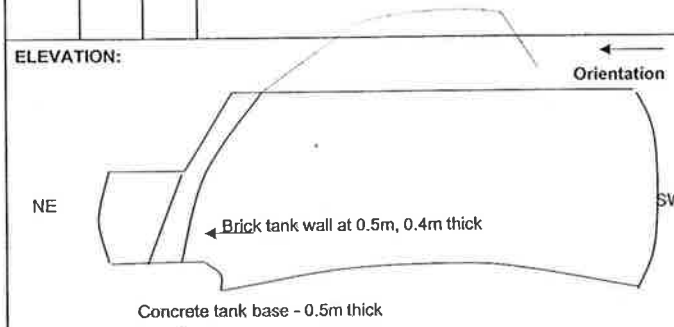
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gáis	Parkman Environment		Limerick Gasworks		TP37
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	02/03/2001	SW-NE	1.6 x 3.6 x 1.2m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.2	1		0.05 - MADE GROUND - Loose slightly clayey gravelly fine to medium sand with occasional brick fragments and plastic, many rootlets and grass at top of layer.			
			MADE GROUND - Loose to compact light brown/grey sandy medium to coarse angular to sub angular gravel of limestone		0.5m	
1		2		▼	1.0m	
1.1	3		TP abandoned @ 1.2m due to water level and pit collapse		1.5m	
					2.0m	
					2.5m	
					3.0m	
					3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)
Very unstable / light brown water with slight hydrocarbon and sheen standing at 1.0m.

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

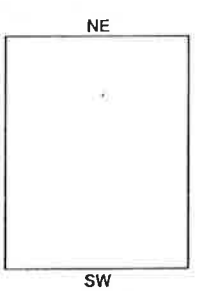
Trial Pit Log

CLIENT:	CONSULTANT:	PROJECT:	TRIAL PIT:
Bord Gàis	Parkman Environment	Limerick Gasworks	TP 38

LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	27/02/2001	NE - SW	1.3 x 3.3 x 1.7m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.2m - MADE GROUND. Reinforced Concrete			
0.5	1		1.3m - MADE GROUND. Loose - medium compact brown sandy gravel of brick and iron oxide fragments with many coarse angular gravel to cobble sized iron oxide fragments.		0.5m 1.0m	
1.5 1.55	2	3	MADE GROUND. Compact to very compact slightly sandy, slightly gravelly angular cobbles of limestone with some demolition rubble.	▼	1.5m	
			Trial pit abondoned @ 1.7m due to pit collapse and water obscuring view.		2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)

Very unstable below 0.2m/brown water standing @ 1.55m.

SAMPLE DESCRIPTION:

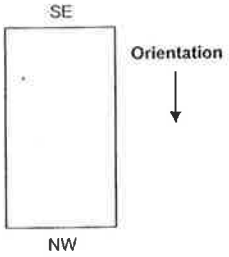
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP 39
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	28/02/2001	SE - NW	1.1 x 3.8 x 3m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.4m - MADE GROUND. Loose brown clayey sand with some fine to coarse angular to rounded gravel of limestone and brick with many rootlets and grass at the top.			
0.5	1		0.6m - MADE GROUND. Compact dark grey/black with blue staining (especially between 0.4 - 0.6m in south west side) very sandy fine to coarse angular to rounded gravel of ash, brick and limestone: some patches of spent lime.		0.5m	
			1.2 - MADE GROUND - Compact to very compact brown/red medium to coarse, angular to sub angular gravel of ash, clinks and brick with iron oxide staining.		1.0m	
1.5	2		MADE GROUND - Loose light brown/grey medium to coarse lime sand with some fine to coarse, angular to rounded gravel of lime, Below 2.6m water contaminating fill.		1.5m	
					2.0m	
2.6		3		▼	2.5m	
2.8	4					
			Trial pit ended at 3.0m		3.0m	
					3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)
Stable/dark grey water with oily sheen and tarry odour standing at 2.6m

SAMPLE DESCRIPTION:

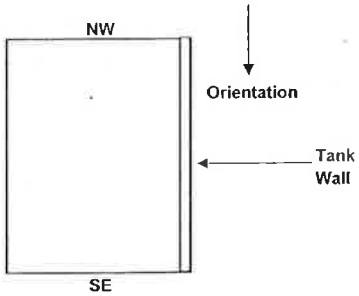
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP40
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	28/02/2001	NW - SE	2.5 x 3.5 x 2.5m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.5m - MADE GROUND. Loose to moderately compact brown sandy fine to coarse angular to rounded gravel of brick and limestone, with many angular cobbles of tarmac, limestone and brick.		0.5m	
0.7m	1		1.9m - MADE GROUND. Compact light brown / brown sandy gravelly clay with many angular cobbles of limestone.		1.0m 1.5m	
2.2 m	2		MADE GROUND. Very compact grey/black sandy gravelly clay with many angular cobbles of limestone; slightly tarry odour - possible rockhead.		2.0m 2.5m	
			Trial pit abandoned @ 2.5m due to possible rockhead.		3.0m 3.5m 4.0m 4.5m 5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)

Very unstable / no water

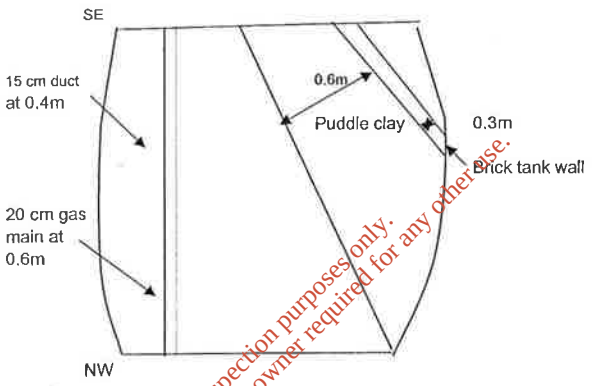
SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

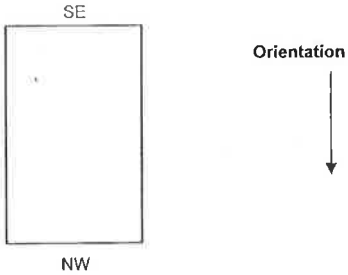
Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	**Parkman Environment**		**Limerick Gasworks**		**TP41**
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	**JCB 3CX**	**02/03/2001**	**SE-NW**	**1.2 x 2.5 x 0.9m**	**25837**

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.05m- MADE GROUND- Loose slightly clayey gravelly fine to medium sand with occasional brick fragments and plastic, many rootlets and grass at top of layer.			
0.5m	1		0.2m - MADE GROUND - Loose slightly clayey gravelly fine to medium sand with occasional brick fragments and plastic, many rootlets and grass at top of layer.		0.5m	
0.8m	2		Unused duct encountered at 0.4m. Gas main encountered @ 0.6m			
			Trial pit abandoned @ 0.9m due to gas main adjacent to excavation		1.0m	
					1.5m	
					2.0m	
					2.5m	
					3.0m	
					3.5m	
					4.0m	
					4.5m	
					5.0m	



ELEVATION:



REMARKS (pit stability / water encountered)

Stable/grey water with hydrocarbon odour and sheen standing at 0.9m

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP42
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	02/03/2001	NE-SW	1.7 x 3.3 x 0.5m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.3m 0.4m	1 2		0.04m - MADE GROUND - compact dark grey/black sandy silty fine to coarse angular to rounded gravel and limestone 0.5m - compact brown sandy medium to course angular to rounded GRAVEL of limestone with many angular cobbles of limestone (weathered rock), @ 0.5m rockhead encountered, traces of tar within rock. Trial pit ended @ 0.5m due to rockhead		0.5m 1.0m 1.5m 2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m	

ELEVATION:

NE

Orientation

SW

REMARKS (pit stability / water encountered)
stable/brown water with hydrocarbon sheen, slight odour and a few globules of tar standing @ 0.4m

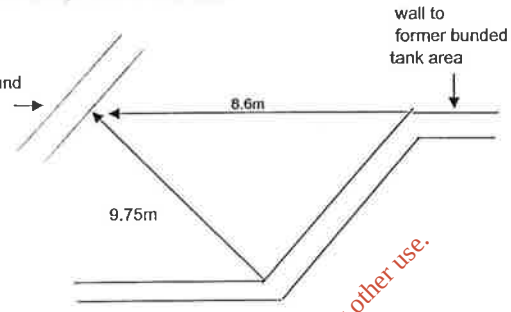
SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

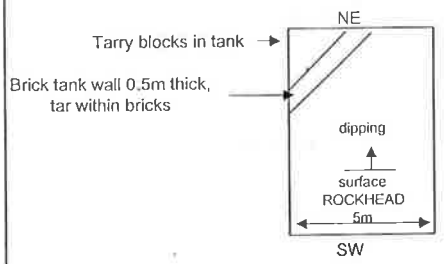
CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	**Parkman Environment**		**Limerick Gasworks**		**TP43**
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	**JCB 3CX**	**01/03/2001**	**NE-SW**	**5 x 9 x 0.5m**	**25837**

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.4m	1		MADE GROUND - Loose to compact brown sandy, very gravelly clay fill with many angular cobbles of limestone, some patches of brown/ light brown clay, rock head @ 0.5m - tar visible in fissures in the rock.		0.5m	
			Trial pit ended at 0.5m due to rockhead.			



1.0m
1.5m
2.0m
2.5m
3.0m
3.5m
4.0m
4.5m
5.0m

ELEVATION:



Orientation

9m

REMARKS (pit stability / water encountered)
stable/no water

SAMPLE DESCRIPTION:

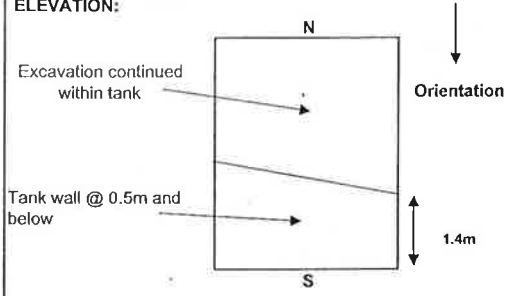
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP 47
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	27/02/2001	N -S	1.4 x 4.4 x 3.5m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			0.4m MADE GROUND. Loose brown sandy gravelly clay with some rootlets.			
			1.1m MADE GROUND. Soft silty sand with tarry appearance and odour.		0.5m	
1.0 m	1				1.0m	
			MADE GROUND. Soft brown sandy gravelly clay with some angular cobble to boulder sized limestone fragments and some whole and fragmented bricks; hydrocarbon odour; becoming wet and tarry below 2.5m.		1.5m	
2.0 m	2				2.0m	
					2.5m	
2.75 m		3		▼		
3.0 m	4				3.0m	
			Trial pit ended @ 3.5m		3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:



REMARKS (pit stability / water encountered)

Unstable throughout / black water standing @ 2.75m in 5 minutes.

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP48
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	01/03/2001	N-S	1.5 x 3.5 x 3.6m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
			MADE GROUND - soft slightly sandy very gravelly clay fill with many cobbles of limestone, some pottery frags, brick, pipes and cables, tarry appearance and odour, heavier with depth, liquid tar oozing in places.		0.5m 1.0m	
1.5m	1				1.5m	
					2.0m	
2.5m	2				2.5m	
					3.0m	
3.5m		3			3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:

N

S

Orientation

REMARKS (pit stability / water encountered)
Unstable/fast, black water entry @ 2.2m in North end, filled to 3.0m in 5 mins / hydrocarbon odour and sheen

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

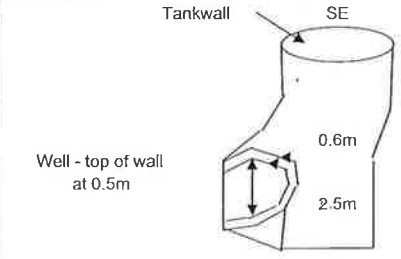
Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP49
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	28/02/2001	SE-NW	3.5 x 5.5 x 2.7m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.3m	1		0.45m -MADE GROUND- Loose brown slightly clayey sandy fine to coarse, angular to rounded gravel of brick, ash, tarmac, grass at top of layer.		0.5m	
			MADE GROUND - Compact clayey sandy fine to coarse, angular to rounded gravel of brick, limestone and concrete with many angular cobbles of limestone and concrete, very clayey in places.		1.0m	
1.5m	2				1.5m	
					2.0m	
2.4m		3		▼	2.5m	
2.6m	4		TP ended at 2.7m.			
			INSIDE WELL (WELL @ 0.5m): MADE GROUND - Loose grey/dark grey slightly silty sandy fine to coarse, angular to rounded gravel with many angular cobbles of limestone with tarry coating. Water standing @ 0.7m in well with tarry odour, well is at least 1.5m deep. Well is of concrete construction similar to 'Rowley Rag' type in concrete ie. with many angular inclusions.		3.0m	
					3.5m	
					4.0m	
0.5m well water	5*	6*			4.5m	
					5.0m	

* Samples within well

ELEVATION:



REMARKS (pit stability / water encountered)
very unstable/brown water with much silt, slight hydrocarbon odour and sheen standing @ 2.4m

SAMPLE DESCRIPTION:

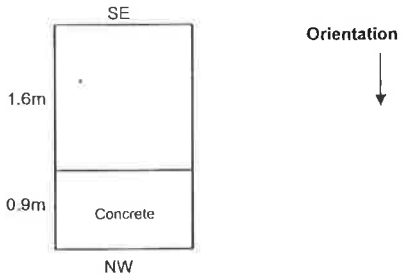
PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

Trial Pit Log

CLIENT:	CONSULTANT:		PROJECT:		TRIAL PIT:
Bord Gàis	Parkman Environment		Limerick Gasworks		TP51
LOGGED BY:	PLANT:	DATE:	ORIENTATION:	PIT DIMENSIONS	JOB NUMBER:
OK	JCB 3CX	03/03/2001	SE-NW	1.2 x 2.5 x 1.35m	25837

SAMPLE Depth (m)	SAMPLE No.	WATER	DESCRIPTION	LEGEND	DEPTH (THICKNESS) (m)	LEVEL (m O.D.)
0.3m	1		0.45m - MADE GROUND - Compact black/dark brown tarmac surfacing and sandy fine to coarse angular to rounded gravel, becoming tarry towards base with tarry odour.			
1.0m	2		MADE GROUND - Compact black sandy fine to coarse angular to rounded gravel with many angular cobbles of reinforced concrete and reinforcing bar, very tarry odour and appearance, very difficult to excavate.		0.5m	
1.25m		3		▼	1.0m	
			Trial pit abandoned @ 1.35m due to difficulty of excavation		1.5m	
					2.0m	
					2.5m	
					3.0m	
					3.5m	
					4.0m	
					4.5m	
					5.0m	

ELEVATION:



Orientation ↓

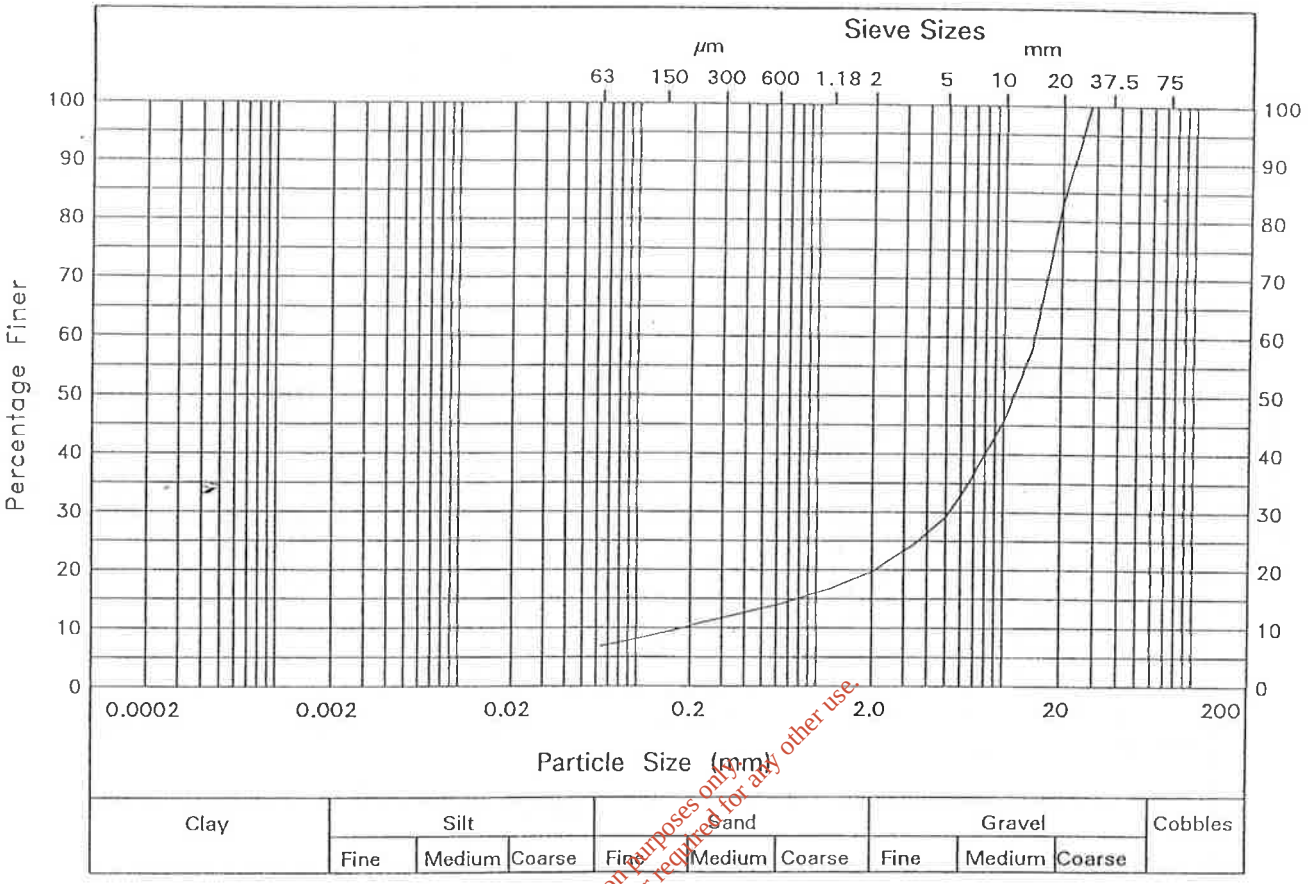
REMARKS (pit stability / water encountered)
Stable/black water with very tarry odour and appearance, and a hydrocarbon sheen standing @ 1.25m

SAMPLE DESCRIPTION:

PARKMAN ENVIRONMENT, Parkman House, Lloyd Drive, Ellesmere Port, South Wirral CH65 9HQ
TELEPHONE: 0151 356 5555 FACSIMILE: 0151 356 4225

GAS MONITORING RESULTS

Sampling Date	05/04/2001				10/05/2001							
Gas Results	CH_4 %	CO_2 %	O_2%	Water Level mbgl	CH_4 %	CO_2%	O_2%	Water Level mbgl	CH_4 %	CO_2%	O_2%	Water Level mbgl
BH31	0	0	20.3	1.9	0	0	20.6	2.8				
BH32	0	0.1	18.3	1.34	0	0	20.5	1.42				
BH33	0.3	0	15.9	0.8	0	0	20.7	0.37				
BH34	0	0.2	19.8	0	0	0	20.6	2.85				
BH11	-	-	-	-	0.2	0	20.2	-				

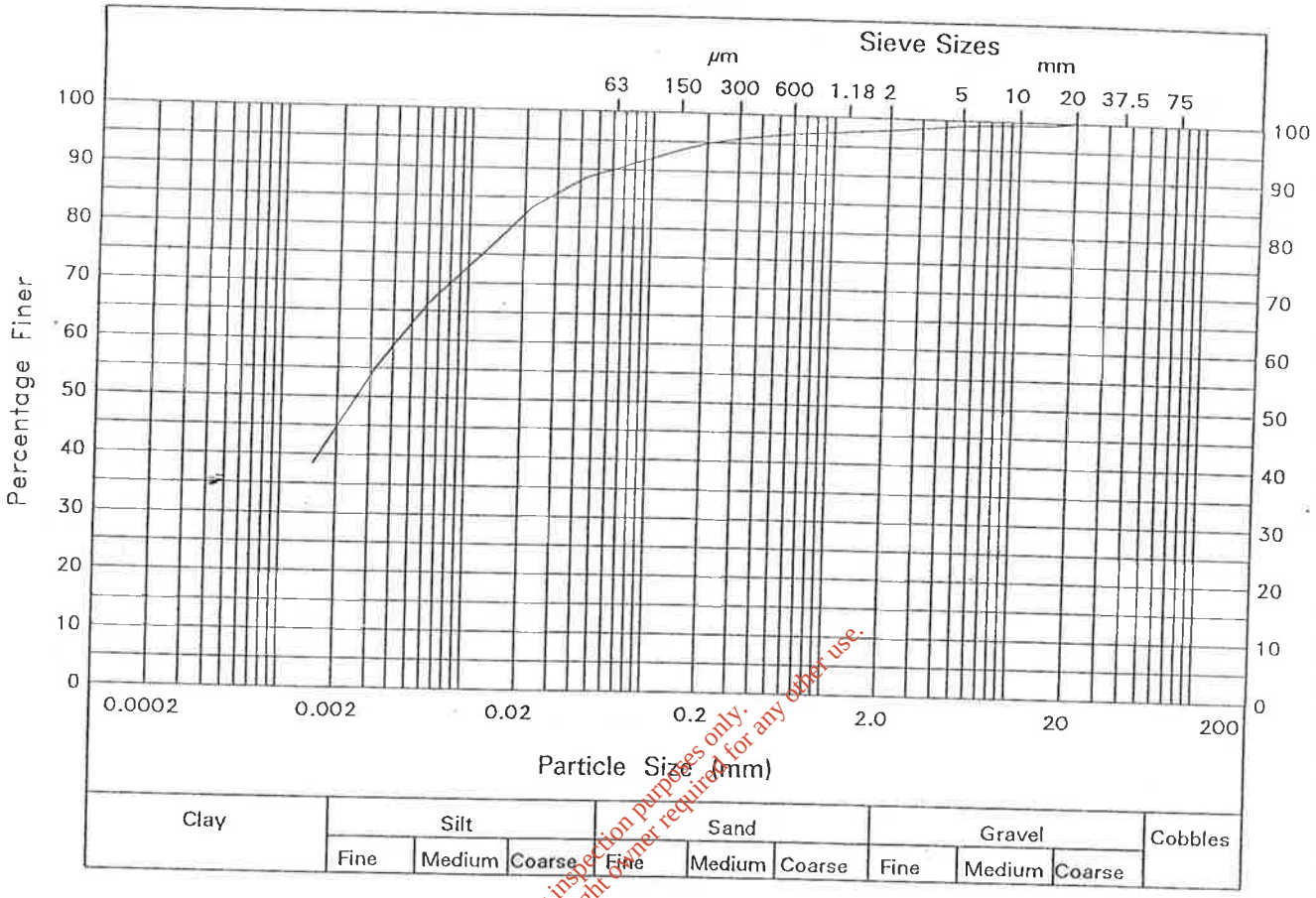


Particle Size	% Passing	Particle Size	% Passing
28 mm	100	150 µm	9
20 mm	83	75 µm	7
14 mm	58	63 µm	7
10 mm	46		
6.3 mm	34		
5 mm	29		
3.35 mm	24		
2 mm	20		
1.18 mm	17		
600 µm	14		
300 µm	12		
212 µm	11		

Hole TP 36	Description *Light brown sl sandy GRAVEL
Depth 0.50 -0.50	
Type B	
Test Performed Wet	Uniformity Coefficient = 77

Form 25/4

Laboratory - Particle Size Plot	**Project** Limerick Gas Works Parkman Environmental	**Contract** 171016/2
GEOTECH		**Sheet**

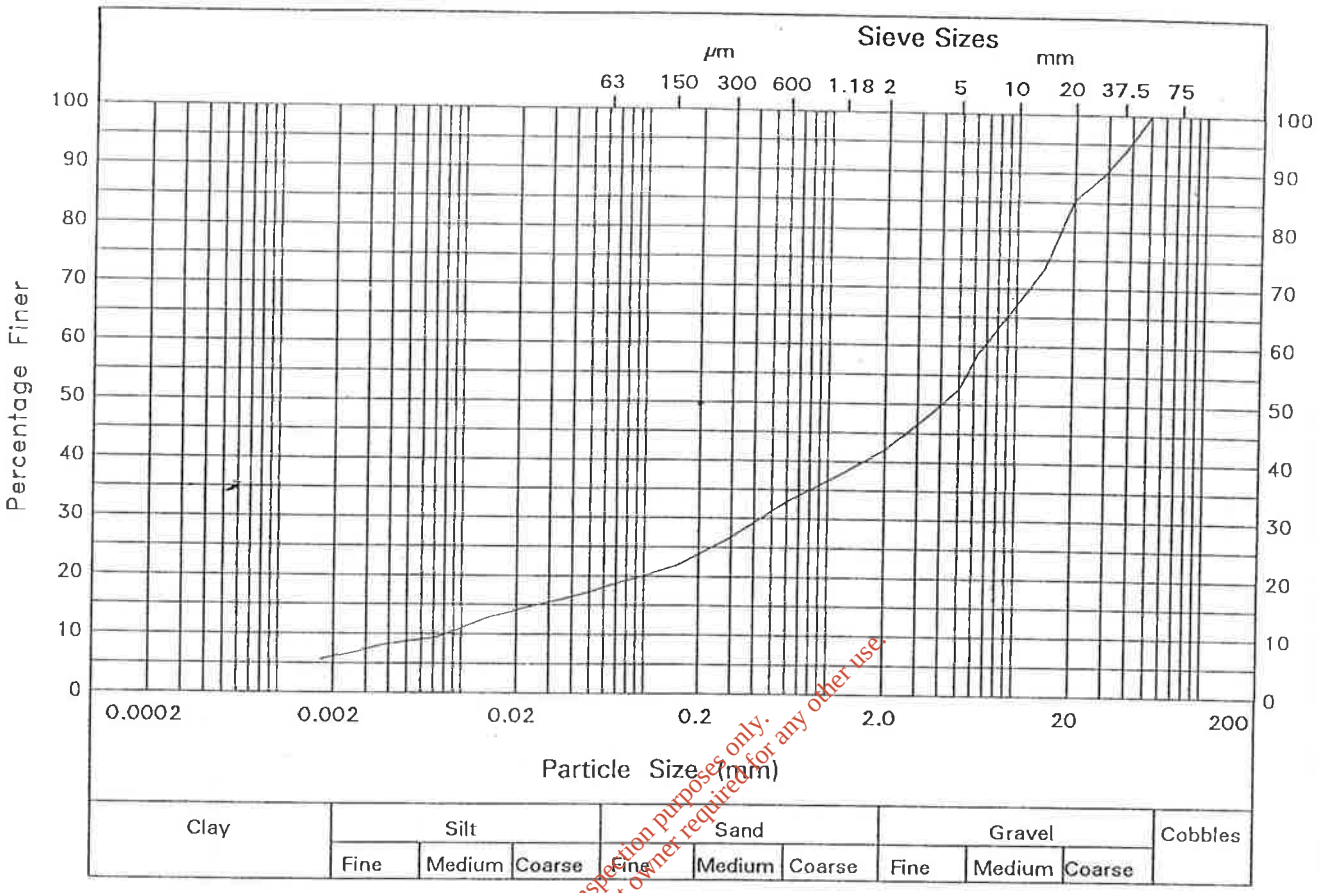


Particle Size	% Passing	Particle Size	% Passing
20 mm	100	75 μm	91
14 mm	99	63 μm	90
10 mm	99	43 μm	88
6.3 mm	99	22 μm	83
5 mm	99	12 μm	75
3.35 mm	99		
2 mm	98		
1.18 mm	97		
600 μm	97		
300 μm	96		
212 μm	95		
150 μm	94		

Hole TP 41	Description *Brown mottled black very sl gravelly stiff CLAY
Depth 0.50 -0.50	
Type B	
Test Performed Wet	Uniformity Coefficient not applicable.

Form 25/4

Laboratory - Particle Size Plot GEOTECH	**Project** Limerick Gas Works Parkman Environmental	**Contract** 171016/2 **Sheet**



Particle Size	% Passing	Particle Size	% Passing
50 mm	100	300 μm	27
37.5 mm	94	212 μm	24
28 mm	89	150 μm	22
20 mm	85	75 μm	19
14 mm	73	63 μm	18
10 mm	67	50 μm	17
6.3 mm	59	26 μm	15
5 mm	53	14 μm	13
3.35 mm	48		
2 mm	42		
1.18 mm	38		
600 μm	33		

Hole BH 31	Description *Black gravel with pockets of brown CLAY
Depth 0.00 -0.50	
Type B	
Test Performed Wet	Uniformity Coefficient not applicable.

Form 25/4

Laboratory - Particle Size Plot	**Project** Limerick Gas Works Parkman Environmental	**Contract** 171016/2
GEOTECH		**Sheet**

Samples				Classification					Strength			Other Tests
Hole	Depth	Type	Description	<425 I_P	Prep w_L	w_P	Water %	γ_b Mg/m^3	Test	σ_3 kPa	C kPa	
BH 31	0.00 - 0.50	B	*Black gravel with pockets of brown CLAY									Particle Size analysis
TP 35	2.00 - 2.00	B	*Light brown sl gravelly SAND				30					
TP 36	0.50 - 0.50	B	*Light brown sl sandy GRAVEL									Particle Size analysis
TP 41	0.50 - 0.50	B	*Brown mottled black very sl gravelly stiff CLAY									Particle Size analysis

Remarks

Form 10/2

Laboratory - Results Summary

GEOTECH

Project
Limerick Gas Works
Parkman Environmental

Contract
171016/2

Sheet

Health & Safety Hazard Assessment

Project name	*Limerick Gasworks, Dock Road, Limerick*
Employer	*Bord Gais, Eireann*
Consulting engineer / architect	*Parkman Limited*
Is any of the investigation over land thought / known to contain hazardous materials?	*Yes*

If Yes

1, Do the contract documents define the area thought / known to contain hazardous materials?	*Yes*
2, Give details of where hazardous materials may be found.	
In any fill materials (Made Ground) encountered on site. A degree of contamination may also be encountered in the underlying natural strata (Soils and rock).	
3, Has and hazard assessment been carried out for this site? If so, by whom? *Parkman Limited*	*Yes*
4, Are details of possible hazardous materials contained in the contract documentation?	*Yes*
5, Is a hazard assessment available? *Attached*	*Yes*

Form completed by *T Brown*	
Date *14.12.00*	
On Behalf of *Parkman :Limited*	
Signature	

Specific details of areas where made ground / hazardous materials are expected

The following information is required for each area involved

Project Name	Limerick Gasworks, Dock Road, Limerick
Location	Limerick, Ireland
Exploratory Hole nos. or area	Bord Gais, Eireann
Present owner/tenent/ operator	Bord Gais, Eirean
Prevoius owner	-
Prevoius use of site	Quarry, Coal Gas Manufacturing and Purification, Land Reclamation

Brief description of nature of hazard expected
By-products from the production and storage of 'Town Gas' (mainly spent oxides and tars)

Has the site ever been used for landfill / tipping?	*Yes*
If so give details and materials thought to have been placed on site Backfilling of former underground features such as tar tanks and general raising of ground (including infilling of former quarry)	
Has the site been licensed?	*No*
if so give details	
Is the licence current	*No*

Assessment of this part of the site under SISG Classification	RED

Special Precautions to be taken – as SISG recommendation

Additional Precautions advised

Designated clean area to be provided. No eating/smoking/drinking to be permitted outside this area. Use of personal VOC. monitoring to be provided for persons working with tar. No lighting of fires. Wear appropriate PPE and RPE for 'Red Category' site.

Form completed by *T Brown*
Date *14.12.00*
On Behalf of *Parkman Limited*
Signature

Checklist of hazards expected – tick as appropriate
If asterisked boxes are ticked please give more details

1	Methane	✓	(Upto 90% recorded)
2	Carbon dioxide	✓	
3	Hydrogen sulphide		
4	Other gases	✓	Hydrogen Cyanide, Phenol/Benzene Volatiles
5	Heavy metals	✓	As, Cd, Cr, Hg, S, Pb, Zn, Ni, Cu, etc
6	Polychlorinatedbiphenyls (PCB)	✓	Associated with former sub-station
7	Hydrocarbons	✓	Phenols, PAH's, BTEX
8	Phenol	✓	
9	Pesticides		
10	Asbestos	✓*	
11	Domestic refuse		
12	Industrial waste	✓	Tar may be acidic
13	pH conditions	✓	
14	Coal tars / polynuclear aromatic hydrocarbons (PAH)	✓	
15	Cyanide	✓	(spent oxide)
16	Combustability hazards (e,g, coal dust)	✓	
17	Radioactivity		
18	Weil's Disease (rats)	✓	
19	Other contaminants		

Form completed by *T Brown*
Date *14.12.00*
On Behalf of *Parkmond Limited*
Signature

Item	Site designation		
	GREEN	YELLOW	RED
Personal Protective Equipment			
Hard hat	*	*	✓
Eye protection		*	✓
Face shield		*	✓
Hand protection	*	*	✓
Overalls	*	*	
Disposable overalls			✓
Waterproof	*	*	
Disposable waterproofs			✓
Industrial boots	*	*	✓
Wellington boots with sole and toe protection	*	*	✓
Respiratory equipment		*	✓
Site equipment/services			
Mobile telephone (outside contaminated area)		*	✓
Ropes, cones and barriers			✓
Safety-warnings signs	*	*	✓
Clean water supply	*	*	✓
Changing room/washing facilities		*	✓
Decontamination unit/washing facilities			✓
Emergency equipment			
Fire extinguisher	*	*	✓
Fire blanket	*	*	✓
First aid kit	*	*	✓

Gasdetection/gas monitoring equipment (where required)
Methane (flammable gas) Hydrogen Sulphide Carbon Dioxide deficiency. Other gases and fumes

Drilling plant/safety equipment (where required)
Spark arrestors and automatic air intake shutdown valves
Air blower
Vertical exhaust stacks and air intakes should be located not less than 1.5m above ground level

RISK ASSESSMENT IN DESIGN SCHEDULE

Job Number:25837 Job Title: Limerick Gasworks

Stage: Ground Investigation

Assessor: Tony Brown 14/12/00 Signature: Date: 14/12/00

Checker: John Crowther 14/12/00 Signature: Date: 14/12/00

Sheet No. 1 of 1

Activity/ Element	Potential Hazards	Population At Risk				Risk Analysis P*S=RF				Risk Evaluation		Describe Control	Residual Risk Evaluation				Residual Risk Description	Refer To Person	Info Destination S&H Plan/ Safety file
		Contractor	Client	Public	Tenant	P	S	R	Cat. L/M/H	Eliminated	Controlled		P	S	U	C.A.T.E.R.			
Trial Pitting and Borehole Excavation	Fall into Pit	✓				4	3	12	M		✓	Keep away from pit excavation if possible. Stand at end pf pit. Do not enter.	2	3	6	I	Personnel falling or tripping into pit accidentally.	Project Supervisor (Construction)	S&H Plan
	Hit by machinery	✓				4	5	20	M		✓	Wear high visibility clothing, keep away from machinery.	1	5	5	I	Accident occurring despite controls	Project Supervisor (Construction)	S&H Plan
	Contact with contaminated material	✓				6	5	30	H		✓	Wear PPE & RPE for red classification site, no eating, drinking or smoking.	1	5	5	I	Damage to clothing	Project Supervisor (Construction)	S&H Plan
	Buried services	✓				3	9	27	M		✓	CAT scan location, use service location plan, liase with service companies. Dig hand excavated inspection pit (if in doubt).	1	9	9	I	Failure to locate services despite controls	Project Supervisor (Construction)	S&H Plan
Other personnel entering working area.	Contact with contaminated material, injury caused by tripping/ falling.			✓	✓	6	5	30	H		✓	Public excluded from site. Tenants excluded from working areas by Contractors/Parkman Staff.	1	5	5	I	Breach by trespassers	Project Supervisor (Construction)	S&H Plan
Public present on site after completion of works.	Subsidence in area of exploratory holes –physical injury.			✓	✓	4	3	12	M		✓	Good specification of reinstatement.	1	3	3	I	Unexpected consolidation of ground after reinstatement.	Project Supervisor (Construction)	S&H Plan
	Contact with contaminated material disturbed during investigation			✓	✓	4	5	20	M		✓	Most heavily contaminated material to be replaced in excavations. Contaminated water to be stored in tank. Remaining contaminated material to be securely stored on site.	1	5	5	I	Contact with low levels of contamination.	Project Supervisor (Construction)	S&H Plan

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FAXED

FAX

To	Noel Kiely	Date	12 July 2000
Of	Waterford Corporation	Direct Contact fax/tel/e-mail	
Fax	00353 5 1870813	Job No	25836/2/1
From	Tony Brown		
Re:	Environmental Information		

Noel

I spoke to one of your colleagues this afternoon and understand that you may be able to supply the following information in connection with the site identified on the attached plan. The study area is bounded to the north by John's River and to the south by Johnstown Industrial Estate. The information is required in connection with a desk study which is being currently prepared on the site.

1. Are you aware of any substantial sources of contamination within 500m of the site which could affect the environmental integrity of the site (except for the gasworks themselves)?
2. Are there any known landfills within 500m of the site?
3. Does the Corporation have any data on Water Quality in the vicinity of the site (particularly John's River)?
4. Are there any licenced groundwater abstractions within 500m of the site?
5. Are there any licenced discharges to the river within 500m of the site?
6. Are there any cases of statutory nuisances within 500m of the site which would affect the environmental integrity of the site?

We thank you in advance for your help in this matter. If you have any queries, please do not hesitate to contact me.

Regards

Total number of pages 2	*Please contact Parkman if any pages are missing or unclear.*

Parkman Ltd
Parkman House, Lloyd Drive, Ellesmere Port, South Wirral L65 9HQ
Tel: 0151 356 5555 Fax: 0151 356 4255

1996

Certificate no FS 15024

WATERFORD CORPORATION
BISHOPS PALACE,
THE MALL,
WATERFORD.

FAX NO. 051 - 870813
TEL NO. 051 - 309900

CITY ENGINEERS

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To: TONY BROWN
From: CHRIS O'SULLIVAN
Fax: 0044 1513564255
Pages: 1
Phone: 0044 1513565555
Date: 21/8/00
Re: ENVIRONMENTAL INFORMATION JOB No. 25836/2/1
CC:

☐ Urgent ☑ For Review ☐ Please Comment ☐ Please Reply ☐ Please Recycle

• Comments: Regrets for delay but I now confirm hereunder the following (i.e. replies in order of your queries);

(i) No.

(ii) NONE THAT WOULD HAVE BEEN USED WITHIN THE PAST (40-50) YEARS

(iii) YES. ANALYSIS OF JOHN'S RIVER WATER INDICATES SERIOUS POLLUTION. B.O.D., AMMONIA, PHOSPHATE, IRON LEVELS ARE HIGH. A PROGRAMME FOR IMPROVING THE WATER QUALITY IS BEING IMPLEMENTED.

(iv) NONE KNOWN.

(v) No.

(vi) No.

I trust that the above answers your queries,

Regards,

Chris O Sullivan
EE Sanitary & Environment

TP 31

TP 31 Spoil

TP 32

TP 32 Spoil

TP 33

TP 33 Spoil

TP 34

TP 34 Spoil

TP 35

TP 35 Looking North at Tank Wall

TP 35 Looking South at Tank Wall

TP 36 Looking North West Showing Brickwall on Rignt Hand Side

TP 36 View of 0.5m Thick Gasholder Base

TP 36 Spoil

TP 37 View North Showing Brick Tank Wall

TP 37 Spoil

TP 38

TP 38 Spoil

TP 39

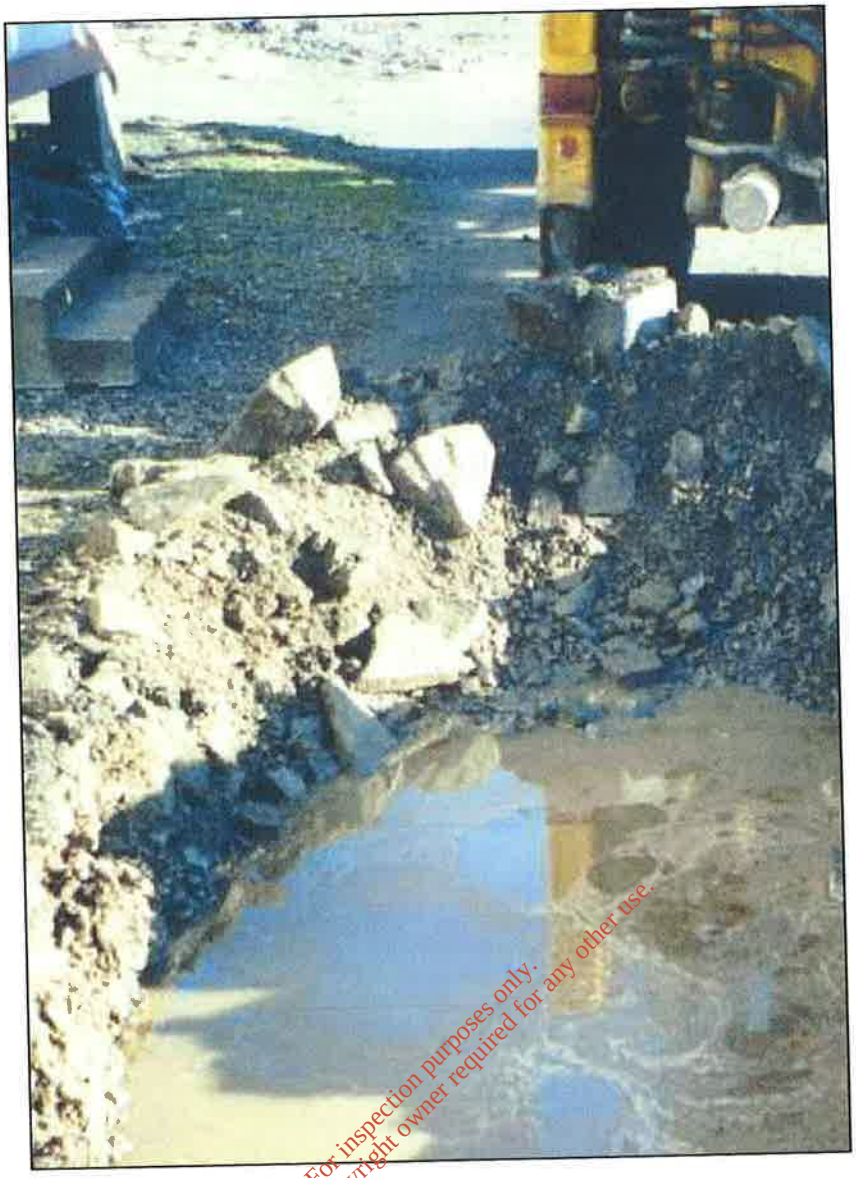
TP 39 Spoil

TP 40

TP 40 Spoil

TP 41 View South East Showing Service Duct and Gas Main in Left Hand Side

TP 41 Spoil



TP 42

TP 42 Spoil

TP 43 View North East

TP 43 View North East

TP 43 View SW

TP 47 Showing Tank Wall

TP 47 Spoil

TP 48 View North into Contents of Tank

TP 48 Spoil

TP 48B View into Contents of Tank

TP 49 View North of Wall

TP 49 View East of Wall

TP 49 View South Towards Tank Wall With Well Shown on Left Hand Side

TP 49 Spoil

TP 51

TP 51 Spoil

BORD GÁIS

Limerick Gasworks
Dock Road, Limerick

Site Investigation
General Report
Volume 2

October 2001

Parkman Environment,
Parkman House, Lloyd Drive
Ellesmere Port, South Wirral
CH65 9HQ

Report No:
25837/OR/04B

Copy No:

REPORT CONTROL SHEET

BORD GÁIS

PROJECT NAME: Limerick Gasworks

REPORT TITLE: Site Investigation General Report Volume 2

REPORT REFERENCE: 25837/OR/04B

Version Date	Detail	Prepared by Date	Checked by Date	Approved by Date
A	Draft for Client Comment	D Watts	T Brown	J Crowther
B	Final	D Watts	T Brown	J Crowther

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Page No.

VOLUME 2

TABLES

DRAWINGS

Note
All Figures, Appendices and References referred to in the text are located in Volume I of this report.

0.0 EXECUTIVE SUMMARY

Appointment	Parkman Environment were appointed by Bord Gáis Éireann in a letter dated 30th May 2000 to provide Engineering Consultancy Services for the documentation / remediation of the former gasworks sites at Limerick and Waterford. This document comprises Volume 2 (general information) for the Phase II (intrusive investigation) report for the Limerick Gasworks site.
Location	The site lies to the south-east of the Dock Road in the City of Limerick, approximately 100m from the River Shannon; the approximate National Grid Co-ordinates are E 157600 N 157200.
Services	All main services are present in Dock Road, St. Alphonsus Street and O'Curry Street; some gas services enter the site along the north-west boundary of the site and an electricity cable is shown running into the electricity sub-station from O'Curry Street. Private services may also exist on the site.
Geology & Hydrogeology	The site is underlain by various thicknesses of Made Ground, overlying Lower Carboniferous Limestone (Visean Limestone); thin layers of Alluvium deposits have been identified in some locations overlying the bedrock. The Limestone is considered to be a locally important aquifer and due to limited drift cover could be considered vulnerable. The nearest recorded abstraction is 6 km to the south-east of the site.
Site History	A limestone quarry extended over most of the eastern quadrant of the site prior to 1840. The gasworks was established to the north-west of the quarry in the 1830's. Several generations of gasworks producing 'town' gas occupied the site until gas manufacture was converted to oil - gas production in the late 1960's / early 1970's. The arrival of natural gas to Limerick in 1986 made the generating process redundant and most above ground structures were demolished by 1988.
Previous Site Investigations & Results	Two previous site investigations have been carried out on site in 1990 and 1995 comprising a total of 27 trial pits and 12 boreholes. Visual and olfactory evidence of organic contaminations was noted in a large number of exploratory holes, particularly over the south-western part of the site. Tarry staining was identified in the bedrock joints in four boreholes. Groundwater was contaminated with heavy oils and oozing tarry liquid particularly on the western side of the site. The results of leachate testing showed that the potential for leaching was low.
Recent Site Investigation	A total of 17 trial pits and 4 rotary boreholes were excavated between 26 February and 6 March 2001. Samples of soil and water were selected and sent to City Analytical Services plc (CAS) in Coventry, UK for subsequent chemical analysis. Samples were also taken for geotechnical analysis. Gas/water monitoring standpipes with taps were fitted to all 4 boreholes.

Remediation Components	Hydrocarbons are considered to be the major contaminant across the site, with a lesser degree of cyanide contamination adjacent to the former purifiers. Any contaminated groundwater encountered would require treatment prior to discharge to foul sewer. The remediation strategy will include preparation of a QRA, obtaining appropriate licences and permits including a waste management licence and EIS, selection of contractor, physical siteworks including demolition and remediation trials, validation and monitoring. The main available remedial options are bioremediation, soil washing, thermal treatment, solidification/stabilisation/encapsulation and chemical treatment.

1.0 INTRODUCTION

1.1 Terms of Reference

Parkman Environment were appointed by Bord Gáis Éireann in a letter dated 30 May 2000 (ref. No. 00/004) to provide engineering consultancy services for the decontamination/remediation of the former gasworks sites at Limerick and Waterford. These services include the preparation of Phase I (Document Review) and Phase II (Intrusive Investigation) reports. This document comprises Volume 2 (General Report) of the Phase II report for the Limerick gasworks site. Factual data in connection with the intrusive investigation is presented in Volume 1.

Bord Gáis propose to either dispose of the sites in their current condition or alternatively, remediate them ready for development.

The site reviewed in this report is based on the boundaries as defined by Bord Gáis Éireann at the time of the review. Parkman Environment prepared this Report based on the available information obtained during the study period. Every reasonable effort has been made to obtain all relevant information. Sources examined are listed in section 1.2.

This Report has been prepared and written for the exclusive benefit of Bord Gáis for the purpose of providing environmental information relevant to the existing potential environmental liabilities associated with the site in accordance with the Brief. The Report contents should not be used out of that context. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the Report after the date of its submission.

1.2 Methodology

The preparation of the Phase II report involves a review of all current available site information, a review of the information collected during the recent site investigation and discussion of available remediation techniques.

In undertaking the study, the following sources have been consulted: -

Limerick Corporation - Environment, Community & Sport Department
- City Engineer's Department
Environmental Protection Agency
The National Library of Ireland
Geological Survey of Ireland
The Map Library, Trinity College, Dublin
Eircom Ireland
ESB
Bord Gáis Éireann
GVA Donal O'Buachalla (Estate Agents)

Contact details for the above are provided in Appendix A of Volume I of this report. Other references used in completing this report are provided in Section 8.0 of

Volume I of this report.

A walkover survey was undertaken on 13 July 2000 and Mr Michael Shouldice, the Site Manager for Bord Gáis, was interviewed by Parkman.

Site investigation works were carried out between 26 February 2001 and 6 March 2001.

GVA Donal O' Buachalla (Estate Agents) were also consulted with respect to potential future uses for the site.

1.3 Report Format

This Report (volume 2) is sub divided into five sections. Following this Introduction [Section 1], the findings of the Phase I Desk Study are reviewed [Section 2]. The information gathered during the recent site investigation is then presented [Section 3]. Finally, the remediation components are discussed [Section 4]. All of these sections are summarised in tabular form in the Executive Summary [Section 0].

2.0 DESK STUDY ASSESSMENT

2.1 Site Location and Description

Limerick gasworks lies to the south-east of the Dock Road in the City of Limerick, approximately 100m from the River Shannon. The Shannon Bridge lies approximately 400m to the north-east of the site. The approximate National grid co-ordinates of the site are E 157600 N 157200 (see figure 1).

Access to the site is either from Dock Road, which forms the north-western site boundary, or from O'Curry Street forming the north-eastern boundary.

The site is approximately rectangular, 130m x 110m, and covers an area of 1.4 hectares (3.5 acres) including the "house pound" area in the northern corner, adjacent to the junction of Dock Road and O'Curry Street. Part of the site was a former limestone quarry and rock faces are evident in the north-eastern and south-eastern boundaries.

The main area of the site is generally level at about 5.00m OD [Malin Head Datum] but it rises to approximately 8.00m OD towards the site boundaries to the south and east (see figure 2).

The site is used as a depot for Bord Gáis, and includes a two-storey office adjacent to the south-west boundary. Other buildings on-site include a derelict former store building constructed of stone in the eastern corner and various other smaller brick buildings including the former No.'s 3 & 4 Store, the former Naphtha Process Control building (two-storey), ESB sub-station and the former Governor House.

In addition, high stone walls remain around the location of the former gasholder No 2 (T12) whilst the concrete bund walls and slab are present around the former Tank No 1 (T31). An above ground installation [AGI] remains towards the north west corner of the site adjacent to the site access from Dock Road.

The north-eastern boundary along O'Curry Street comprises a 2m high limestone block wall that becomes higher (3.5m) halfway along the boundary towards the south-east. The south-eastern boundary comprises a 6m high limestone block wall that retains the adjacent former Garda training centre, at a level some 2m above the Bord Gáis site level. This wall becomes a 3m high brick retaining wall (which retains limestone fill on the site side) in its south-western end adjacent to residential properties. The south-western boundary comprises a 2.5m high brick wall, which retains fill to 2.5m on the site side. The north-western boundary along Dock Road comprises a 2.5m high limestone block wall.

2.2 Statutory Authorities/Services

Limerick Corporation report that they are not aware of any other substantial sources of contamination within 500m of the gasworks site.

There are no known landfills within 500m of the site.

There are no statutory nuisances within 500m of the site.

Limerick Corporation sewers presently discharge into the River Shannon although a new main drainage scheme is currently being constructed and will subsequently collect all such discharges and route them to a new sewage treatment facility. No other discharges are made into the river. Correspondence with Limerick Corporation is included in Appendix F.

Details of consultees that provided services information in the vicinity of the study area are included in Appendix F.

All main services are provided along the Dock Road, St. Alphonsus Street and O'Curry Street. Electricity cables are shown running into the electricity sub-station from O'Curry Street. Bord Gáis pipelines are shown entering the AGI in the western corner of the site. Low pressure 180mm PE gas pipes also exist in the site along the eastern end of the Dock Road boundary. Private services may also exist on the site.

Figures 3a-e show the layout of services in relation to the site at a scale of 1:1000.

2.3 Geology, Hydrology and Hydrogeology

The Geological Survey of Ireland Sheet 17 Limerick, 1:100,000 Scale (ref. 7), the "Geology of the Shannon Estuary" (ref. 8) and the local geological memoir were consulted and indicated that the bedrock beneath the site comprises the Visean Limestones of the Lower Carboniferous Period. These limestones are 'oolitic' (small (≤1mm diameter) carbonaceous accretionary bodies cemented together, resembling fish eggs) in places, representing a shallow marine carbonaceous shelf depositional environment. These deposits occasionally contain clay 'wayboards' which formed when the limestone was periodically exposed above sea level. The limestone often contains chert nodules (siliceous concretions) and thin interbedded shales. The Visean Limestone is also known as 'Clean Shelf Limestone'. It is over 800m thick and lies conformably on the Waulsartion Limestone, described as a massive unbedded lime mudstone representing a deeper marine depositional environment.

Beneath the site, the beds dip 8° to the north. The site is located on the southern limb of an east-west trending syncline.

The rockhead is close to the surface with little or no drift cover. Should any be present, it is likely to comprise very recent fill [made ground used as backfill in the construction of the gasworks and infilling of the quarry] or Recent alluvium associated with the River Shannon flood plain.

The site is situated on the southern bank of the Shannon River, which flows westwards towards the Atlantic Ocean. The Shannon River will be tidally affected at this point.

The site comprises approximately 60% hard cover and 40% free draining material (with many underground structures that may impinge on the flow of water through the made ground). There is a slight fall in the site level from the south-east (3m OD) to the north-west (5m OD), and so any surface infiltration that does not enter the surface drainage system will tend to flow in the fill materials towards the north-west corner, i.e. towards the River Shannon. The River Shannon water level is typically 3m OD near the site.

Drainage of the site is to the city's sewers, which discharge directly into the river. The 'Site Investigation Report - Limerick Gasworks Site ' (ref 2) records that storm water flooding has occurred in the past along the Dock Road at its junctions with O'Curry Street and Alphonsus Street, i.e. close to the site.

The maximum recorded flood level for the City is reported as 4.25m OD (Malin Head).

The Groundwater Protection Maps for County Limerick (Maps 1-6) (ref. 6) indicate that the Clean Shelf Limestone is a 'Locally Important Aquifer' that is generally Moderately Productive (40-100m^3/d). The aquifer is controlled by fissure flow and well-developed karst features have been observed in the area. The nearest abstraction well is 6 km to the south-east of the site. The oolitic limestones of the Limerick Syncline are known to have relatively high permeabilities. The aquifer is considered 'Vulnerable' due to the lack of impermeable cover.

The majority of the ground water is hard, containing calcium bicarbonate (Ca $(HCO_3)_2$). Iron and manganese have been found in elevated concentrations west of Limerick. Elevated nitrates have been encountered in some locations due to agricultural activities. Groundwater quality of smaller, shallower sources is generally poorer than the larger, deeper sources.

There are no recorded active wells or boreholes in the vicinity of the site although the historical site plan dated 1977 shows a well 5m to the north west of Gasholder No3 (T11).

It is likely that hydraulic continuity exists between the Made Ground/Alluvial deposits and the bedrock.

The proximity of the site to the tidal inlet of the River Shannon would suggest the potential for groundwater on site to be tidally affected; this would need to be confirmed by on-site monitoring.

2.4 Site History

An extract from the Autumn 1987 Limerick Journal entitled "150 Years of Limerick Gas" (ref.10) provided a background history to the site.

The article states "In 1826, the London-based United General Gas Company took over the Hibernian Gas Company in Dublin and soon began to spread its operations

to the large urban areas throughout the country. It set up businesses in Limerick in the 1830's and became the sole manufacturer of gas in the city. But the service was very poor and the people's patience became so exhausted that in the year 1837 a public protect meeting was convened in the City Courthouse.... shortly afterwards, the newly reformed Corporation purchased premises in Watergate for the manufacture of gas, with the aid of a loan of £24,000. In 1878 following a Parliamentary enquiry and the passing of the Corporation Gas Act, the Local Authority took over the private firm and in 1884 moved from Watergate to the more spacious premises at the Dock Road."

Coal based gas manufacture is reported to have continued on site until the early 1970's and the article also states that "it was only in 1974 that the new catalytic oil-gas plant was finally completed in the city.....in 1986, natural gas was piped to Limerick on a spur line from the main Dublin-Cork pipeline. In early 1987, new natural gas pipelines were laid throughout the city and the change over from 'town' gas was complete. The old manufacturing process has been rendered obsolete and the plant at the Dock Road is nothing more that a relic of industrial archaeology."

2.5 Assessment of Previous Site Investigations

2.5.1 Description of Works Undertaken

Two site investigations have been carried out previously to assess the level of contamination on site (see figure 6 in Phase I report).

The first was carried out in 1990 by Gibb Environmental (environmental sampling) and Irish Geotechnical Services Limited (trial pitting and borehole excavation) under the direction of O'Connor Sutton Cronin and Associates Limited (ref.1). This comprised ten trial pits to between 1.4m and 2.3m deep and six boreholes to between 4m and 7.6m deep, the latter to prove rock.

Twenty-one soil samples were analysed for pH, sulphate, sulphide, cyanide (total & free), phenols, and toluene extractable material, with four also analysed for speciated PAH's and calorific value. Four water samples were analysed for pH, ammonia nitrogen, sulphate, total organic carbon (T.O.C.), total cyanide and total phenols as tar acids. One sample of water and one sludge sample were analysed for speciated PAH's.

The second investigation was carried out by K T Cullen and Company and Glover Site Investigations Limited under the direction of Ove Arup & Partners in 1995 (ref.2) and comprised 17 trial pits to between 0.15 m and 3.7m deep and 6 boreholes to between 5m and 11.8m deep and 5 surface (scraped) samples.

Fifty-five soil samples were analysed for pH, sulphates, total cyanide, toluene extractable material and total phenols. Based on the results obtained, selected samples were then subjected to analysis for dependant options comprising PAH'S, BTEX, free & complex cyanide, thiocyanate and water soluble sulphate.

In addition, selected samples were also analysed in respect of metals, mineral oils and total VOC's and a further two were the subject of a leachability test.

Twenty-three water samples were taken and analysed for a suite comprising total phenols, sulphide, ammoniacal nitrogen, total cyanide, speciated PAH's, pH, temperature and conductivity. Eleven samples were also subjected to a suite of tests including organic and inorganic determinands.

Monitoring was carried out subsequently on two occasions in respect of groundwater levels and gas levels.

The results of both investigations are reported and discussed in Ove Arup's April 1996 Site Investigation Report on Limerick Gasworks Site (ref. 3).

2.5.2 *Details of Ground Conditions*

The following succession of strata was identified from the two previous investigations: -

Table 2.5.2 Summary of ground conditions (1990 and 1995 investigations)

Stratum	Thickness (m)	
	Range	Average
Made Ground	0.2 - 7.3	2.6
Alluvium	0.0 - 4.4	1.8
Limestone	4.2m proven	

The Made Ground was found to be variable in nature and consistency. The exploratory holes describe the made ground as variable but predominately granular.

The Made Ground contains sand, gravels, cobbles, clays, brick rubble, spent oxides, ash, concrete etc. and was often contaminated with tarry liquid and occasionally has a strong phenolic odour. The deepest thicknesses of made ground were associated with either the old quarry or former tanks that extended underground.

The Alluvial deposits were found in at least three excavations (BH11, TP7 and TP27) towards the northern end of the site beneath the Made Ground, and were described as soft to firm brown plastic silty clays. Some materials encountered in other excavations may have also been Alluvial deposits, although it was unclear from the descriptions provided.

The top 0.5m to 1.0m of the bedrock was generally weathered and comprised of gravel to boulder size fragments of angular limestone. Below this level the bedrock comprises strong dark to medium grey coarse grained fresh, bedded Limestone. Total Core Recoveries (TCR) were in the range 14% to 100% with an average of 76%. Rock Quality Designation (RQD) values were also in range 14% to 100% with an average of 64%. The rockhead was often described as "stained with black tar" over a depth of up to 3m.

The bedrock surface was found to be very uneven due to previous quarrying activities and excavation for underground tanks and tank foundations. The natural slope of the bedrock is from approximately 7m OD at the southern boundary to 3m OD at the northern boundary.

Rockhead was encountered at a depth of 8.6m (-1.64m OD) in BH11 near the middle of the site from the 1995 investigation. This identifies a former quarry feature. This is shown on the historical map for 1872, reference Figure 4C included in the Phase I report.

Groundwater was encountered in all of the trial pits and boreholes at depths between 0.3m and 2.8m in the Made Ground. The general direction of groundwater flow was found to be north/north-west towards the River Shannon from a level of approximately 7m OD on the southern side of the site to approximately 4m OD on the northern side of the site (The River Shannon water level is typically 3m OD near the site).

2.5.3 *Details of Analysis*

Initial screening of the site investigation data has been undertaken using the UK ICRCL Threshold Trigger Values (least sensitive end use), for soils (where available), with the Dutch Intervention Values considered for soil contaminants not covered by the ICRCL list. The only exception to this is in the case of PAH where screening assessment criteria has been set at the Acton Trigger Level for the most sensitive end use. Figure 6 in the Phase I report identifies the soil samples where contamination levels have exceeded these initial screening levels.

This screening provides a basic assessment of the areas of site requiring remedial action, although it is recommended that a site specific quantitative risk assessment be carried out to establish remedial action values.

In general, the most significant soil contamination at Limerick gasworks was organic, with evidence of heavy staining by tars and tarry liquid with a phenolic odour being encountered in most of exploratory holes, particularly over the south western part of the site. Tarry staining penetrated into the bedrock joints in BH's 7, 8, 10 and 11. Elevated levels of organic contaminants were encountered in TP's1, 2, 8, 15, 19, 22, 23 and 24, mostly in the vicinity of former tanks. The contamination is most likely due to spillages and leaks from the tanks. Visual evidence of spent oxide ("blue billy") was encountered in the central area of the site (old quarry area), with associated elevated cyanide levels.

Generally there were no significantly elevated metal levels found at the site with the exception of the area around the chimney of the original gasworks (in the vicinity of T12), the elevated levels apparently being associated with ash from burning.

The groundwater encountered in the trial pits on the western side of the site were contaminated with heavy oils and oozing tarry liquid. Floating product with

globules of tarry material was detected in three of sixteen trial pits, these are associated with buried structures (e.g. tar tanks). Tarry liquid was discovered to have penetrated downwards into the joints of the bedrock across the central area of the site.

Elevated levels of contaminants in groundwater occurred in generally the same areas as elevated levels of soil contamination, possibly suggesting that the groundwater is not very mobile. Generally, no significantly high metal concentrations were detected in the groundwater, except in trial pits in the area of the old gasworks (near T12).

The results of chemical testing on the surface samples scraped from the masonry walls around the site showed elevated levels of sulphates and various organics.

The results of leachate testing showed that the potential for leaching was low, the measured concentrations being less than 0.1% of the original value. The exception was that 28% of the phenol in TP15 was extractable following leaching.

A second set of groundwater samples were taken about six weeks after the initial sampling. There was no significant difference in the results, one possible exception was BH8, where there was a significant increase in the concentration of phenol and a decrease in the concentration of PAH's. These results were associated with a significant decrease in temperature of the sample.

Elevated levels of methane (>1%) were recorded within borehole monitoring installations during a total of seven visits in BH's 7, 8 and 10 although the most significant levels (up to 90%) were recorded in BH12. The levels of methane recorded were generally significantly higher than the explosive limit (5 - 15%). The velocity of the gas flow was measured and found to be negligible. A tube sample of gas was taken from BH12 and analysed using GCMS. Traces of Kinsale Natural Gas was detected, suggesting that the elevated methane levels may have been due to a leak in a nearby gas main.

Levels of carbon dioxide ranged between 1.7 - 3.2% in BH's 7, 8, 10 and 12. Levels of oxygen were reduced significantly in all boreholes and were accompanied by elevated levels of carbon dioxide and methane. No hydrogen sulphide was found in any of the standpipes.

2.6 Development

2.6.1 Development Options

GVA Donal O'Buachalla have indicated in correspondence that the site may be suitable for three potential uses as listed below: -

i. Commercial offices, retail, leisure, car sales etc.

ii. Residential, but excluding townhouses with gardens.

iii. Car park, either a surface or multi-storey.

It is noted that storm water flooding has occurred in the past along the Dock Road at its junctions with O'Curry Street and Alphonsus Street. Limerick Corporation require a minimum floor level of 4.7m OD for any new development. The maximum recorded flood level for the City is reported as 4.25m OD.

It is likely that the No. 5 Stores building in the eastern corner of the site will remain as a part of any proposed development.

2.6.2 *Access*

Current site access is either via Dock Road, which forms the north-western site boundary, or from O'Curry Street forming the north-eastern boundary. The site access from O'Curry Street was not secured at the time of the site visit and does not appear to be generally locked. The access gate off Dock Road is the main access to the site for Bord Gáis personnel and is kept locked and secure when the site is not in use.

The current site access off Dock Road would be considered most suitable with respect to the proposed uses of the site although the access from O'Curry Street may be appropriate for small vehicles such as cars.

2.6.3 *Services*

All main services (gas, electricity, telecommunications, water and sewerage) are present in the Dock Road and O'Curry Street. Electricity cables are shown running into the electricity sub-station from O'Curry Street. Bord Gáis pipelines are shown entering the AGI located in the western corner of the site. Low pressure 180mm PE gas pipes also exist in the site along the eastern end of the Dock Road boundary.

In view of the above and further to initial discussions with the statutory utilities, there should be no problems in providing these services at the site. However, detailed discussions will be required to determine the most appropriate connections to existing services, once the precise requirements of the development are known.

2.6.4 *Boundary Conditions*

Existing site boundaries comprise a 2m high limestone block wall (which becomes higher (3.5m) halfway along the boundary towards the south-east) along the north-eastern boundary along O'Curry Street. The south-eastern boundary comprises a 6m high limestone block wall that retains the adjacent former Garda training centre at a level some 2m above the Bord Gáis site level. This wall becomes a 3m high brick retaining wall (which retains limestone fill on the site side) along its south-western end, adjacent to residential properties. The south-western boundary comprises a 2.5m high brick wall, which retains fill to 2.5m on the site side. The north-western boundary along Dock Road comprises a 2.5m high limestone block wall. The boundaries are considered generally secure at present, although trespassers can

gain access over a low wall along O'Curry Street or via the gates on O'Curry Street which do not appear to be generally locked.

A survey of the boundary walls has been carried out by Parkman (report No. 25837/OR/02) on the 6th and 7th March 2001. The report concludes that in places the walls are in a poor state of repair and it is recommended that they are demolished prior to remediation, especially in areas when excavation is required close to the walls.

3.0 SITE INVESTIGATION

3.1 Field and Laboratory Work

The recent site investigation was planned and supervised full-time by Parkman Environment who also scheduled the analysis of soil and water samples. The ground investigation was carried out by Geotech Specialists Limited. A total of 17 trial pits and 4 rotary boreholes were excavated between 26 February and 6 March 2001. Trial pitting was conducted using a JCB 3CX excavator. Rotary holes were drilled using a Soil Mech 215 rig. These exploratory holes were set out to identify the location of underground structures associated with building foundations, various former tanks, and the depth and nature of made ground and the underlying natural strata. The locations of the exploratory holes are shown on Drawing No. 25837/OB/01 (see Volume I).

Samples of soil and water were selected and sent to City Analytical Services plc (CAS) in Coventry, UK for subsequent analysis. Analyses were carried out in accordance with British Gas Property "Guidance for Assessing the Potential Contamination on Gasworks Sites" Version 2.4. The results of contamination analyses are included in Appendix A; trial pit and borehole logs are presented in Appendix B, and photographs taken during the investigation are included in Appendix G. Bulk samples were taken for geotechnical analysis. The results of the geotechnical testing carried out are included in Appendix D. All appendices referred to above are contained in Volume I.

Gas monitoring standpipes with taps were fitted to all 4 boreholes. These took the form of slotted pipes surrounded with gravel, sealed at the surface with bentonite clay and covered with vandal proof covers.

Monitoring of water levels within all installations (including boreholes from previous investigations that still remain) has been undertaken on two occasions so far, on 2 April and 8 May 2001.

On-site monitoring of gas by a GA-90 infrared detector from the recent installations has been undertaken on two occasions so far, on 2 April and 8 May 2001.

Groundwater samples were also taken from the gas/water monitoring installations. Samples were sent to CAS plc for analysis.

Details of the water and gas monitoring are included in Appendix C.

Samples were obtained from two local quarries and sent to CAS for analysis. The samples were taken to provide information on potential sources of backfill during any future remedial works. The results of the chemical analysis are included in Appendix A.

3.2 General Ground Conditions

The following section describes the ground conditions identified by the recent site investigation carried out by Parkman Environment.

The general sequence of ground conditions comprises made ground overlying river deposits of silt and limestone bedrock.

The made ground was found to predominantly comprise granular material of sand and gravel/cobbles of limestone, brick, and concrete with some clay and pieces of clinker, glass and metal. Gravel to cobble sized pieces of iron oxide and some spent oxide was identified near the former purifiers. Hydrocarbon contamination was recorded in approximately 70% of the trial pits excavated. The depth of made ground varied between 0.04m and greater than 3.6m below ground level (mbgl) in the trial pit excavations although it is noted that some of them were excavated within former tanks. Made ground was recorded to a depth of 7.15mbgl in BH34, which is located in the area of the former quarry. It is noted that BH34 was drilled using rotary open hole techniques; here soil and rock descriptions rely on 'chippings' being retrieved to the surface during drilling which results in difficulties in determining precise depths for interfaces between different strata.

The deposits of natural soft grey clay and sandy silt were observed in three of the trial pits (TP's 33, 34 and 35), located within the central and eastern areas of the site. The top of this layer was encountered at depths between 1.8 and 2.8mbgl. The full thickness of this layer was not identified although it was proven to a thickness of 0.9m in TP33.

The surface of the limestone bedrock was identified by each of the rotary boreholes and four of the trial pits. The bedrock surface was found to be very uneven due to previous quarrying activities and excavation for underground tanks and tank foundations. The depth to the bedrock surface varied from outcropping at the surface at BH33 to 7.15 mbgl for BH34. In general the rock surface was found to be dipping to the north at levels of approximately 7m OD at the southern boundary and approximately 3m OD at the northern boundary. Previous investigations identified that the rock was 'stained with black tar' over a depth of up to 3m (see section 2.5.2).

Table 3.2A Summary of ground conditions (2001 investigation)

Stratum	Thickness (m)	
	Range	Average
Made Ground	0.0 - 7.15	2.3
Alluvium	0.0 - 0.9	0.53
Limestone	8.45m proven	

During the site investigation a number of structures were targeted. The following table details the targets and findings of each exploratory hole.

Table 3.2B Exploratory Hole Targets

Exploratory Hole	Target	Site Findings
TP31	General Coverage	Hydrocarbon odour 0.15-2.9mbgl
TP32	General Coverage	Stained/hydrocarbon odour 0.1-0.5mbgl
TP33	Investigate Former No.5 Store	Some lime present 0.3-1.8mbgl
TP34	General Coverage	Slight hydrocarbon odour 0.75-1.3m
TP35	Leaks/Spills From Tank T11	Strong tarry odour inside tank, black tarry water standing at 1.5mbgl Relatively clean outside the tank
TP36	Retort Area, Leaks/Spills from Tank T12	Slight hydrocarbon odour from groundwater
TP37	Leaks/Spills from Tanks T12, T13, T14, T15	Slight hydrocarbon odour from groundwater
TP38	Former Purifiers	0.2m thick reinforced concrete at surface
TP39	Leaks/Spills from Tanks T20, T21 and T22	Blue staining 0.4-0.6mbgl Oily sheen/tarry odour from groundwater
TP40	General Coverage	Slight tarry odour 1.9-2.5mbgl Generally clean
TP41	Leaks/Spills from Tanks T16, T17, T18, T19, T23	Hydrocarbon odour from groundwater TP ended at 0.9m due to location of gasmain
TP42	Leaks/Spills from Tanks T26, T28	Rockhead at 0.5m with traces of tar
TP43	Leaks/Spills from Tank T28	Rockhead at 0.5m with traces of tar within fissures
TP44	General Coverage	Pit cancelled due to services location and proximity to occupied offices
TP45	General Coverage	Pit cancelled due to services location and proximity to occupied offices
TP46	Infilled Pit	Pit cancelled due to services location and proximity to occupied offices
TP47	Tank T11	Tarry fill to 3.5m within tank
TP48	Tank T28	Tarry fill to 3.6m within tank, including oozing liquid tar
TP49	Leaks/Spills From T11	Outside of tank wall located
TP50	General Coverage	Pit cancelled due to density of vegetation/lack of space
TP51	General Coverage	Very tarry odour 0.4-1.35mbgl Very tarry water
BH31	General Ground Conditions/Analysis of Water Within Rock	Limestone bedrock surface at 1.85mbgl
BH32	General Ground Conditions/Analysis of Water Within Rock	Limestone bedrock surface at 1.65mbgl

Exploratory Hole	Target	Site Findings
BH33	General Ground Conditions/Analysis of Water Within Rock	Limestone bedrock surface at 0mbgl
BH34	General Ground Conditions/Analysis of Water Within Rock	Limestone bedrock surface at 7.15mbgl

3.3 Groundwater Conditions

A total of 20 exploratory holes encountered groundwater during the investigation. Perched water was encountered in several excavations within tanks or above concrete bases/cohesive layers. The natural groundwater was located at approximately 5.5-6.5m OD in the south and south eastern areas of the site. The levels decrease to 3-3.5m OD to the north and west of the site in the direction of the River Shannon. The table below details the groundwater levels and observations within excavations.

Groundwater levels were subsequently measured in monitoring installations constructed within boreholes and their results are considered to be more reliable as water levels have time to reach a steady state condition. These results are included and discussed in Section 3.7.2. An initial analysis of the groundwater levels suggests a hydraulic gradient in the region of 1 in 26 in a north westerly direction, and that there is hydraulic continuity between the bedrock and overburden materials.

Table 3.3 Groundwater Conditions

Exploratory Hole	Ground Level m OD	Depth to Water Strike m OD *	Observations
TP31	5.16	3.16	-
TP32	7.13	3.63	Minor seepage
TP33	7.99	5.49	-
TP34	6.71	4.66	Hydrocarbon sheen
TP35	8.30	5.30	Brown water
TP36	5.85	3.65	Hydrocarbon odour
TP37	5.88	4.88	Hydrocarbon sheen
TP38	7.07	5.52	Brown water
TP39	7.97	5.37	-
TP41	6.01	5.11	Hydrocarbon odour
TP42	7.17	6.77	Hydrocarbon sheen, some tar
TP47	8.18	5.43	Black water
TP48	7.09	4.09	Black water, hydrocarbon odour/sheen
TP49 (outside well)	7.71	5.31	Hydrocarbon odour/sheen

Exploratory Hole	Ground Level m OD	Depth to Water Strike m OD *	Observations
TP49 (inside well)	7.71	7.01	Tarry odour
TP51	6.34	5.09	Very tarry odour, hydrocarbon sheen
BH31	6.30	4.45	-
BH32	5.12	3.37	-
BH33	7.33	-	-
BH34	7.85	0.60	-

*During excavation of exploratory hole m OD- metres above Ordnance Datum

3.4 Basis of Environmental data Assessments

The chemical test results have been compared against applicable 'generic guidelines'. Ireland has no formal guidance to this extent, but Dutch Guidelines are frequently used within the country and these have been adopted (where available) for our assessment. It must be remembered, however, that the Dutch Guidance has been derived from extremely conservative assumptions, which apply to all uses of all sites in the Netherlands, and these assumptions are based on a 'standard Dutch soil' i.e. 10% organic matter and 25% clay. The Dutch approach for which the 'Intervention Values' were derived was based upon the principal of 'multifunctionality' i.e. a site clean to the values could be used for any purpose. This has now proven to be unsustainable on economic grounds as a national strategy. The UK ICRCL guideline levels are sometimes quoted which are based on specific end use; these comprise 'Threshold' and 'Action' trigger values given in ICRCL 59/83 'Guidance on the Assessment and Redevelopment of Contaminated Land' 2nd Edition. The Netherlands, in common with many other countries including the UK, is leaning towards a site specific risk assessment approach.

In this case, chemical test results for soil samples are compared against Dutch Intervention Levels or, where they are not available, ICRCL levels for the intended end use of hard cover.

Chemical test results for water samples are compared against Dutch Intervention Levels or, where they are not available, Maximum Allowable Concentrations for drinking water in the UK quoted in the Water Supply (Water Quality) Regulations 1989.

Leachate test results are compared against a factor of ten times the Maximum Allowable Concentrations quoted in the UK drinking water standards. These guideline values have been used for comparison purposes only; it has been assumed that leachate will be diluted by a factor of ten before reaching a receptor.

Finally, it is reiterated that the proposed guideline values are to be used for comparison purposes only; it is anticipated that the site would be subject to a quantitative risk assessment (QRA) which would derive site specific clean-up criteria. The methodology for undertaking a QRA should be agreed with the

Environmental Protection Agency prior to carrying out the assessment.

With respect to assessing sulphate concentration in soils and water, reference is made to BRE Digest 363 which advises on the durability of concrete in the ground.

CIRIA 149 (Protecting Development from Methane) suggests that the highest measured gas parameter should be used as a determining factor in recommending gas precautionary measures. CIRIA 149 presents six 'characteristic situations' dependent on the levels of methane, carbon dioxide and emission rates encountered. The report also stipulates requirements (e.g. well constructed ground slab, low-permeability gas membrane, etc.) with respect to any proposed development where methane and carbon dioxide levels exceed 0.1% and 1.5% by volume in air respectively. It is noted that Irish legislation has stricter guidelines on carbon dioxide levels than the UK (0.5% as opposed to 1.5%) and it is usual to increase the characteristic situation by one for construction activities in Ireland where elevated levels of carbon dioxide are found (see Section 3.7.1).

3.5 Discussion of Contamination Results

In order to assess the levels of contaminants found within the site, the soil analysis results have been compared against the guidance levels outlined in Section 3.4. Locations where determinands exceed guidance levels identified in Section 3.4 are indicated on Drawing no. 25837/OB/02. As part of the site investigation, water and leachate samples from across the site were also analysed for contamination; locations where determinands exceed guidance levels identified in Section 3.4 are indicated on Drawing no. 25837/OB/03 and Drawing no. 25837/OB/04 respectively. All laboratory test results associated with the investigation are included in Appendix A (Volume 1).

Analysis of the soil samples generally indicated the presence of contamination in the form of tars and oils; the most common determinands at elevated concentrations being PAH, TPH, phenols, cyanide, benzene, toluene and xylene. This type of contamination was found at elevated levels at locations across the site. The heaviest tar contamination was found within, or in the vicinity of, historic structures such as former tar tanks and gasholder wells. Contamination with heavy metals was not significant across the site although two elevated levels of lead were identified. Less common contaminants detected at elevated concentrations were sulphur and sulphate. Analysis of the leachate samples prepared from the soil samples indicate the most leachable compound to be cyanide (between 0.03 and 71% of the original values), with lesser amounts of phenols (between 0.8 and 65% of the original values) and ammonium (between 3 and 20% of the original values). The remaining analytes had a very low leaching potential, with measured concentrations being less than 0.1% of the original values.

Analysis of groundwater sampled during the investigation identified that the most common contaminants in groundwater were PAH, benzene, xylene, cresol, phenol, sulphate and cyanide. Elevated levels of arsenic, chromium, nickel and lead were encountered in a number of locations. The heaviest tar contamination was found within, or in the vicinity of historic structures such as former tar tanks and

gasholder wells. It is noted that these results may be more elevated than those taken from borehole installations after steady state conditions have been allowed to establish. Analysis of groundwater sampled from borehole installations is discussed in Section 3.7.2.

Samples were taken from two local quarries to obtain information with regard to potential sources of fill. Subsequent chemical analysis found the samples to be clean in comparison with the proposed guidelines.

The following tables show the range of contaminants in samples compared to the relevant action levels for soils, water and leachate.

Table 3.5A Comparison of chemical test results for soil samples against proposed guidelines

Contaminant	On site range (mg/kg air dried soil)	Dutch Intervention Level (except where stated) (mg/kg)	Samples Where Proposed Guidelines have been exceeded (concentration mg/kg)
Arsenic	0.32 - 26	55	0
Boron (water soluble)	0.041 - 0.64	3***	0
Cadmium	0.16 - 0.5	12	0
Chromium	1.1 - 36	380	0
Copper	0.34 - 94	190	0
Mercury	0.025 - 1.4	10	0
Nickel	0.73 - 32	210	0
Lead	0.84 - 1100	530	TP34 1.2m (1100), TP48 2.5m (1100)
Selenium	0.047 - 0.81	6*	0
Zinc	1.2 - 160	720	0
Total Phenols	<0.5 - 3700	45	TP35 1.0m (620), TP39 0.5m (90), TP47 1.0m (400), TP48 1.5m (370), TP48 2.5m (1800), TP49WELL 0.5m (180), TP51 0.3m (3700)
Sulphur (Elemental)	54 - 20000	5000**	TP49WELL 0.5m (20000)
Sulphate (Total) as SO_4	5.5 - 4100	2000*	TP33 0.6m (3100), TP35 2.0m (4100)
PH	6.3 - 12	NL*	-
Total Cyanide	0.27 - 15000	70	Tp33 0.6m (120), TP33 1.5m (410), TP34 1.2m (120), TP35 2.0m (180), TP39 0.5m (15000), TP39 1.5m (200), TP39 2.8m (120), TP49 0.3m (150), TP49 1.5m (400), TP49 (640)
TPH (Total)	38 - 140000	800▲	TP34 2.0m (1200), TP35 1.0m (16000), TP39 2.8m (1700), TP47 1.0m (16000), TP48 2.5m (120000), TP49WELL 0.5m (26000), TP51 0.3m (140000), TP51 1.0m (1500)
Total PAH	<10 - 27000	40	BH32 0.5m (330), TP31 0.6m (66), TP31 1.1m (42), TP31 2.2m (65), TP32 0.2m (3800), TP33 0.6m (180), TP34 0.3m (65), TP34 1.2m (620), TP34 2.0m (140), TP35 1.0m (6900), TP35 2.0m (200), TP35 3.0m (52), TP38 0.5m (500), TP38 1.5m (99), TP39 0.5m (3100), TP39 1.5m (68), TP39 2.8m (910), TP40 2.2m (56), TP41 0.8m (51), TP47 1.0m (2700), TP47 2.0m (130), TP48 1.5m (1200), TP48 2.5m (27000), TP49 0.3m (92), TP49 1.5m (190), TP49 2.6m (180), TP49WELL 0.5m (1000), TP51 0.3m (1500), TP51 1.0m (430)

Contaminant	On site range (mg/kg air dried soil)	Dutch Intervention Level (except where stated) (mg/kg)	Samples Where Proposed Guidelines have been exceeded (concentration mg/kg)
Benzene	<0.1 - 200	1	TP35 1.0m (62), TP47 1.0m (23), TP48 1.5m (11), TP48 2.5m (200), TP49WELL 0.5m (15), TP51 0.3m (150), TP51 1.0m (1.9)
Toluene	<0.1 - 240	130	TP48 2.5m (240), TP51 0.3m (200)
Xylene's	<0.1 - 450	25	TP35 1.0m (260), TP47 1.0m (130), TP48 1.5m (50), TP48 2.5m (450), TP49WELL 0.5m (37), TP51 0.3m (410)
Loss on Ignition (%)	0.05 - 45	25#	TP39 0.5m (28), TP48 2.5m (37), TP51 0.3m (45)

Key
- * ICRCL Threshold Trigger Level for Parks, Playing Fields, Open Space
- ** ICRCL Threshold Trigger Level for All Proposed Uses
- *** ICRCL Threshold Trigger Level for any uses where plants are to be grown
- NL No Limit
- ▲ Dutch Guidelines (from Moen et al, 1986)
- # Common Practice Site Trigger Level

Table 3.5B Comparison of chemical test results for water sampled during the investigation against proposed guidelines

Contaminant	On site range (mg/l)	Dutch Intervention Level (except where stated) (mg/l)	Samples Where Proposed Guidelines have been exceeded (concentration mg/l)
Arsenic	<0.01 - 0.42	0.06	TP47 2.75m (0.09), TP49 WELLW (0.42)
Cadmium	<0.005 - 0.0054	0.006	0
Chromium	<0.01 - 0.08	0.03	BH10 2.0m (0.08), TP35 1.5m (0.06), TP47 2.75m (0.05)
Copper	<0.01 -0.03	0.075	0
Mercury	<0.001 - 0.002	0.0003	TP49 WELLW (0.002)
Nickel	<0.01 - 0.28	0.075	TP35 1.5m (0.13), TP36 2.2m (0.28), TP47 2.75m (0.1)
Lead	<0.01 - 0.9	0.075	TP34 2.05m (0.19), TP35 1.5m (0.9), TP35 3.0m (0.12)
Selenium	<0.002 - 0.027	0.01*	TP47 2.75m (0.027)
Zinc	<0.01 - 0.78	0.8	0
Total Cyanide	<0.2 - 540	3	TP35 1.5m (270), TP38 1.55m (5.5), TP39 2.6m (4.7), TP49 2.4m (540), TP49 WELLW (15)
Conductivity (µS/cm)	380-5100	1500*	BH10 2.0m(2300), TP34 2.05(1700), TP35 3.0m (2400), TP39 2.6m (1600), TP47 2.75m(5100), TP51 1.25m (1800)
Cresols	<0.0005-1200	0.2	BH7 1.0m(11), BH10 2.0m(130), TP35 3.0m(380), TP36 2.2m(15), TP39 2.6m(3.6), TP47 2.75m(550), TP48 3.5m(170), TP49 2.4m(4.5), TP49 WELLW (1200), TP51 1.25m(18)
Catechol	<0.0005-33	1.25	BH10 2.0m(7.9), TP35 1.5m(13), TP47 2.75m(27), TP48 3.5m(31), TP49 WELLW(33), TP51 1.25m(3.5)
Phenol	<0.0005-440	2	BH7 1.0m(3.3), BH10 2.0m(110), TP35 1.5m(190), TP47 2.75(360), TP48 3.5m(87), TP49 2.4m(2.6), TP49 WELLW(440), TP51 1.25m(9.8)
Sulphate	8.2 - 1300	250*	BH7 1.0m (1000), BH10 2.0m (280), TP33 2.5m (480), TP34 2.05m (400), TP35 1.5m (1100), TP35 3.0m (1000), TP38 1.55m (840), TP39 2.6m (390), TP47 2.75m (1300), TP48 3.5m (340), TP49 2.4m (740), TP49 WELLW (690)

Contaminant	On site range (mg/l)	Dutch Intervention Level (except where stated) (mg/l)	Samples Where Proposed Guidelines have been exceeded (concentration mg/l)
Ammonium	0.64 - 1500	3	BH7 1.0m (32), BH10 2.0m (1500), TP33 2.5m (9.6), TP34 2.05m (23), TP35 1.5m (13), TP35 3.0m (9.6), TP36 2.2m (7.5), TP39 2.6m (3.9), TP47 2.75m (490), TP48 3.5m (140), TP49 WELLW (690), TP51 1.25m (15)
Iron	0.07 - 70	0.2*	BH7 1.0m (5.7), BH10 2.0m (40), TP33 2.5m (21), TP34 2.05m (16), TP35 1.5m (70), TP35 3.0m (64), TP36 2.2m (0.29), TP38 1.55m (2.0), TP39 2.6m (21), TP47 2.75m (68), TP48 3.5m (12), TP49 2.4m (1.3), TP49 WELLW (29), TP51 1.25m (0.45)
TPH	<0.1 - 440	0.15▲	BH7 1.0m (7.2), BH10 2.0m (14), TP34 2.05m (5.1), TP35 1.5m (22), TP35 3.0m (0.25), TP36 2.2m (77), TP37 1.0m (1.8), TP39 2.6m (7.2), TP42 0.4m (4.7), TP47 2.75m (27), TP48 3.5m (16), TP49 2.4m (1.3), TP49 WELLW (440), TP51 1.25m (86)
PH	6.7 - 12	<5.5 >9.5*	BH7 1.0m (11), TP35 1.5m (9.9), TP48 3.5m (9.8), TP49 WELLW (11), TP51 1.25m (12)
Total PAH	0.00095 - 1.7	0.08175	BH7 1.0m (0.37), BH10 2.0m (0.37), TP34 2.05m (0.09), TP35 1.5m (0.38), TP36 2.2m (0.33), TP37 1.0m (0.12), TP38 1.55m (0.25), TP39 2.6m (0.87), TP42 0.4m (0.12), TP47 2.75m (0.35), TP48 3.5m (0.35), TP49 2.4m (0.12), TP49 WELLW (1.7), TP51 1.25m (0.71)
Benzene	<0.01-30	0.03	BH7 1m(1.6), BH10 2m(1.7), TP34 2.05m(1.6), TP35 1.5m(1), TP36 2.2m(0.49), TP37 1.0m (0.31), TP39 2.6m(1.1), TP42 0.4m (0.33), TP47 2.75m (18), TP48 3.5m(7.3), TP49 2.4m(0.065), TP49 WELLW (30), TP52 1.25m (1.6)
Toluene	<0.01-7.8	1	BH10 2m (7.5), TP35 1.5m(4.4), TP47
Ethylbenzene	<0.01-0.32	0.15	BH10 2m(0.32), TP35 1.5m(0.21), TP47 2.75m(0.21), TP48 3.5m(0.19), TP49 WELLW(0.3), TP51 1.25m(0.24

Contaminant	On site range (mg/l)	Dutch Intervention Level (except where stated) (mg/l)	Samples Where Proposed Guidelines have been exceeded (concentration mg/l)
Xylene's	<0.01-3.8	0.07	BH7 1m(0.3), BH10 2m(3.8), TP34 2.05(0.23), TP35 1.5m(2.1), TP36 2.2m(0.14), TP37 1m(0.22), TP39 2.6m(0.42), TP42 0.4m(0.41), TP47 2.75m(2.5), TP48 3.5m(2.1), TP49 WELLW (3), TP51 1.25m(2.2)

Key

* UK Water Supply (Water Quality) Regulations 1989

▲ Dutch Guidelines (from Moen et al, 1986)

NOTE Some of the water samples (BH7 & BH10) relate to boreholes excavated in the previous investigation (see Section 2.5).

Table 3.5C Comparison of chemical test results for leachate samples against proposed guidelines

Contaminant	On site range (mg/l)	Proposed Guideline Level (mg/l)	Samples Where Proposed Guidelines have been exceeded (concentration mg/l)
Arsenic	<0.01	0.5▲	0
Cadmium	<0.005	0.05▲	0
Chromium	<0.01	0.5▲	0
Copper	<0.01	30▲	0
Mercury	<0.001	0.01▲	0
Nickel	<0.01	0.5▲	0
Lead	<0.01	0.5▲	0
Selenium	<0.002 - 0.003	0.1▲	0
Zinc	<0.01 - 0.02	50▲	0
Iron	<0.01 - 2.7	2▲	TP39 0.5m (2.7)
Ammonium	<0.64 - 14	5▲	TP48 2.5m (14)
Total Cyanide	0.3 - 3.8	0.5▲	TP31 2.2m (0.9), TP32 0.2m (0.8), TP32 3.4m (0.9), TP34 0.3m (0.6), TP34 2.0m (0.7), TP35 2.0m (1.3), TP37 1.1m (0.6), TP39 0.5m (3.8), TP39 2.8m (2.5), TP47 1.0m (1.4), TP47 3.0m (0.8), TP48 2.5m (0.6), TP51 0.3m (0.6), TP51 1.0m (1)
Phenol	<0.0005-46	0.005▲	TP39 0.5m (0.02), TP47 1m(20), TP47 3m(4.6), TP48 2.5m(46), TP51 0.3m(20), TP51 1m(1.2)
PH	7.1 - 11	<5.5 >9.5▲	TP37 1.1m (9.6), TP51 0.3m (9.6), TP51 1.0m (11)
Total PAH	0.00028 - 0.69	0.002▲	TP32 0.2m (0.026), TP36 2.3m (0.0027), TP39 0.5m (0.0062), TP39 2.8m (0.037), TP47 1.0m (0.69), TP47 3.0m (0.075), TP48 2.5m (0.6), TP51 0.3m (0.27), TP51 1.0m (0.034)

Key

▲ 10 x Maximum Allowable Concentration from UK Water Supply (Water Quality) Regulations 1989

3.6 Discussion of Geotechnical Results

3.6.1 Particle Size Distribution

Five particle size analyses were scheduled on samples of made ground. Two of the samples, both from TP35, were considered to be too highly contaminated by the testing laboratory for analysis. The remaining three samples (BH32 (0-0.5m), TP36 (0.5), TP41 (0.5m)) were tested. Two of the samples (BH32 and TP36) were classified as sandy gravels. The remaining sample from TP41, a puddle clay lining to a tank, was classified as a sandy gravelly clay.

3.6.2 Permeability Tests

We are intending to carry out in-situ permeability tests during one of the forthcoming monitoring events, results of which will be presented in the final issue of this report.

3.7 Interpretation of Readings from Gas/Water Installations

3.7.1 Soil Gas Monitoring

The soil gas installations have been monitored on two occasions to date using a GA90 infrared detector. The results are tabulated below and included in Appendix C of Volume 1B.

Table 3.7.1 Soil gas monitoring results

Sampling Date	02/04/01			08/05/01					
Gas Results	CH_4%	CO_2%	O_2%	CH_4%	CO_2%	O_2%	CH_4%	CO_2%	O_2%
BH31	0	0.2	19.8	0	0	20.6			
BH32	0	0	15.9	0	0	20.5			
BH33	0.3	0.1	18.3	0	0	20.7			
BH34	0	0	20.3	0	0	20.6			
BH11	-	-	-	0	0.2	20.2			

In accordance with CIRIA 149 'Protecting Development from Methane' (see Section 3.4), Characteristic Situation 2 would be applicable as the highest concentration of methane detected is above 0.1%. Characteristic Situation 2 recommends the following precautionary means for all types of structures: -

- Ventilation of confined spaces
- Well constructed ground slab
- Low permeability gas membrane
- Minimum penetration of ground slab by services

It is noted that the results of further soil gas monitoring may change to recommended precautionary measures in relation to building construction.

3.7.2 *Water Monitoring*

Water levels within monitoring installations have been monitored on one occasion to date. The results are tabulated below.

Table 3.7.2A Water levels

	Water Depth (m OD)		
Sampling Date:	02/04/01	08/05/01	
BH31	4.395	5.045	
BH32	3.777	3.697	
BH33	6.526	6.956	
BH34	7.845	4.995	
BH11*	-	-	

*Note - this borehole relates to a previous investigation (see Section 2.5.1).

Water was sampled from all borehole monitoring wells on 11 April 2001, 16 May 2001 and 28 June 2001. The samples were sent to City Analytical Services in the UK for chemical analysis. Before the water was sampled, the monitoring wells were purged of three times their volume to allow steady-state conditions more representative of the general groundwater conditions. The test results are included in Appendix C of Volume 1B. The results generally indicate that the water samples from boreholes 33 and 7 (from the recent investigation and a previous investigation respectively) were contaminated with hydrocarbons. Elevated lead and sulphate concentrations were detected in water samples from across the site. The following table indicates the locations where concentrations of contaminants in water samples exceed Dutch Intervention Levels.

Table 3.7.2B Comparison of chemical test results for water sampled from borehole installations against proposed guidelines

Contaminant	On site range (mg/l)	Dutch Intervention Level (except where stated) (mg/l)	Samples Where Proposed Guidelines have been exceeded (concentration mg/l)		
			11 April 2001	16 May 2001	28 June 2001
Arsenic	<0.01-0.03	0.06	0	0	0
Cadmium	<0.005-0.027	0.006	0	BH10 (0.018), BH31 (0.009)	BH11 (0.027), BH32 (0.0073)
Chromium	<0.01-0.04	0.03	0	BH10 (0.04)	0
Copper	<0.01-0.05	0.075	0	0	0
Mercury	<0.001	0.0003	0	0	0
Nickel	<0.01-0.09	0.075	0	BH31 (0.09)	0
Lead	<0.01-0.38	0.07	BH31 (0.19), BH32 (0.11), BH34 (0.09)	BH10 (0.16), BH11 (0.08), BH31 (0.2), BH33 (0.13)	BH10 (0.2), BH11 (0.21), BH32 (0.12), BH33 (0.38)
Selenium	<0.002-0.01	0.01*	0	0	0

Contaminant	On site range (mg/l)	Dutch Intervention Level (except where stated) (mg/l)	Samples Where Proposed Guidelines have been exceeded (concentration mg/l)		
			11 April 2001	16 May 2001	28 June 2001
Zinc	<0.1-2.2	0.8	0	BH10 (2.2)	0
Total Cyanide	0.2-9.9	3	BH7 (4.4)	BH7 (9.9)	0
Cresols	0.0005-31	0.2	BH33 (31), BH7 (12)	0	BH7 (2.1), BH10 (28), BH11 (1.1), BH33 (18)
Catechol	0.0005-0.51	1.25	0	0	0
Phenol	0.0005-20	2	BH33 (20), BH7 (3.9)	0	BH10 (10), BH33 (13)
Sulphate	29-1600	250*	BH31(550), BH33(510), BH7(1100)	BH7 (980), BH11 (410), BH31 (360), BH34 (580)	BH7 (1600), BH11 (410), BH31 (300)
PH	6.7-9.8	<5.5 >9.5*	BH7 (9.8)	0	BH7 (9.7)
Total PAH	0.0011-3.6	0.08175	BH33 (0.75), BH7 (0.4)	BH7 (3.6), BH10 (2.8), BH32 (0.088), BH33 (0.17), BH34 (0.13)	BH7 (1.3), BH10 (0.34), BH11 (1.1), BH33 (1.1)
Benzene	0.01-16	0.03	BH33 (16), BH7 (2.7)	BH7 (1.6), BH10 (7.5), BH11 (0.51), BH33 (13)	BH7 (1.7), BH33 (7.2)
Toluene	0.01-5.5	1	BH33 (5.5)	BH10 (4.5), BH33 (4.3)	BH10 (3.8), BH33 (3.2)
Ethylbenzene	0.01-0.3	0.15	BH33 (0.25)	BH10 (0.23), BH11 (0.19), BH33 (0.19)	BH10 (0.3), BH11 (0.18)
Xylene's	0.01-3.6	0.07	BH33 (3), BH7 (1.1)	BH7 (1), BH10 (3), BH11 (1.3), BH32 (0.15), BH33 (2.3), BH34 (0.074)	BH7 (0.85), BH10 (3.6), BH11 (1.2), BH32 (0.31), BH33 (2.1)
TPH	0.1-66	0.15	BH32 (0.44), BH33 (9), BH34 (0.54), BH7 (13)	BH7 (66), BH10 (15), BH11 (1.9), BH31 (0.16), BH32 (9.3), BH33 (14), BH34 (0.87)	BH7 (8.2), BH10 (26), BH11 (4.8), BH31 (0.35), BH32 (1.1), BH33 (9.1)

Key

* Water Supply (Water Quality) Regulations 1989

3.7.3 *Monitoring over 13 Hour period*

Monitoring of water levels in boreholes is to be carried out every hour over a 13 hour period in the near future to determine tidal influences on the site.

4.0 REMEDIATION COMPONENTS

4.1 General

This section describes the main aspects to be considered in respect to any proposed remediation scheme. An outline remediation strategy and options for treatment of contaminated soils are also presented.

4.2 Demolition

It is anticipated that all above ground structures are to be demolished as part of any remediation scheme, perhaps with the exception of the large building in the eastern corner of the site identified as 'No. 5 Stores' on Drawing no. 25837/OB/01. This may be retained as a feature in the proposed development.

It is also anticipated that the majority of floor slabs, foundations, underground tanks etc, will require removal as part of the reclamation works. The review of historical plans and information gathered during the ground investigation works indicated that a large amount of underground obstructions, tanks, redundant services, etc. are present. Only after demolition of the existing buildings can details of floor slabs for removal be ascertained in these areas.

Demolition of several boundary and internal walls, which generally comprise brick or limestone masonry, will also be required as part of the remediation works.

Experience of other similar gasworks has found that 'hard dig' accounts for a volume equivalent to a thickness of 0.5 - 1.0m across the whole site.

4.3 Hydrocarbons

The presence of hydrocarbons is a considerable issue in relation to the potential remediation of the site. Several underground tar tanks or similar have been identified with high total PAH, total phenol, TPH and BTEX (benzene, toluene, ethylbenzene and xylene). Currently organics of the following physical conditions are anticipated, in unknown volumes:

- Made ground/demolition material contaminated by hydrocarbons (PAH's, phenols, BTEX, etc.)
- Free product floating in the ground water in the area of T12 (gas oil/lighter fractions of PAH's)
- Liquid, semi liquid and viscous tar

4.4 Heavy Metals/Cyanides

Contamination in the form of heavy metals was not significant across the site, although elevated levels of cyanide were located in the area of the former purifiers. Heavy metals are not generally suitable for thermal treatment although cyanide can be degraded by this process. On-site solidification or stabilisation can

be effective for these materials, although such treatments would be subject to consultation with the relevant authorities and the surrender of a waste licence, which may be complicated.

4.5 Groundwater

Any proposed remediation scheme should ensure removal of the primary sources of groundwater contamination. Contaminated waters arising during the works would be treated on-site with the resulting cleaned water recycled within the site or disposed of through foul sewers. It is considered that source removal of contaminants should be a satisfactory solution in terms of groundwater, within the general groundwater context of the site.

4.6 Planning, Licences and Permits

4.6.1 Waste Management Licence

It is our understanding that any processing of contaminated materials on-site will require a Waste Management Licence from the Environmental Protection Agency (EPA). Discussions should be held with the Agency at an early stage in the scheme to establish the conditions that are likely to be imposed in connection with the remediation scheme.

Contaminated materials being transported from site would be subject to duty of care transference procedures. In particular, any waste being transferred overseas would be subject to Transfrontier Shipment of Waste Notification in accordance with EU legislation.

4.6.2 Planning

Planning permission would be required in relation to any development. It is also our understanding that a two-stage Environmental Impact Statement (EIS) would be required. The first stage would relate to the remediation works, with the second covering aspects with respect to specific development proposals.

4.6.3 Water

A temporary waste water discharge consent will be required for the works and any trials. Consented discharges to foul sewer will need to meet criteria acceptable to Limerick Corporation.

4.6.4 Odour, Dust, Noise and Vibration

Strict measures to control odour, dust, noise and vibration will be required if planning permission and a waste licence are to be obtained from Limerick Corporation and the EPA respectively. In particular, it is our opinion that the EPA will require that odour control measures are sufficient to prevent nuisance to local residents.

Finally, it is noted that ambient levels of odour, dust, noise and vibration should be monitored prior to works commencing. This would be a requirement of the waste licensing and planning permission processes.

4.6.5 Asbestos

A full specification for the removal of asbestos encountered will be required as part of the demolition process.

4.6.6 Health and Safety

All site operations must comply with relevant legislation including Safety, Health and Welfare at Work regulations 1995. It is anticipated that the remediation contractor would act as Project Supervisor (Construction) in accordance with this legislation.

4.7 Remediation / Reclamation Strategy

4.7.1 General

The remediation/reclamation strategy would comprise the following components: -

- Prepare Quantitative Risk Assessment (QRA); methodology should be agreed with the EPA prior to undertaking the assessment.
- Agreement of site clean-up criteria derived by QRA with Regulatory Authorities.
- Obtain appropriate licenses and permits.
- Discussions with Limerick Corporation and EPA to confirm the requirements for a Waste Management Licence, Environmental Impact Statement and Planning Permission.
- Ensure adequate site security (site should also be vacated by existing Bord Gais staff).
- Trials to assess suitability of alternative remediation techniques.
- Selection of experienced remediation contractor.
- Demolition of structures, removal of foundations, underground tasks, floor slabs etc.
- Construction of any physical barriers required (e.g. cut - off trenches etc.).
- Removal/treatment of liquid, semi-liquid and viscous tar from within underground tanks, pipelines, etc.
- Removal/treatment of soil contaminated with PAH's, phenols, cyanides, sulphur

and heavy metals in addition to potentially combustible material (where required).

- Treatment of contaminated groundwater encountered during excavation works.
- Validation before, during and after remedial actions.
- Longer term monitoring (if required).

The selection of the most appropriate remediation method or combination of methods will depend on the assessment of a wide range of site-specific factors. These include: -

- Location of the site (site access, value, adjacent property etc.).
- Nature of ground conditions (soils, dip of strata etc.).
- Nature and extent of contamination (soils, water, leachate).
- Hydrogeological regime.
- Proposed use(s) of the site.
- Suitability of remediation techniques.
- Time available for remediation.
- Liabilities (statutory and non-statutory).
- Cost of remediation works.

The various remedial techniques available must therefore be considered in terms of attaining an overall remedial solution. No suitably licensed landfills are available for soils contaminated to the levels identified on-site and therefore landfilling of material in Ireland is not an available option. The UK Waste Plan and EU legislation on the Transfrontier Shipment of Waste also prevents contaminated material being transferred to landfill in Northern Ireland, Great Britain or elsewhere in Europe.

In view of this, the main available options are discussed in the following sections.

4.7.2 Bioremediation

This option has been used in the U.S.A. on gaswork type-sites, although timescales for bio-treatment are quoted generally in terms of 9 months to several years. The anticipated concentrations of organic contaminants denote that traditional in-situ or landfarming techniques would probably take in excess of a year for the anticipated volumes. Some of the soil at the Limerick site may not be suitable due to the presence of 'heavy' fraction PAH's which are unlikely to be broken down by the process. A number of proprietary methods employing "aggressive" blending

techniques with the addition of water, materials and organisms such as fungi and bacteria may be viable. This process is generally more cost effective than thermal processes, although it is unlikely that the viability of such a process could be determined without trials. It could be considered in conjunction with another treatment as part of a waste minimisation strategy. The anticipated timescales would be a major factor in deciding whether or not this approach should be pursued.

4.7.3 Soil Washing

This process involves the segregation of the soil into predominantly granular materials, based upon grain size and density properties, resulting in "clean" coarse materials and a clay fraction ("filter cake") into which most of the contamination is generally concentrated. There are a number of optimisation techniques that can be used as a part of the soil washing process including solvent washing where organic contaminants are removed to liquid phase for disposal or treatment. The "filter cake" residue would require further treatment or disposal. It is anticipated that this would comprise approximately 15-20% of the initial volume if the treatment of the predominantly granular proportion of the Made Ground was undertaken. However, due to the likely high concentrations of contaminants including cyanide, sulphur etc, it may prove difficult to find a secondary treatment for this material which can reduce contamination levels to acceptable limits.

Low temperature thermal desorption plants are available as both mobile and fixed in the U.K, Holland and Germany and may represent one secondary treatment option. However this process may struggle to process fine-grained materials with a high moisture content and high 'heavy fraction' organics. Both the Department of the Environment, Transport and the Regions and the Environment Agency's Transfrontier Shipment Division in the U.K. confirm that contaminated material would only be allowed to enter the country if it was to be incinerated. This presently occurs when clinical waste from hospitals in Ireland enters the U.K. Contaminated material would be only allowed into Holland if the contamination levels of treated materials fall below "Category 2 Building Material" levels (defined as material that is considered to be suitable for use as a sub-base in road construction in Holland). It is possible that the "filter cake" may contain high concentrations of heavy metals, treatment of which is unlikely to reduce contamination to acceptable levels.

It is known that some fixed soil washing plants in Europe have licences to dispose of limited volumes of the 'filter cake' into lined lagoons. Leachate is collected from the lagoons over long periods and treated prior to discharge into foul sewer systems.

4.7.4 Thermal Treatment

Low temperature desorption or incineration can treat a wide variety of contaminants, although sulphur and heavy metals are not treated.

Treatment on-site would be more cost effective than shipping the waste overseas.

Dutch-based mobile plants will operate to emission standards approximately 1/10th of those common to the EU. Planning permission and Waste Management Licence are likely to be required by the Regulatory Authority, and it is possible that on-site treatment could be rejected if there was sufficient local opposition to such proposals. It is possible that the resulting residues could be used on site. Discussions with specialist contractors and trials would be required to ascertain whether or not this option was viable.

Incineration cannot be considered on cost grounds for the large-scale treatment of soils, although some of the liquid/semi-liquid tars and free product could be considered for this process if a recycling facility was not identified for treating these materials.

4.7.5 Solidification, Stabilisation and Encapsulation

Cement, lime and other similar treatments are not considered suitable due to the contaminants present, difficulty with obtaining warranties, and political implications. It is anticipated that there would be problems with long term liabilities, planning, suitability to any proposed development, and EPA waste licence requirements if material was encapsulated in-site.

4.7.6 Chemical Treatments

All such methods need to be considered and controlled carefully due to the sensitivity of the river to chemically enhanced groundwater. Chemical compounds containing powerful oxidising agents are commercially available which can rapidly degrade hydrocarbon contaminated soils and may be worth further consideration. Soil vapour extraction techniques would not be suitable for the range of contaminants identified on site.

A simple summary of remedial options is given in the table overleaf: -

Table 4.7.5 Remedial Options Available

Technique	Comments	Decision
Bioremediation	**Against:** May not be suitable due to spectrum of contaminants present (including heavy fraction organic), timescales **For:** Possible treatment of lighter fraction hydrocarbons	Trial required
Soil Washing	**Against:** Problem with disposal of contaminated fine residue, not suitable for high organic concentrations **For:** Versatile, wide range of contaminants, cost	Possible option Trial required
Low Temperature Desorption	**Against:** Cost, possible rejection of residues for landfill abroad, shipping, licence of mobile plant **For:** Wide range of contaminants treatable, mobile plant on site	Possible option Trial required
Incineration	**Against:** Cost, shipping **For:** Wide range of contaminants treatable	Possible option for treatment of contaminated residues, liquid, semi-liquid and viscous tars
Cement and Lime Stabilisation	**Against:** Not suitable for range of contaminants, long term durability and warranty, EPA licence requirements **For:** Cost	Rejected
Repository/Encapsulation	**Against:** Planning, long term liability, space, EPA licence requirements **For:** Cost	Only considered on cost basis as an option Not recommended
Chemical Treatment	**Against:** Cost, political aspects, groundwater **For:** Possible treatment on site	May be suitable for selected materials Trial required
Soil Vapour Extraction	**Against:** Not suitable for range of contaminants **For:** Cost	Rejected

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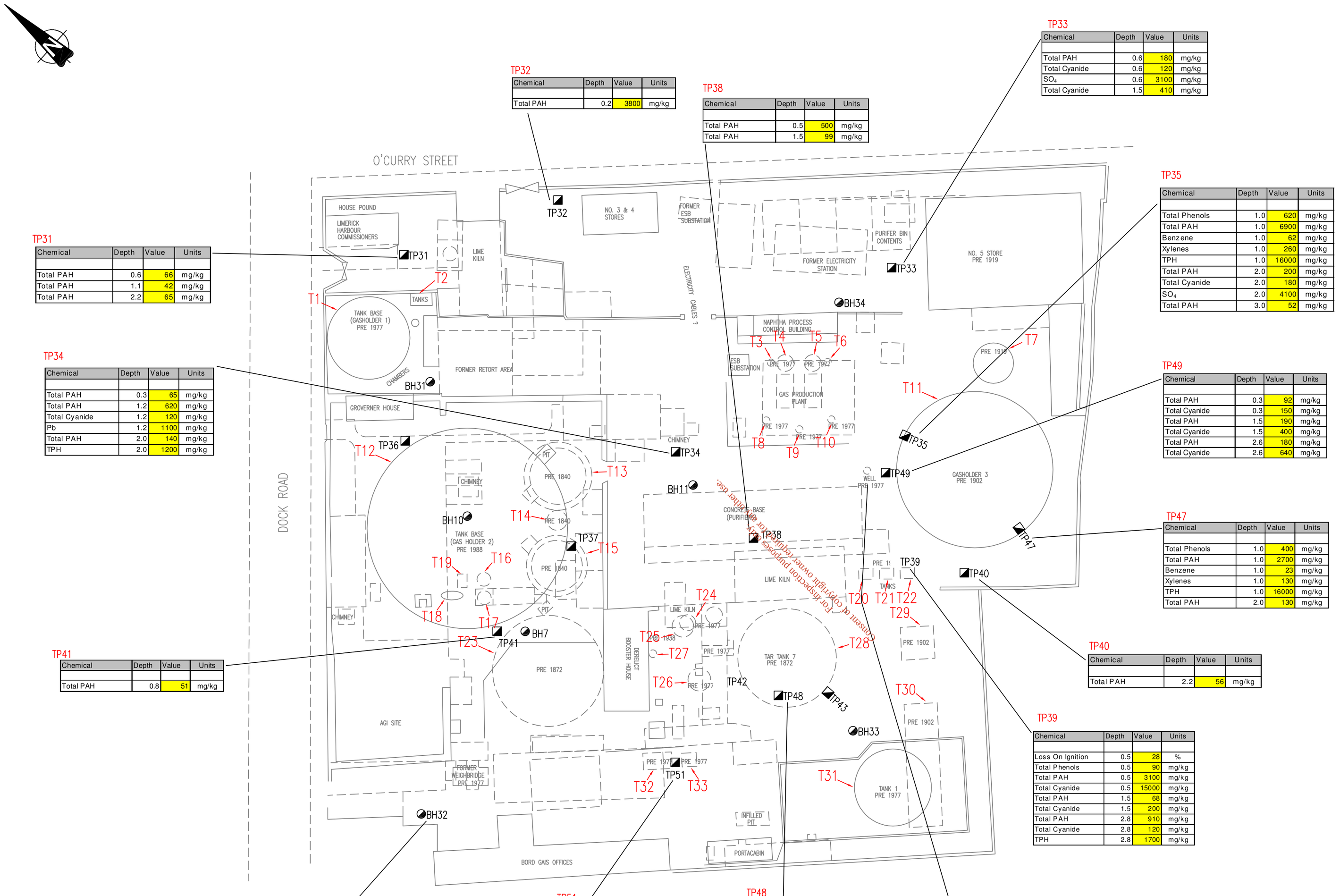
DRAWINGS



TP31

Chemical	Depth	Value	Units
Total PAH	0.6	66	mg/kg
Total PAH	1.1	42	mg/kg
Total PAH	2.2	65	mg/kg

TP32

Chemical	Depth	Value	Units
Total PAH	0.2	3800	mg/kg

TP33

Chemical	Depth	Value	Units
Total PAH	0.6	180	mg/kg
Total Cyanide	0.6	120	mg/kg
SO_4	0.6	3100	mg/kg
Total Cyanide	1.5	410	mg/kg

TP34

Chemical	Depth	Value	Units
Total PAH	0.3	65	mg/kg
Total PAH	1.2	620	mg/kg
Total Cyanide	1.2	120	mg/kg
Pb	1.2	1100	mg/kg
Total PAH	2.0	140	mg/kg
TPH	2.0	1200	mg/kg

TP35

Chemical	Depth	Value	Units
Total Phenols	1.0	620	mg/kg
Total PAH	1.0	6900	mg/kg
Benzene	1.0	62	mg/kg
Xylenes	1.0	260	mg/kg
TPH	1.0	16000	mg/kg
Total PAH	2.0	200	mg/kg
Total Cyanide	2.0	180	mg/kg
SO_4	2.0	4100	mg/kg
Total PAH	3.0	52	mg/kg

TP36

Chemical	Depth	Value	Units
Total PAH	0.5	330	mg/kg

TP37

Chemical	Depth	Value	Units
Loss On Ignition	0.3	45	%
Total Phenols	0.3	3700	mg/kg
Total PAH	0.3	1500	mg/kg
Benzene	0.3	150	mg/kg
Toluene	0.3	200	mg/kg
Xylenes	0.3	410	mg/kg
TPH	0.3	140000	mg/kg
Total PAH	1.0	430	mg/kg
Benzene	1.0	1.9	mg/kg
TPH	1.0	1500	mg/kg

TP38

Chemical	Depth	Value	Units
Total PAH	0.5	500	mg/kg
Total PAH	1.5	99	mg/kg

TP39

Chemical	Depth	Value	Units
Loss On Ignition	0.5	28	%
Total Phenols	0.5	90	mg/kg
Total PAH	0.5	3100	mg/kg
Total Cyanide	0.5	15000	mg/kg
Total PAH	1.5	68	mg/kg
Total Cyanide	1.5	200	mg/kg
Total PAH	2.8	910	mg/kg
Total Cyanide	2.8	120	mg/kg
TPH	2.8	1700	mg/kg

TP40

Chemical	Depth	Value	Units
Total PAH	2.2	56	mg/kg

TP41

Chemical	Depth	Value	Units
Total PAH	0.8	51	mg/kg

TP47

Chemical	Depth	Value	Units
Total Phenols	1.0	400	mg/kg
Total PAH	1.0	2700	mg/kg
Benzene	1.0	23	mg/kg
Xylenes	1.0	130	mg/kg
TPH	1.0	16000	mg/kg
Total PAH	2.0	130	mg/kg

TP48

Chemical	Depth	Value	Units
Total Phenols	1.5	370	mg/kg
Total PAH	1.5	1200	mg/kg
Benzene	1.5	11	mg/kg
Xylenes	1.5	50	mg/kg
Loss On Ignition	2.5	37	%
Total Phenols	2.5	1800	mg/kg
Total PAH	2.5	27000	mg/kg
Pb	2.5	1100	mg/kg
Benzene	2.5	200	mg/kg
Toluene	2.5	240	mg/kg
Xylenes	2.5	450	mg/kg
TPH	2.5	120000	mg/kg

TP49

Chemical	Depth	Value	Units
Total PAH	0.3	92	mg/kg
Total Cyanide	0.3	150	mg/kg
Total PAH	1.5	190	mg/kg
Total Cyanide	1.5	400	mg/kg
Total PAH	2.6	180	mg/kg
Total Cyanide	2.6	640	mg/kg

TP49 Well

Chemical	Depth	Value	Units
Total Phenols	0.5	180	mg/kg
Total PAH	0.5	1000	mg/kg
Sulphur	0.5	20000	mg/kg
Benzene	0.5	15	mg/kg
xylenes	0.5	37	mg/kg
TPH	0.5	26000	mg/kg

BH32

Chemical	Depth	Value	Units
Total PAH	0.5	330	mg/kg

TP51

Chemical	Depth	Value	Units
Loss On Ignition	0.3	45	%
Total Phenols	0.3	3700	mg/kg
Total PAH	0.3	1500	mg/kg
Benzene	0.3	150	mg/kg
Toluene	0.3	200	mg/kg
Xylenes	0.3	410	mg/kg
TPH	0.3	140000	mg/kg
Total PAH	1.0	430	mg/kg
Benzene	1.0	1.9	mg/kg
TPH	1.0	1500	mg/kg

Key

Approximate Location of Former Structure

Trial Pit

Borehole

Total PAH – Total Polyaromatic Hydrocarbons
Pb – Lead
TPH – Total Petroleum Hydrocarbons
SO_4 – Sulphate

Notes

Soil results are compared against Dutch Guidelines, Intervention Valves (1994) where available on Threshold or Action Trigger levels in ICRCL 59/83 2nd Edition 1987 (UK Guidlines).

Version	Amendment	Originated by and date	Checked by and date	Approved by and date
A	First Issue	15.10.01	D.H. 15.10.01	T.B. 15.10.01

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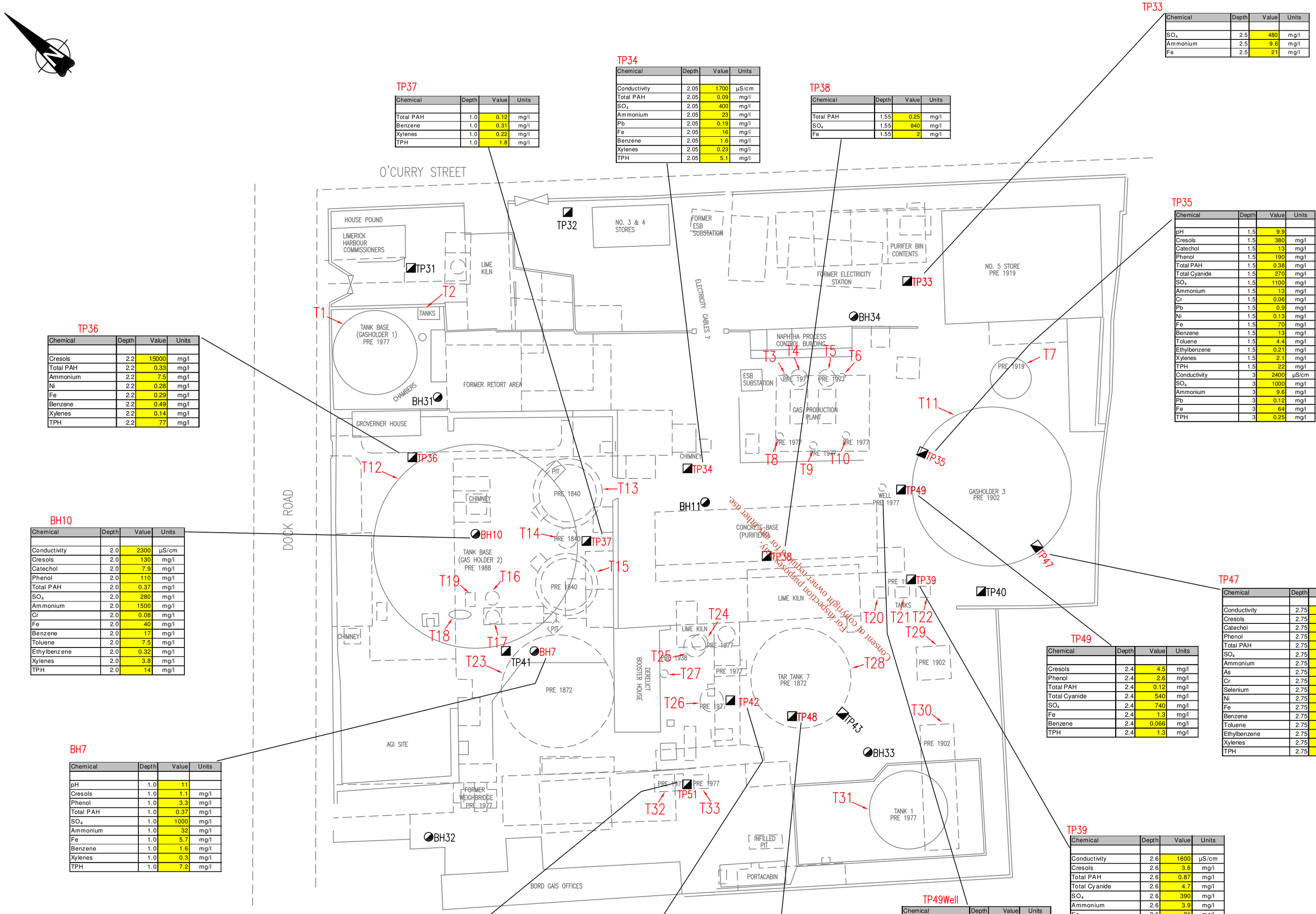
Certificate no. FS 15024

Client	Bord Gais Eireann
Project	Limerick Gasworks
Drawing Title	Elevated Contamination Levels – Soils
Purpose	Information
Draft / Issue	Issue
Scale	1:500 (A2)
Issuing Office	Cheshire
Telephone	0151 356 1666
Drawing Number	25837/OB/02
Version	A



TP33

Chemical	Depth	Value	Units
SO_4	2.5	480	mg/l
Ammonium	2.5	9.6	mg/l
Fe	2.5	21	mg/l

TP34

Chemical	Depth	Value	Units
Conductivity	2.05	1700	µS/cm
Total PAH	2.05	0.09	mg/l
SO_4	2.05	400	mg/l
Ammonium	2.05	23	mg/l
Pb	2.05	0.19	mg/l
Fe	2.05	16	mg/l
Benzene	2.05	1.6	mg/l
Xylenes	2.05	0.23	mg/l
TPH	2.05	5.1	mg/l

TP35

Chemical	Depth	Value	Units
pH	1.5	9.9	
Cresols	1.5	380	mg/l
Catechol	1.5	13	mg/l
Phenol	1.5	190	mg/l
Total PAH	1.5	0.38	mg/l
Total Cyanide	1.5	270	mg/l
SO_4	1.5	1100	mg/l
Ammonium	1.5	13	mg/l
Cr	1.5	0.06	mg/l
Pb	1.5	0.9	mg/l
Ni	1.5	0.13	mg/l
Fe	1.5	70	mg/l
Benzene	1.5	1.3	mg/l
Toluene	1.5	4.4	mg/l
Ethylbenzene	1.5	0.21	mg/l
Xylenes	1.5	2.1	mg/l
TPH	1.5	22	mg/l
Conductivity	3	2400	µS/cm
SO_4	3	1000	mg/l
Ammonium	3	9.6	mg/l
Pb	3	0.12	mg/l
Fe	3	64	mg/l
TPH	3	0.25	mg/l

TP36

Chemical	Depth	Value	Units
Cresols	2.2	15000	mg/l
Total PAH	2.2	0.33	mg/l
Ammonium	2.2	7.5	mg/l
Ni	2.2	0.28	mg/l
Fe	2.2	0.29	mg/l
Benzene	2.2	0.49	mg/l
Xylenes	2.2	0.14	mg/l
TPH	2.2	77	mg/l

TP37

Chemical	Depth	Value	Units
Total PAH	1.0	0.12	mg/l
Benzene	1.0	0.31	mg/l
Xylenes	1.0	0.22	mg/l
TPH	1.0	1.6	mg/l

TP38

Chemical	Depth	Value	Units
Total PAH	1.55	0.25	mg/l
SO_4	1.55	840	mg/l
Fe	1.55	2	mg/l

TP39

Chemical	Depth	Value	Units
Conductivity	2.6	1600	µS/cm
Cresols	2.6	3.6	mg/l
Total PAH	2.6	0.87	mg/l
Total Cyanide	2.6	4.7	mg/l
SO_4	2.6	390	mg/l
Ammonium	2.6	3.9	mg/l
Fe	2.6	21	mg/l
Benzene	2.6	1.1	mg/l
Xylenes	2.6	0.42	mg/l
TPH	2.6	7.2	mg/l

TP47

Chemical	Depth	Value	Units
Conductivity	2.75	5100	µS/cm
Cresols	2.75	550	mg/l
Catechol	2.75	27	mg/l
Phenol	2.75	360	mg/l
Total PAH	2.75	350000	mg/l
SO_4	2.75	1300	mg/l
Ammonium	2.75	490	mg/l
As	2.75	0.09	mg/l
Cr	2.75	0.05	mg/l
Selenium	2.75	0.027	mg/l
Ni	2.75	0.1	mg/l
Fe	2.75	68	mg/l
Benzene	2.75	18	mg/l
Toluene	2.75	5.2	mg/l
Ethylbenzene	2.75	0.21	mg/l
Xylenes	2.75	2.5	mg/l
TPH	2.75	27	mg/l

TP49

Chemical	Depth	Value	Units
Cresols	2.4	4.5	mg/l
Phenol	2.4	2.6	mg/l
Total PAH	2.4	0.12	mg/l
Total Cyanide	2.4	540	mg/l
SO_4	2.4	740	mg/l
Fe	2.4	1.3	mg/l
Benzene	2.4	0.066	mg/l
TPH	2.4	1.3	mg/l

BH10

Chemical	Depth	Value	Units
Conductivity	2.0	2300	µS/cm
Cresols	2.0	130	mg/l
Catechol	2.0	7.9	mg/l
Phenol	2.0	110	mg/l
Total PAH	2.0	0.37	mg/l
SO_4	2.0	280	mg/l
Ammonium	2.0	1500	mg/l
Cr	2.0	0.08	mg/l
Fe	2.0	40	mg/l
Benzene	2.0	17	mg/l
Toluene	2.0	7.5	mg/l
Ethylbenzene	2.0	0.32	mg/l
Xylenes	2.0	3.8	mg/l
TPH	2.0	14	mg/l

BH7

Chemical	Depth	Value	Units
pH	1.0	11	
Cresols	1.0	1.1	mg/l
Phenol	1.0	3.3	mg/l
Total PAH	1.0	0.37	mg/l
SO_4	1.0	1000	mg/l
Ammonium	1.0	32	mg/l
Fe	1.0	5.7	mg/l
Benzene	1.0	1.6	mg/l
Xylenes	1.0	0.3	mg/l
TPH	1.0	7.2	mg/l

TP51

Chemical	Depth	Value	Units
pH	1.25	12	
Conductivity	1.25	1800	µS/cm
Cresols	1.25	18	mg/l
Catechol	1.25	3.5	mg/l
Phenol	1.25	9.8	mg/l
Total PAH	1.25	0.71	mg/l
Ammonium	1.25	15	mg/l
Fe	1.25	0.45	mg/l
Benzene	1.25	1.6	mg/l
Toluene	1.25	1.8	mg/l
Ethylbenzene	1.25	0.24	mg/l
Xylenes	1.25	2.2	mg/l
TPH	1.25	86	mg/l

TP42

Chemical	Depth	Value	Units
Total PAH	0.4	0.12	mg/l
Benzene	0.4	0.33	mg/l
Xylenes	0.4	0.41	mg/l
TPH	0.4	4.7	mg/l

TP48

Chemical	Depth	Value	Units
pH	3.5	9.8	
Conductivity	3.5	4200	µS/cm
Cresols	3.5	170	mg/l
Catechol	3.5	31	mg/l
Phenol	3.5	87	mg/l
Total PAH	3.5	0.35	mg/l
SO_4	3.5	340	mg/l
Ammonium	3.5	140	mg/l
Fe	3.5	12	mg/l
Benzene	3.5	7.3	mg/l
Toluene	3.5	3.1	mg/l
Ethylbenzene	3.5	0.19	mg/l
Xylenes	3.5	2.1	mg/l
TPH	3.5	16	mg/l

TP49Well

Chemical	Depth	Value	Units
pH		11	
Cresols		1200	mg/l
Catechol		33	mg/l
Phenol		440	mg/l
Total PAH		1.7	mg/l
Total Cyanide		15	mg/l
SO_4		690	mg/l
Ammonium		220	mg/l
As		0.42	mg/l
Hg		0.002	mg/l
Fe		29	mg/l
Benzene		30	mg/l
Toluene		7.8	mg/l
Ethylbenzene		0.3	mg/l
Xylenes		3	mg/l
TPH		440	mg/l

Key

Approximate Location of Former Structure

TP33 Trial Pit

BH11 Borehole

TP37 / BH10 Exploratory hole locations indicating postion where water samples were taken during the site investigation

Total PAH – Total Polyaromatic Hydrocarbons
As – Arsenic
Cr – Chromium
Pb – Lead
Hg – Mercury
Ni – Nickel
Zn – Zinc
Fe – Iron
TPH – Total Petroleum Hydrocarbons
SO_4 – Sulphate
mg/l – Milligrams per litre

Notes

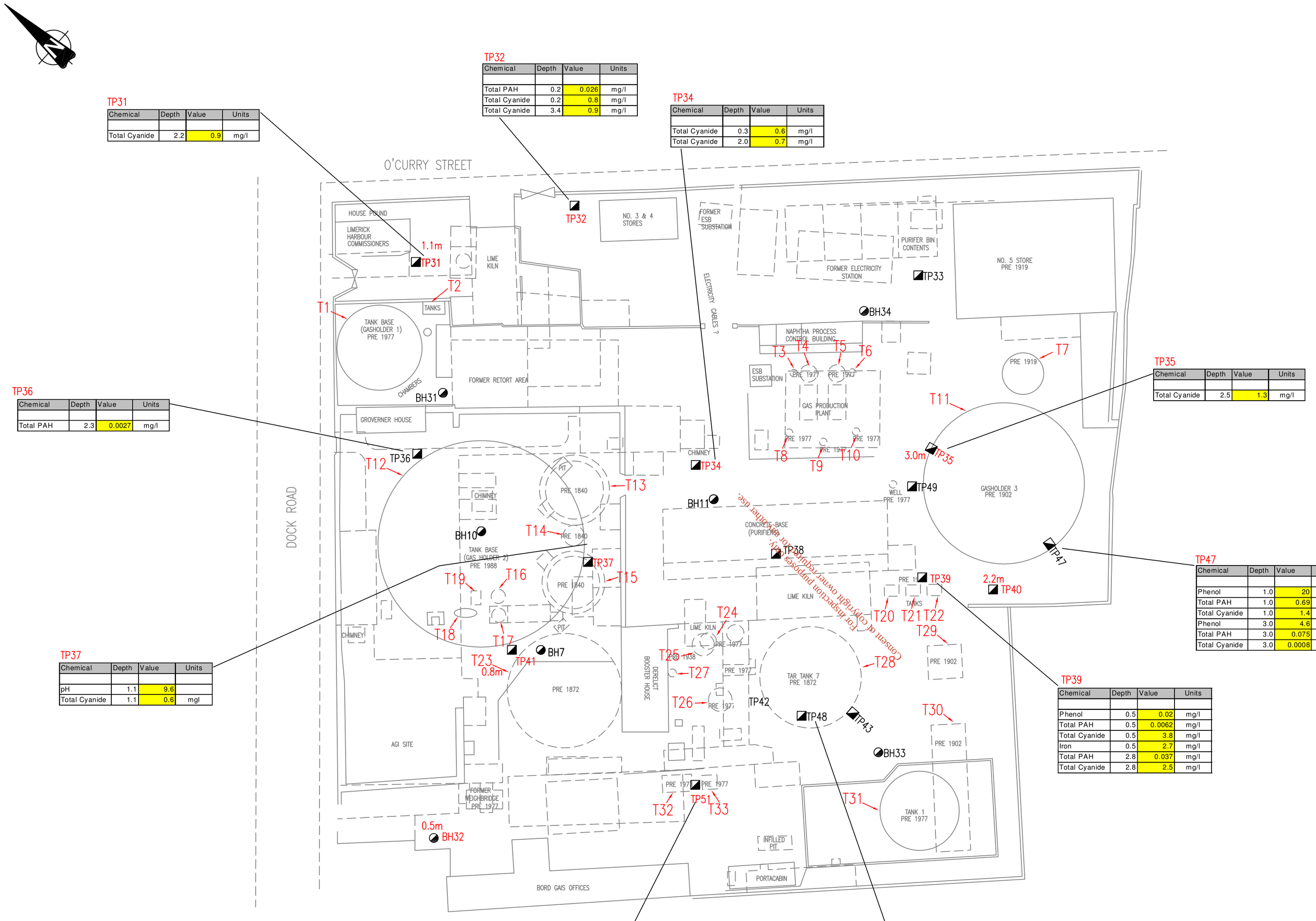
Water results are compared against Dutch Guidelines, Intervention Valves (1994) where possible or maximum allowable concentrations given in the Water Supply (Water Quality) Regulations 1989 (UK Legislation).

Version				
A	First Issue	15.10.01	D.H. 15.10.01	T.B. 15.10.01
Version	Amendment	Originated by and date	Checked by and date	Approved by and date

PARKMAN

BSI REGISTERED FIRM — Certificate no. FS 15024

Client	Bord Gais Eireann
Project	Limerick Gasworks
Drawing Title	Elevated Contamination Levels – Water
Purpose	Information
Draft / Issue	Issue ●
Scale	1:500 (A2)
Issuing Office	Cheshire
Telephone	0151 356 1666
Drawing Number	25837/OB/03
Version	A



TP31

Chemical	Depth	Value	Units
Total Cyanide	2.2	0.9	mg/l

TP32

Chemical	Depth	Value	Units
Total PAH	0.2	0.026	mg/l
Total Cyanide	0.2	0.8	mg/l
Total Cyanide	3.4	0.9	mg/l

TP34

Chemical	Depth	Value	Units
Total Cyanide	0.3	0.6	mg/l
Total Cyanide	2.0	0.7	mg/l

TP35

Chemical	Depth	Value	Units
Total Cyanide	2.5	1.3	mg/l

TP36

Chemical	Depth	Value	Units
Total PAH	2.3	0.0027	mg/l

TP37

Chemical	Depth	Value	Units
pH	1.1	9.6	
Total Cyanide	1.1	0.6	mgl

TP47

Chemical	Depth	Value	Units
Phenol	1.0	20	mg/l
Total PAH	1.0	0.69	mg/l
Total Cyanide	1.0	1.4	mg/l
Phenol	3.0	4.6	mg/l
Total PAH	3.0	0.075	mg/l
Total Cyanide	3.0	0.0008	mg/l

TP39

Chemical	Depth	Value	Units
Phenol	0.5	0.02	mg/l
Total PAH	0.5	0.0062	mg/l
Total Cyanide	0.5	3.8	mg/l
Iron	0.5	2.7	mg/l
Total PAH	2.8	0.037	mg/l
Total Cyanide	2.8	2.5	mg/l

TP51

Chemical	Depth	Value	Units
pH	0.3	9.6	
Phenol	0.3	20	mg/l
Total PAH	0.3	0.27	mg/l
Total Cyanide	0.3	0.6	mg/l
pH	1.0	11	
Phenol	1.0	1.2	mg/l
Total PAH	1.0	0.034	mg/l
Total Cyanide	1.0	1	mg/l

TP48

Chemical	Depth	Value	Units
Phenol	2.5	4.6	mg/l
Total PAH	2.5	0.6	mg/l
Total Cyanide	2.5	0.6	mg/l
Ammonium	2.5	14	mg/l

Key

Approximate Location of Former Structure

TP33 Trial Pit

BH11 Borehole

TP37, BH18 Exploratory hole locations indicating position where leachate samples were taken during the site investigation

0.7m, 2.2m Depths from which leachate samples were taken.

Total PAH – Total Polyaromatic Hydrocarbons
mg/l – Milligrams per litre

Notes

Leachate results were compared against 10 x Maximum Allowable Concentrations given in the water supply (Water Quality) Regulations 1989 (UK Legislation).

Version	Amendment	Originated by and date	Checked by and date	Approved by and date
A	First Issue	15.10.01	D.H. 15.10.01	T.B. 15.10.01

PARKMAN

Certificate no. FS 15024

Client	Bord Gais Eireann
Project	Limerick Gasworks
Drawing Title	Elevated Contamination Levels – Leachate
Purpose	Information
Draft / Issue	Issue ●
Scale	1:500 (A2)
Issuing Office	Cheshire
Telephone	0151 356 1666
Drawing Number	25837/OB/04
Version	A