Land Quality Management Ltd

For: Belfast City Council

Stage 3 Way Forward, Belfast Gas Works

Report No.: 1083-0/2
Status: Final

November 2012

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Stage 3 Way Forward, Belfast Gas Works

Final Report

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Land Quality Management Ltd Document Control

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Project Title	Stage 3 Way Forward, Belfast Gas Works
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LQM Report Number	1083-0/2

Document Version	Final Report	
Main Author	Judith Nathanail	signature
Approved for issue by	Dr C P Nathanail	signature
Position	Director	
Date	13 November 2012	
Status	Confidential	

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EXECUTIVE SUMMARY

(1) In November, 2010 Belfast City Council (BCC) commissioned Land Quality Management Ltd (LQM) to undertake contaminated land assessment works at the former Belfast City Gasworks, east of Ormeau Road, Belfast. The Site has been considered in terms of three zones: The Developed Area; The proposed Marriot Hotel; The undeveloped Northern Fringe.

(2) No risks to current receptors warranting immediate remedial action were identified.

(3) Legal drivers have been identified requiring protection to: Current and future users (planning); Surface water (under the Water Order 1999) and Aquifer (under the Water Order 1999 and Groundwater Regulations 2009). It is not clear whether there is a legal driver to address the contamination already present in the sandstone aquifer.

(4) Many uncertainties were identified in the preliminary conceptual site model (PCSM). Suggested actions to address each uncertainty have been detailed. Stakeholders need to be aware of these to assist in their decisions on the site. The major uncertainties relate to:

- The extent of coal tar contamination in the sandstone aquifer.
- Groundwater conditions;
    - depth to groundwater (minimal data); and
    - contradictions in the data on groundwater flow direction for the Marriot and Northern Fringe parts of the Site
- The absence of specific consideration of the potential for vapours entering buildings in the Developed Area.
- Impact of existing piled foundations in respect of upward vapour migration and possibly also downward migration of contaminants to the underlying aquifer.

(5) This report outlines likely risk assessment strategies (Section 6) and possible methods of risk management/ remediation (Section 7) and may be a useful reference when contamination issues are relevant to the evaluation of applications for planning permission

at the site. Its findings, if not the whole report, should be made available to potential developers of the Northern Fringe.

(6) There is a great deal of information which might be inexpensively obtained to address the identified uncertainties. Gaining this sooner rather than later (or finding out and documenting that it does not exist) will assist in subsequent decision making. Monitoring of existing wells to establish how groundwater depth varies with time should begin to be carried out as soon as possible as it will provide valuable data for designing a groundwater quality monitoring strategy.

(7) NIEA should be briefed on the findings of this report at the earliest opportunity as they can assist both with some of the uncertainties identified in the PCSM and with formulating a plan to comply with existing (and perhaps future) legislation. There is evidence of significant quantities of contamination in the sandstone aquifer hence NIEA's view in relation to existing groundwater contamination should be sought. At present, it is not clear any of the existing legislation would require BCC to deal with it nor that a technically feasible economically viable means of doing so can be developed.

(8) The uncertainties around possible vapour intrusion in the Developed Area may be resolved by obtaining the relevant information listed in Table 2. If this is not possible a ground vapour or indoor air monitoring programme may be required. Details are in Section 5.3.

(9) There is contamination in the soils and groundwater at the site. Likely risk assessment and some remediation methodologies exist. Piling should be carried out in a way that does not create new pathways by following the principles in Environment Agency of England and Wales guidance. It may be useful to draw this to the attention of the developers at an early stage to allow them to incorporate likely suitable foundations into their design and the need for the foundations work risk assessment could be included in any planning conditions where appropriate. Stakeholders should also be made aware of some remaining uncertainties, listed in Table 2. Any planning permission granted will need to ensure that the proposed development is compatible with this contamination by:

a. Preventing the creation of new pathways.

b. Interrupting pathways to new receptors, especially direct and vapour exposure to contaminants.

c. Breaking pollutant linkages causing pollution of groundwater.

d. Ensuring that verification reports demonstrating pollutant linkages have been broken are required in the planning condition.

(10) In addition to imposing planning conditions to address contamination it is essential to ensure that the planning conditions are complied with and hence can be discharged. This applies to all development on the Northern Fringe and on the 'Marriot site'.

(11) This executive summary should be read for information only. Action should be based on consideration of the full report and references cited.

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CONTENTS

1 INTRODUCTION 7
1.1 Background 7
1.2 Aim and objectives 7
1.3 Site Location and Zoning 7
1.4 Reporting 8
1.5 References 8
1.6 Additional Note 8

2 IMMEDIATE RISKS TO CURRENT RECEPTORS 9

3 UNCERTAINTIES IN THE PRELIMINARY CONCEPTUAL SITE MODEL (PCSM) 11
3.1 Introduction 11
3.2 Uncertainties in Groundwater Flow Direction 11
3.3 Uncertainties in PCSM 11
3.4 The Impact of Uncertainties on Decision Making 16

4 POTENTIAL LEGISLATIVE RESPONSIBILITIES 17
4.1 Introduction 17
4.2 Additional note 17
4.3 Belfast City Council Legal Review 21
4.4 Summary of Legislative Risks 24
4.5 Actions to address risks 24

5 STRATEGY FOR FURTHER WORKS 27
5.1 Introduction 27
5.2 Groundwater and surface water monitoring programme 27
5.3 Air monitoring within buildings in the Developed Area 29

6 RISK ASSESSMENT METHODOLOGIES 30
6.1 Introduction 31
6.2 CSM 31
6.3 Data Analysis 32
6.4 Risk Assessment Methodologies for Human Health 33
6.5 Risk Assessment Methodologies for Surface Water and Groundwater Risk Assessment 36

7 REMEDIATION STRATEGIES 42
7.1 Introduction 43
7.2 Relevant Pollutant Linkages (RPLs) 43
7.3 Remediation Strategies for Human Health 43
7.4 Remediation Strategies for Groundwater and Surface Water 45
7.5 Remedial works at similar sites 47

8 CONCLUSIONS 49

9 RECOMMENDATIONS 51
9.1 Short Term Actions 51
9.2 Liaison with NIEA 51

9.3 Groundwater and surface water monitoring 52
9.4 Possible vapour pathway to current users in the Developed Area 52
9.5 Proposed future development 52

10 LIMITATIONS 55

11 REFERENCES 57

APPENDIX 1 List of previous reports relating to site provided to LQM by BCC

1 INTRODUCTION

1.1 Background

(12) In November, 2010 Belfast City Council (BCC) commissioned Land Quality Management Ltd (LQM) to undertake contaminated land assessment works at the former Belfast City Gasworks (Purchase Order No. P03500050601).

1.2 Aim and objectives

(13) The aim of the whole work is "To provide the council with reasoned, expert and authoritative advice relating to the ownership and development of the Gasworks site. This advice will be used to inform the sustainable, appropriate, cost-effective and proportionate environmental management of the site in its current state and to guide its future development." (Belfast City Council, 2010).

(14) The objectives of this work were broken down into three stages:

a. LQM Stage 1: Produce and deliver a Preliminary Contaminated Land Risk Assessment in line with the Model Procedures for the Management of Land Contamination (CLR11).

b. LQM Stage 2: Liaise with the Council's Legal Services on the legal liabilities associated with the site; and

c. LQM Stage 3: Produce and deliver a 'Way Forward' document for the Gasworks Site.

(15) This report forms the output of Stage 3.

1.3 Site Location and Zoning

(16) The Site is the former Gas Works Site east of Ormeau Road, Belfast. Its location is more fully identified in the Stage 1 report. Three zones are addressed in this report:

Zone 1: The Developed Area

Zone 2: The Marriot Hotel

Zone 3: The Northern Fringe.

(17) Of these, the Northern Fringe is the most important area to address as the Developed Area is already developed and the Marriot Hotel received planning permission around the time of our being appointed. Two other zones were mentioned in the Stage 1 report which are not considered further: Zone 4 McAuley Street and Zone 5 River Terrace Allotments. This is because the specific issues at Zone 4 were resolved and the proposals relating to Zone 5 are not going to go forward. In fact the documents relating to Zone 5 were provided by BCC to LQM as background information only.

1.4 Reporting

(18) A Stage 1 report was issued to Belfast City Council in Draft in March 2010. There was considerable delay before the issue of the Stage 2 Legal Review from Belfast City Council, which was issued in Draft in December 2011 and in final in February 2012. With some amendments the Stage 1 report was issued in final in October 2012. This Stage 3 report was issued in draft in August 2012 and is now issued in Final.

1.5 References

(19) The list of previous reports relating to the site provided to LQM by BCC is reproduced from the Stage 1 report and presented in Appendix 1. The references for the previous reports are therefore not included in the general reference list at the end of this document.

(20) Legislation referred to in this report is listed in Tables 3 and 4 in Section 3 and is not included in the general reference list at the end of this document.

1.6 Additional Note

(21) As this report was being finalised, it became apparent that Marriot were no longer considering building a hotel on this site. However, the appellation has been retained to consistency with the documentation reviewed and the preliminary risk assessment.

2 IMMEDIATE RISKS TO CURRENT RECEPTORS

(22) Consideration was given in respect of whether there were immediate risks to current receptors. No risks to current receptors were identified which warrant immediate action.

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3 UNCERTAINTIES IN THE PRELIMINARY CONCEPTUAL SITE MODEL (PCSM)

3.1 Introduction

(23) The PCSM identified uncertainties for each of the zones. Some of those uncertainties are points of detail, which may not need to be addressed at a strategic level. This section identifies the uncertainties that impact on decision making and therefore require addressing.

3.2 Uncertainties in Groundwater Flow Direction

(24) Of particular significance are uncertainties in groundwater flow direction. These are summarised in Table 1.

Table 1 Reported Groundwater Flow Directions

	Groundwater Flow Direction	
	Zone 2: Marriott	**Zone 3: Northern Fringe**
Perched groundwater	North[1,2]	West
Groundwater in sandstone	South/ South East	West/ North West
Reference	RPS 2010a p2	RPS 2009a p26

3.3 Uncertainties in PCSM

(25) The uncertainties, the receptor(s) they relate to and the zones to which they apply are listed in Table 2. Additional uncertainties identified since the Draft PCSM was completed are also identified in Table 2. The highest priority uncertainties have been coloured yellow in Table 2. Those actions which are related have been similarly coloured to assist in quickly seeing the uncertainties which are addressed by related actions.

[1] RPS 2010a suggests perched water flows North due to topography of underlying boulder clay

[2] RPS 2008c p20 indicated that perched water flows "in a north to south direction towards the River Lagan"

Table 2 Uncertainties in PCSM

Uncertainties[3]	Receptor	DA	MA	NF	Actions to Address Uncertainties	Impact on decision making	Feasibility of resolving	Additional to uncertainties recorded in PCSM
Depth to groundwater	Perched water Sandstone aquifer	y	?	?	Groundwater monitoring programme	High	High	
Direction of groundwater flow (see also Table 1 for summary of current information on groundwater flow direction)	Perched water Sandstone aquifer	y	y	y	Groundwater monitoring programme	High	High	
Whether perched water is in hydraulic continuity with the Sandstone aquifer[4]	Perched water Sandstone aquifer	y	y	y	Groundwater monitoring programme	High	High	
Seasonal variation in relationship of the elevations of the perched water table and the potentiometric surface of the sandstone aquifer	Perched water Sandstone aquifer	y	y	y	Groundwater monitoring programme	High	High	
Whether there are any additional surface water receptors of concern	Surface water receptor	y	y	y	Liaison with NIEA	Medium[5]	High	
Whether tidal fluctuations downstream of the weir influence the Lagan and perched water beneath the Gasworks	River Lagan Perched water	y	y	y	Groundwater monitoring programme Review data from DOE monitoring wells in city centre if available (see also Parkman 1993a)	Medium[6]	High	
Significance of the Sandstone Aquifer beneath the gasworks	Sandstone Aquifer	y	y	y	Liaison with NIEA	High[7]	High	
Presence/Location of abstraction and monitoring boreholes in the Sandstone Aquifer and their Source Protection	Sandstone Aquifer	y	y	y	Liaison with NIEA	Medium/ High	Medium	

[3] Uncertainties with the highest impact on decision making are highlighted in yellow.

[4] There is some groundwater data which suggests groundwater in the sandstone could be in hydraulic conductivity with the perched groundwater; however, this might be due to poor construction of 2 monitoring wells in 1 borehole.

[5] Most important surface water receptor is the River Lagan; however if groundwater flow direction is indeed away from the River Lagan, it would be important to know whether there were other surface water receptors which might be affected.

[6] May be resolved as part of groundwater monitoring programme. If not, the need to resolve this could be reassessed in the light of the groundwater data.

[7] Key to understanding to what extent risk management is required at the site.

[8] Water boreholes would be potential receptors in relation to contamination already present within the Sandstone Aquifer. RPS 2009b comments that the Sandstone Aquifer 'is not used for potable purposes (and is not likely to be)'. RPS 2008a and 2008b did not report whether or not water supply boreholes are present in the vicinity of the site.

Uncertainties[3]	Receptor	DA	MA	NF	Actions to Address Uncertainties	Impact on decision making	Feasibility of resolving	Additional to uncertainties recorded in PCSM
Zones[8]								
Whether VOCs are present beneath the site	All receptors but particularly current users and future users	y			None identified. See footnote 10	Medium[9]	Low/Medium[10]	
Whether residual contamination is more extensive than indicated in Parkman 1997a and 1998a	All receptors	y			May not be possible to resolve; but stakeholders need to be aware of this possibility so they can take appropriate action if required	Low/Medium	Low	
The extent to which site investigation was carried out over the developed area post remediation and prior to developing the various parts of the site	Current users	y			Liaise with BCC Archivist to find out if additional site investigation reports are available	Medium	Low/Medium	
Whether or not the vapour pathway has been broken (either as a result of proving its presence is unlikely or by remedial measures)	Current users	y			Air monitoring programme; and/or Liaison with BCC Archivist to find out if there are as built drawings or certification to indicate whether or not membranes were placed in the buildings in the Developed Area	High	High	
Whether or not any special measures were taken to protect buildings and services from residual soil contamination or ground gases.	Current users	y			Liaison with BCC Archivist to find out if there are as built drawings or certification to indicate whether or not any special measures were taken to protect buildings and services from residual soil contamination or ground gases in the buildings in the Developed Area.	Medium[11]	Medium	
Condition of the culvert of the Blackstaff river	River Lagan Perched water		y		Liaison with BCC Archivist to find out if there are as built drawings of the culvert for the Blackstaff river. Testing of water within the culverted Blackstaff river to find out whether likely gasworks contaminants are	Medium	Medium	

[9] This matters because the presence of VOCs beneath the Developed Area could result in a risk of vapours migrating to the surface and entering buildings.

[10] May not be resolvable in itself, but the risk presented by the possible presence of VOCs may be able to be addressed in terms of whether vapours are detected within or beneath buildings on the Developed Area.

[11] May not be resolvable in itself, but may be able to be addressed in terms of whether vapours are detected within buildings on the Developed Area.

Uncertainties[3]	Receptor	DA	MA	NF	Actions to Address Uncertainties	Impact on decision making	Feasibility of resolving	Additional to uncertainties recorded in PCSM
					present			
Depth to base of Gas holder No.6	Sandstone aquifer		y		This might not be possible to resolve; but stakeholders on the Marriot site need to be aware that the depth to the base of the former gasholder No.6 is uncertain	Low/Medium	?	
Missing site history which might suggest reasons for the deeper made ground and thin boulder clay in BHMP9	Sandstone aquifer		y		This might not be possible to resolve; but stakeholders on the Marriot site need to be aware that locally the boulder clay may be thin	Low	Low	
The relative locations of BHMP9, BH01, BH03 and Gasholder No.6	Sandstone aquifer		y		This may not be possible to resolve; but stakeholders need to be aware that the boulder clay may be thin or non-existent around the circumference of former gasholder No.6	Low	Low	
Whether all contaminated material in the former lagoon was removed	All receptors		y		Much of the evidence indicates contaminated material has been removed. However, stakeholders in the Marriot site need to be aware of the possibility of residual contamination in the area of the small lagoon (on the East of the Marriot site).	Low	Low	
Location of former NIE substation	All receptors			y	Initially consult RPS to find out if they have a plan showing the location. Otherwise liaise with BCC archivist	Medium	Medium	
Details of proposed developments	Future users River Lagan Perched Water Sandstone Aquifer			y	When these become available they need to be considered in the light of the presence of contamination at the site. Stakeholders will need to be aware that measures will be required to break the ingestion, dermal, inhalation of dust and inhalation of vapour pathways. Stakeholders also need to be aware of the need to protect water resources including avoidance of creating new	High	High	

Uncertainties[3]	Receptor	DA	MA	NF	Actions to Address Uncertainties	Impact on decision making	Feasibility of resolving	Additional to uncertainties recorded in PCSM
					pathways.			
Whether contamination from the Gas Works site is reaching the Lagan	River Lagan	y	y	y	Surface water monitoring	Medium/ High	Medium[12]	✓
Whether Lagan is in hydraulic conductivity with perched water	River Lagan Perched water	y	y	y	Confirm depth of Lagan with Rivers Authority Groundwater monitoring linked with data from Lagan when available from DSDNI	High	High	✓
Impact of installing piles on groundwater quality and contaminant mobility[13]	Future users River Lagan Perched Water Sandstone Aquifer		y	y	Guidance in (Environment Agency, 2001)	High	High	✓
Whether reported "CH4" represents CH4 or other organic vapours	Future users		y	y	Collect gas samples and send for laboratory analysis	Medium	High	✓
Whether better data on vapour is required to design suitable vapour barriers	Future users		y	y	Liaise with vapour barrier suppliers	Medium	High	✓
Extent of Tar in Sandstone	Wider Sandstone Aquifer	y	y	y	Groundwater monitoring programme will address this to some extent, but may not be possible to completely resolve. Whether or not this needs to be further investigated may become clearer when other uncertainties- including whether or not there is a legal driver in respect of contamination in the sandstone- are resolved.	Medium	Medium	✓

[12] Can be difficult to disprove migration of contaminants from a site into a large surface water body like the Lagan as dilution of contaminants in the river may mean they are not detected during surface water sampling.

[13] Identified by NIEA in NIEA 2010

3.4 The Impact of Uncertainties on Decision Making

(26) The need to address the various uncertainties identified varies. Some uncertainties must be addressed in order to allow effective decisions to be made; for example, it is not possible to properly evaluate the risks presented by contamination in the groundwater without having a clear idea of the direction of groundwater flow. Others are less important in terms of making a decision but their resolution, or at least an understanding of the existence of the uncertainty, may illuminate the decision making process. For example, it may not be possible to determine whether or not all the contaminated material in the lagoon was removed. Knowledge of this may mean that allowance for, say, additional waste disposal of contaminated soil can be made.

(27) Some uncertainties are resolvable – such as groundwater flow direction. Others may not be; for example, the relative locations of BHM9, BH01, BH03 and Gasholder No. 6.

(28) The importance of resolving each uncertainty and the feasibility of resolving each uncertainty is identified in Table 2. The uncertainties which are of the highest importance in terms of their impact on decision making are highlighted in yellow in the uncertainty column.

4 POTENTIAL LEGISLATIVE RESPONSIBILITIES

4.1 Introduction

(29) This section summarises the likely responsibilities arising out of current and proposed legislation, based on the draft legal review provided by Belfast City Council with some additional legislation identified by LQM. For reference, current and proposed legislation relating to contamination on the site has been listed; UK and NI legislation in Table 3, European legislation in Table 4.

4.2 Additional note

(30) As this report was being finalised, one additional piece of legislation was identified by BCC (Neil McDonald/Judith Nathanail email 26th of October 2012). This is the Clean Neighbourhoods and Environment Act (Northern Ireland) 2011. It is understood that this legislation may be able to be used to regulate land contamination issues under its definition of 12 Statutory Nuisance and that BCC's legal services are checking whether or not this is the case.

Table 3 Current and Proposed NI and UK Legislation relating to contamination on the site

Legislation	Description	Comment (from LQM unless otherwise stated)	Source[14]
Part III of the Waste and Contaminated Land (Northern Ireland) Order 1997	Addresses contaminated land in Northern Ireland on similar basis to Part 2A in the rest of the UK. Not yet implemented and no date for implementation. Revised Statutory Guidance for Part 2A for England came into force April 6 2012.		Stage 2
The Water (Northern Ireland) Order 1[15]999	Identifies duties of NIEA which includes "to promote the conservation and cleanliness of water resources (para **4**).		Stage 2
	Enables NIEA to establish water quality objectives (para **6**).		
	Provides measures to combat and prevent pollution of waterways and groundwater in Northern Ireland (para **7**)	It is possible that this might be interpreted as applying to historic contamination but as the offence is "he discharges or deposits" it would probably be limited to contamination in soil (which could get into groundwater) and not apply to contamination already in the groundwater	
	This includes the offence of pollution of water if knowingly or otherwise "he discharges or deposits any poisonous, noxious or polluting matter so that it enters a waterway or water contained in any underground strata". (para **7** (1)(a)).	Exemption 7A (2)(b) might apply.	
Groundwater Regulations (Northern Ireland) 1998 Revoked August 2009 by Groundwater Regulations (NI) 2009	Require NIEA to prevent the direct or indirect discharge of certain substances to groundwater and to control pollution resulting from the direct or indirect discharge of certain other substances.		Stage 2

[14] Whether identified in the Stage2 Report or subsequently by LQM

Legislation	Description	Comment (from LQM unless otherwise stated)	Source[14]
Groundwater Regulations (Northern Ireland) 2009 Implements Groundwater Directive 2006/118/EC (referred to as Groundwater Daughter Directive)	Incorporates the requirements of the 1998 regulations. Require NIEA to prevent the direct or indirect discharge of certain substances to groundwater and to control pollution resulting from the direct or indirect discharge of certain other substances. Defines hazardous substances and non-hazardous pollutants (paras **3** and **4)**		Stage 2
	This includes NIEA identifying "any significant and sustained upward trend in pollutant concentrations, groups of pollutants or indicators of pollution" (para **10** (1)(a)).	Could this be applied to historic contamination in groundwater?	
The Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2003	Implements Water Framework Directive in Northern Ireland		LQM
The Water Framework Directive (Priority Substances and Classification) Regulations (Northern Ireland) 2011	Provides chemical standards for surface water		LQM
Planning (General Development) Order (Northern Ireland) 1993 as amended	Controls redevelopment of land in Northern Ireland Provides that NIEA is a statutory consultee in respect of planning.	Email 16/02/12 JFN/CC notes planning legislation unlikely to reference contaminated land directly	Stage 2
Part 2A of the Environmental Protection Act 1990	Applies to other parts of the UK (England, Scotland and Wales) Revised 2012 statutory guidance for England and Wales has defined "significant pollution of controlled waters" and "significant possibility of pollution of controlled waters".	Stage 2 report and discussions with CC indicate that Part III of the Waste and Contaminated Land (NI) Order 1997 is expected to be almost identical to Part 2A. It is anticipated that NI will look to English experience of Part 2A to be informed on possible impacts of Part III.	Stage 2
Environmental Liability (Prevention and Remediation) Regulations (Northern Ireland) 2009	Relate to future acts of contamination	Stage 2 report notes they are unlikely to be relevant to this site	
Public Health (Ireland) Act 1878	Protects public health Council is regulatory Authority and Consultee of Planning Service	Stage 2 report notes council obliged to act if building(s) may be a risk to public health	Stage 2
Liability in tort	Civil action in negligence or nuisance		Stage 2

Table 4 Current and Proposed European Legislation relating to contamination on the site

Legislation	Description	Source
Dangerous Substance Directive 76/464/EEC 2006/11/EC Dangerous Substances Directive (codified version) - includes the various amendments to 76/464/EEC	Specifies Environmental Quality Standards (EQS) Eliminate pollution by List I substances and minimise pollution by List II substances To be integrated into WFD	LQM
Groundwater Directive 80/68/EEC	To be repealed by the WFD in December 2013	Stage 2
Water Framework Directive 2000/60/E C	Achieve "good ecological and good chemical status" by 2015 Manage whole river basin Implement measures "necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater…" Implemented in part.	Stage 2
Directive 2008/105/EC	Environmental Quality Standards in the field of water policy. Amends and Repeals several Council Directives.	LQM
Groundwater Directive 2006/118/EC Implemented in NI by Groundwater Regulations (Northern Ireland) 2009	Referred to as the Groundwater Daughter Directive (GWDD) UK is required to publish a list of substances that it considers to be hazardous substances on the basis of their intrinsic properties	Stage 2
EU Soil framework directive (proposed)	The draft directive requires member states to 'take appropriate and proportionate measures to limit the intentional or unintentional introduction of dangerous substances on or in the soil.' Under negotiation since 2006 Proposed article 12 provides that where a site is to be sold where a polluting activity has taken place, Member states must ensure that the owner of the site or the prospective buyer makes a soil status report available.	Stage 2

4.3 Belfast City Council Legal Review

(31) As Stage 2 of the current works, Belfast City Council provided a Legal Review addressing legislation relevant to contamination issues on the Site. The issues highlighted are listed below together with some additional comments from LQM:

(32) The Stage 2 report indicates that the Council has several functions in relation to the site:

- Owner/ developer
- Vendor
- A regulator: it is a planning consultee in respect of public health
- As assumed legal successor to Belfast Corporation (and therefore, possibly "The Polluter")

(33) The Stage 2 report noted the lack of historical documents which might assist with understanding the legal status of BCC in terms of whether or not BCC might be regarded as "The Polluter". The legal uncertainties include:

- Whether BCC is a successor to the Belfast Corporation
- Whether the council itself was ever a gas undertaker
- Whether the Department of Commerce (which cleared the site in 1980 and may have spread the contamination around the site) ever indicated they would indemnify the council against any liabilities arising from the site.

(34) The Stage 2 report indicated that contractual liability is unlikely to be an issue for the Council.

(35) The Stage 2 report highlighted several issues in relation to possible statutory liability:

- The importance of the River Lagan as a receptor;

(36) "Potential contamination of the Lagan poses the greatest Legal risk to the Council in terms of the potential for regulatory action"

(37) LQM comment: Current information on the groundwater regime is unclear in respect of whether there is a pollutant linkage between the Site and the River Lagan, although it is reasonable to strongly suspect that one does exist.

- The need to consider the significance of the Groundwater Regulations (NI) 2009 in respect of the site and to liaise with NIEA to understand their likely requirements for any future development. It was noted that the regulations address preventing the input of hazardous pollutants into groundwater and limiting the input of non-hazardous pollutants into groundwater. It was also noted that there are some exempted activities.

(38) "The Groundwater regulations are probably the most unpredictable element of this project... the Council should liaise with the NIEA at the earliest possible opportunity".

(39) LQM comment: There is evidence that hazardous substances as defined in para 3 of the Regulations are present on the site, for example, polyaromatic hydrocarbons and phenols. There may be arguments which could be advanced to apply the exemptions to the Site, but this is by no means certain. In addition some of the contamination is already in the groundwater so it would not come under "prevent" or "limit". There remains the possibility that contamination already in the groundwater may be a concern in respect of an upward trend in contamination concentration.

- The need to control risks to prevent statutory intervention;

(40) *"I think, however, it is clear that should there be a significant possibility of significant harm to human health or significant pollution of controlled waters, that there is likely to be a need for measures to be put in place to control these risks to prevent statutory intervention"*

- The possibility that the Council could be a Class A or a Class B person;

(41) "It can be quite complex legally to decide whether a person falls into class A or class B, but in the present case, it is clear that there is a possibility that the Council could be a class A person given that it may be legally responsible for the old Gasworks. As the owner of the Gasworks estate, the Council could be a class 'B' person, which may be significant given the uncertainties as to whether it is class 'A' or not"

(42) LQM comment: This remains a possibility if Part III comes in. The experience in England is that Part 2A is applied sparingly especially where measures are being taken to address risks presented by contamination at a site.

(43) The Stage 2 report indicated that the Northern Fringe is the zone of most pressing concern to the Council;

(44) "Firstly, when undertaking any site conditioning prior to any sale, the Council can ensure that this is done to an accepted standard satisfactory to the NIEA.

(45) Secondly, and more importantly, the Council should be able to structure any sales of plots of land to ensure that the Developer becomes responsible for any contamination issues. The Council can achieve this by full disclosure of all relevant matters prior to sale together with properly drafted transfer documents.

(46) Any pathways are likely to be introduced by the developer, who will be responsible for site piling etc"

(47) The Stage 2 report highlights NIEAs concern regarding piling.

(48) LQM comment: The issue around piling is the need to avoid creating new pathways for pollutants.

(49) The Stage 2 report notes there might also be potential liability in common law.

(50) The Stage 2 report reviews relevant case law and in respect of Part 2A, notes:

(51) "The Circular Facilities case [16] is very interesting. In that case the sixth of the exclusion tests was utilised, so that liability attached to the party that introduced the pathways. The National Grid[17] case shows that the Council could be liable for the activities of the old Belfast Corporation as its legal successor, and the Redland case[18] shows that even if state of the art decontamination is carried out, there can always be future liability should the statutory Framework change."

16 [2005] EWHC 865 (Admin)

17 [2007] UKHL 30

18 [2010] EWHC 913 (Admin)

(52) No case law in relation to Groundwater Regulations (Northern Ireland) 2009 was identified in the Stage 2 report.

4.4 Summary of Legislative Risks

(53) As the stage 2 report states, "should there be a significant possibility of significant harm to human health or significant pollution to controlled waters… there is likely to be need for measures to be put in place to control these risks to prevent statutory intervention". The main risks identifies fall into the following categories:

- Protection of current users – via Public Health Act 1878
- Planning – Risk to future users and water resources via Public Health Act 1878 and Planning (General Development Order) 1993.
- Protection of groundwater from several pieces of legislation – e.g. via the Water Order 1999. This includes protecting identified groundwater receptors and protecting groundwater as a resource.
- Protection of surface water – the Lagan is an important receptor but more information is required on the groundwater regime.
- Part III of the Water and Contaminated Land Order 1997 – there is possible future liability in respect of current users and water resources.

4.5 Actions to address risks

(54) In respect of planning, the issues include breaking the pathways (to current/future users) and taking measures to prevent the creation of new pathways, particularly from piled foundations. This is further discussed in Sections 5, 6 and 7.

(55) In respect of groundwater and surface water (further discussed in Section 5.2), actions include:

- A groundwater monitoring programme to determine the direction of groundwater flow and look at trends in contaminant concentrations.

- Identification/Confirmation of the water receptors – the River Lagan, other surface water receptors and groundwater.

(56) In respect of preventing possible future Part III land from the granting of planning permission, actions include:

- Imposing suitable planning conditions on proposed redevelopment (Section 9.5)
- Ensuring the discharge of planning conditions (Section 9.5)
- Preventing the creation of new pathways from piling by ensuring that a foundation works risk assessment is carried out as part of the foundation design and ensuring its recommendations are followed (Section 6.4.4).

(57) The legislative uncertainties may be reduced in part by:

- Obtaining historic documents (see Table 2)
- Liaising with NIEA (Section 9.2)

(58) The Stage 2 report provides a recommendation using contractual conditions to protect the Council:

(59) "The Council should be able to structure any sales of plots of land to ensure that the Developer becomes responsible for any contractual issues. The Council can achieve this by full disclosure of all relevant matters prior to sale together with properly drafted transfer documents".

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5 STRATEGY FOR FURTHER WORKS

5.1 Introduction

(60) This section provides a strategy for further works addressing the uncertainties listed in Table 2.

(61) The first step is to collect any additional available information from the BCC archivist; information from the Belfast Sewer Tunnel works and to liaise with NIEA. The information required is listed in Table 2 and liaison with NIEA is discussed in Section 9.2.

5.2 Groundwater and surface water monitoring programme

(62) Many of the uncertainties relating to groundwater and surface water (identified in Table 2) can be addressed by an effective site wide groundwater monitoring programme.

(63) In the short term BCC should arrange for the existing monitoring wells on the Marriot and Northern Fringe to be monitored for depth to groundwater on a regular basis; initially weekly to obtain a picture of groundwater flow directions quickly and then monthly. This could be done by BCC staff and is therefore relatively inexpensive. The collected data together with the surveyed levels of the boreholes provided by RPS should be used to evaluate likely groundwater flow directions in the perched water and sandstone. Water levels at the Lagan Weir should be obtained from DSDNF for each monitoring event (and for the historic monitoring events) to allow an evaluation of the relationship, if any, between the Lagan and the 2 aquifers.

(64) In the medium term it is likely that a network of monitoring wells will need to be established across the site, ideally including the Developed Area. The purpose is to find out the direction of groundwater flow (including whether there is a degree of hydraulic conductivity between the aquifers) and collect groundwater samples for contaminant testing in order to look at trends in contaminant concentration.

(65) Monitoring wells will be required for both the perched and sandstone aquifer. It is recommended that monitoring wells for the two aquifers are in separate boreholes (unlike most of the existing boreholes on the Marriot Site and Northern Fringe). This is more expensive but removes the uncertainly of whether there is a degree of hydraulic conductivity

between the aquifers or if this apparent feature is due to poor construction of the monitoring wells. As a guide, it is suggested that a minimum of 10 locations are used for the monitoring network; making potentially 20 wells; 10 in the perched aquifer and 10 in the sandstone. However, it may be possible to incorporate some of the existing wells into the monitoring network.

(66) Likely depths for the monitoring wells are the top of the boulder clay for the perched aquifer and 3-10 metres into the sandstone for the sandstone aquifer. For both aquifers the depths will be decided in the light of the groundwater monitoring in the existing boreholes and discussions with NIEA.

(67) Boreholes drilled into the sandstone aquifer should be designed to avoid cross contamination between the aquifers. Boreholes drilled in locations where the boulder clay is absent may also require special design.

(68) The network of wells will need to be monitored for depth to groundwater on a regular basis as described above for the existing wells including obtaining information on the water levels at the Lagan Weir. Sampling for contamination concentrations would be expected to be 6 times during the first year reducing to 3-4 times per year for subsequent years. Data on contaminant concentrations should be evaluated on a regular basis (e.g. six monthly or annually) as this may allow for the suite of analysis to be reduced.

(69) The initial suite of contaminants to test for are:

- Metals
- Speciated petroleum hydrocarbons (TPH-CWG)
- Volatile organic compounds
- PAHs – speciated, the National Grid 19 or US EPA 16 are usual suites
- Phenols - speciated

(70) Surface water monitoring to establish whether contaminants are present in the Lagan (or other surface water body if identified) may be required for the longer term. It should be designed in the light of the results from the groundwater monitoring.

(71) Once this data has been collected and other uncertainties relating to water have been addressed it may be necessary to carry out risk assessment for water resources which is described in Section 6.5

5.3 Air monitoring within buildings in the Developed Area

(72) This action is to address the uncertainty relating to current users in the Developed Area; whether or not the vapour pathway has been broken. It will only be required if suitable reliable information such as that identified in Table 2 cannot be obtained. Air monitoring can be time consuming to carry out and the results are sometimes inconclusive hence every effort should be made to find the information listed in Table 2.

(73) The aim of the air monitoring would be to test for volatile contaminants in indoor air, including sub-slab measurements if possible.

(74) In the first instance air quality measurement points should be targeted in the areas most likely to be at risk of exposure to vapours from the subsurface. Currently there is insufficient site investigation information on the Developed Area to suggest locations where vapours may be coming from soils. However, based on the holes in the Boulder Clay found near gas holders on the Marriot site and the Northern Fringe, there is suspected to be a higher risk of vapours from DNAPLs in the sandstone around the edges of the former gas holders.

An initial suite of determinands would be volatile organic compounds (VOCs)

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6 RISK ASSESSMENT METHODOLOGIES

6.1 Introduction

(75) This section summarises the risk assessment methodologies likely to be required to assess the data derived from the strategy for further works described in Section 5. The Risk Assessment for human health and for evaluating risk in relation to piling would be expected to be commissioned by future developers. Risk Assessments for groundwater and surface water across the site may need to be commissioned by BCC (although developers may also commission such Risk Assessments). Prior to undertaking any kind of risk assessment, it is necessary to understand the Conceptual Site Model (CSM) for the site and have analysed the data.

6.2 CSM

(76) The CSM identifies the Pollutant Linkages to be evaluated. On this site the Pollutant Linkages to be evaluated for Human Health are likely to be:

- Ingestion
- Dermal uptake
- Inhalation of dust
- Inhalation of vapours.

(77) If residential properties with gardens were to be constructed then an additional pathway – vegetable uptake – would need to be considered.

(78) The pollutant linkages to be evaluated for groundwater are:

- Migration via the unsaturated zone
- Migration via the saturated zone
- Migration via preferential pathways

6.3 Data Analysis

6.3.1 Approaches to Data Analyses

(79) This section describes methods of describing and displaying data to assist in its interpretation.

6.3.1.1 Soil and Groundwater concentrations

(80) Data should be obtained in a format such as AGS, Excel or a .csv file which will allow data query and integration with other data to be carried out. Unfortunately many laboratories and hence consultants provide their data as .pdf or paper unless specifically requested otherwise.

(81) It is worth specifying to any consultants that BCC commission that they will have to submit their data file in an agreed format as well as their report. Descriptive statistics such as the mean, standard deviation, minimum, maximum and number of data points are used to summarise a data set. These are easy to generate using Excel. Histograms showing the frequency against concentration of each contaminant also provide a picture of the spread of contaminant concentrations. Simple post plots of sample locations and relevant concentrations should be used to display spatial variability. Time series plots should be used to display trends over one or more years.

(82) To understand the distribution of contaminants laterally and with depth, the location of contaminants is plotted onto a site plan. It may be necessary to have plots of lateral extent at different depths and/or in different materials. RPS (2009a) provided plots showing contaminants in soil in made ground, Boulder Clay and sandstone.

(83) To evaluate the distribution of contaminants with depth one option is to plot a graph of depth against concentration for each contaminant using the data from the whole site (or for each zone of the site). Another option, which takes into account the location of the contaminant is to plot contaminant concentrations on one or more geological cross sections across the site.

(84) Where there are several rounds of data for concentration in groundwater graphs of concentration against time can be plotted in order to identify whether there are upward or downward trends in contaminant concentration.

(85) Many consultants apply spatial statistics to data sets of contaminant concentration. However the use of non-spatial statistic based on (CIEH & CL:AIRE, 2008) is very rarely defensible. The application of spatial and non-spatial statistics are only in relation to unbiased sample data; they are not appropriate if targeted sampling has been used (BSI, 2011). Non spatial statistics are not appropriate for data with spatial trends or where data are clustered or from different populations. RPS 2009a has used non-spatial statistics for the soils data on the Northern Fringe. Spatial trends are clearly evident in the soils results beneath the Northern Fringe soil and so their interpretation is not defensible.

6.3.1.2 Depth to groundwater

(86) The elevation above datum of each monitoring well needs to be known in order to interpret data on depth to ground water. This data is collected by the consultant responsible for the construction of the well. Once again BCC could specify that they submit their data files of depth to groundwater, ground level and reduced groundwater level. For each monitoring event, contour plots of depth to groundwater can be plotted in order to identify the likely direction of groundwater flow and possibly also hydraulic gradient. To evaluate seasonal variation to groundwater levels depth to groundwater is plotted against time.

6.4 Risk Assessment Methodologies for Human Health

6.4.1 Outline of Human Health Risk Assessment

(87) Human health risk assessment identifies the concentrations of contaminants at a site which will not present an unacceptable risk to human receptors identified on this site; in this case the current or future users of the site.

(88) In the first instance concentrations of contaminants in the soil are compared to trigger values, also known as Generic Assessment Criteria (GAC). This is known as Generic Quantitative Risk Assessment (GQRA).

(89) If GAC are exceeded consideration is given to either further risk assessment or carrying out risk management measures (see Section 7). Further risk assessment is termed Detailed Quantitative Risk Assessment (DQRA). DQRA may also be required if a GAC does not exist for non-standard land use or if the assumptions in the model are not appropriate for the site.

(90) Both GQRA and DQRA follow similar steps to estimate risk. The difference is that GQRA makes generic assumptions which are generally conservative and may or may not be applicable to a particular site. DQRA uses site specific input values. The steps are:

- Identifying the land use (from the conceptual model)
- Identifying the relevant exposure pathways (from the land use)
- Identifying the critical receptor (the individual or subgroup of the population most likely to be exposed and or susceptible to the presence of soil contamination) e.g. a female child
- Selecting the input data for the critical receptor, the contaminants, the site, soil properties, and pathways
- Calculating average daily exposure (ADE) based on the input data for the critical receptor
- Determining the health criteria value (HCV) based on toxicological data for each route of entry
- The ADE is then compared with the HCV; if ADE is greater that HCV, further action may be required which could be more risk assessment or risk management/ remediation. A more detailed explanation is provided in (Environment Agency, 2009) (Environment Agency, 2008b)

6.4.2 Available Trigger Values in the UK

(91) Available trigger values in the UK are:

- Soil Guideline Values published by the Environment Agency. SGV can be downloaded from the UK Environment Agency.
- LQM/CIEH Generic Assessment Criteria (GAC). The LQM/CIEH GAC are available from Land Quality Management Ltd, Nottingham.
- EIC/AGS/CL:AIRE Generic Assessment Criteria (GAC) can be downloaded from .. http://www.claire.co.uk/index.php?option=com_content&view=article&id=306&Itemid=91, accessed 010512 10.30

(92) All these values are based on CLEA 1.06 published by the Environment Agency. The soil guideline values and other GACs listed above are intended as screening criteria for Human Health. They do not represent a threshold for the significant possibility of significant harm.

(93) At the time of writing, Defra have recently commissioned a project to develop a methodology for deriving category 4 screening levels (C4SLs) and to derive C4SL for 6 substances. This project is due to report by May 2013 and once published, the basis for the C4SL should be reviewed to confirm their relevance to NI planning policy.

6.4.3 DQRA for Human Health Risk Assessment

(94) If DQRA is required, it may be carried out using the CLEA or eventual C4SL algorithms whilst using more site specific input data or by using other risk assessment tools such as RBCA or Risk Human. Calculation of DQRA may include collection of additional site investigation data such as tests for bioavailability or vegetable uptake. DQRA is based on site specific (not generic) assumptions about the source, pathways and receptors relevant to the site.

(95) The Environment Agency has provided an Excel spreadsheet to facilitate calculations which can be obtained from their website. They have also provided recommended physical-chemical data for 66 organic chemicals in (Environment Agency, 2008a). A populated spreadsheet is available from www.environment-agency.co.uk which can be copied into the CLEA software.

(96) In respect of the Northern Fringe a site investigation and risk assessment (RPS 2009a) has been carried out for Belfast City Council. There are some deficiencies in the data analysis, particularly the use of spatial statistics on a data set which has spatial trends. However there is a strong possibility that the ingestion, dermal uptake and inhalation of dust pathways will be broken by the construction of buildings and hardstanding. This of course would be the developer's responsibility to demonstrate. The main pathway requiring risk assessment is expected to be inhalation of vapours.

6.4.4 Foundation risk assessment

(97) Guidance is provided by the Environment Agency in (Environment Agency, 2001). The construction of buildings on the Marriot site and the Northern Fringe may require the use of

piled foundations. Consideration needs to be given to avoid creating new pathways. The EA (Environment Agency, 2001) identifies six scenarios of concern. The two scenarios of most concern to the site are:

- Creation of preferential pathways through a low permeability layer (the boulder clay) allowing downward migration to an underlying aquifer (the sandstone).
- Creation of preferential pathways through a low permeability layer (the boulder clay) allowing upward migration of vapours from DNAPL in the sandstone.

(98) To address these risks a foundation works Risk Assessment report is produced (Environment Agency, 2001). This outlines the problem, identifies the initial preferred method of piling, considers the potential impacts and identifies changes to the preferred measures including QA/QC measures and monitoring.

(99) In respect of the scenario for downward migration of contamination to the aquifer changes to the pile design are likely to be required. The scenario of upward migration of vapours is more likely to be dealt with by breaking the vapour pathway.

6.5 Risk Assessment Methodologies for Surface Water and Groundwater Risk Assessment

(100) In the rest of the UK, a risk based approach is taken to assessing and managing contamination in respect of water resources. It is anticipated that Northern Ireland would be informed by practice on mainland UK. On mainland UK the wider resources to be protected are known as "controlled waters" which are defined in UK legislation.

(101) LQM looked at some of the legislation identified in the Stage 2 report to try and clarify the definitions relation to protected waters. The Water Order 1999 protects:

- Water contained in underground strata and;
- Waterways (defined in 2 (2)) which includes rivers, inland waters and tidal waters

(102) The 2009 Groundwater Regulations protects groundwater (defined in 2 (1)) as

(103) "all water which is below the surface of the ground in the saturation zone and in direct contact with the ground of subsoil."

6.5.1 Outline of Surface Water and Groundwater Risk Assessment

(104) Surface Water and Groundwater risk assessment is used to evaluate the risk presented by contaminants in soil and groundwater to identified surface water and groundwater receptors. Consideration is given to contamination in soil, which may enter groundwater, and contamination in groundwater, which may migrate to an identified receptor. At the simplest level contaminant concentrations present in the groundwater beneath the site are compared to identified water quality standards (which are used to define Target Concentrations as further described below). This is termed GQRA. RPS 2009a has compared the results in the Northern Fringe to target concentrations.

(105) If the Target Concentrations are exceeded, DQRA is carried out. RPS 2009a has not carried this out for the Northern Fringe but recommended that DQRA is carried out. In England and Wales there are two methodologies primarily used:

- The remedial target methodology published by the Environment Agency (Environment Agency, 2006). This comprises a report, an excel spreadsheet and a user manual and can be obtained from: http://www.environment-agency.gov.uk/research/planning/40373.aspx

- CONSIM, a software tool developed by Golder Associates on behalf of the Environment Agency to assess the risk to groundwater from leaching contaminants. It can be purchased from Golder Associates: http://www.consim.co.uk/.

(106) Both use a similar approach. The following discussion is primarily based on the remedial targets methodology.

6.5.2 Water Quality Standards

(107) Under the Water Framework Directive (Priority Substances and Clarification) Regulations (Northern Ireland) 2011, there are now Environmental Standards for many contaminants in respect of surface water. These were not available when RPS 2009a was written. Where these are not appropriate, or for contaminants not included, Water Quality Standards (WQS) used to set Target Concentrations are:

- Environmental Quality Standards (EQS) specified under Dangerous Substances Directive (76/464/EEC)

- Environmental Quality Standards (EQS) specified under Water Framework Directive (2000/60/EC)
- UK Drinking Water Standards (UK DWS)
- World Health Organisation (WHO) Guidelines for Drinking Water Quality
- Council Directive 98/83/EC on the quality of water intended for human consumption

(108) There are other standards which may be relevant for certain uses of the water e.g. angling or bathing. A list of some of these can be found in (Environment Agency, 2006).

(109) A useful online resource is provided by the Environment Agency's chemical standards database. This summarises statutory and non-statutory chemical standards (including water quality standards) for most contaminants and can be found at: http://evidence.environment-agency.gov.uk/ChemicalStandards/home.aspx. This does not include the chemical standards from The Water Framework Directive (Priority Substances and Classification) Regulations (Northern Ireland) 2011, which would be expected to take priority in respect of surface water in Northern Ireland.

6.5.3 DQRA for groundwater and surface water risk assessment

(110) The aim of DQRA for groundwater and surface water risk assessment is to address the question of not presenting an unacceptable risk at an identified receptor, such as the River Lagan or the sandstone aquifer.

(111) DQRA for groundwater and surface water risk assessment considers the decrease in contaminant concentration along the flowpath from a source to a receptor. This decrease may be observed, but is more usually modelled. Key definitions (described in simple terms here and more fully defined and explained in 6.5.4 to 6.5.6 below) are:

- Target concentration (TC) – the concentration of a contaminant which must not be exceeded
- Compliance point (CP) – the location at which a target concentration must not be exceeded. The compliance point is located at some point along the flow path between the source and receptor.

- Remedial target (RT) – the maximum concentration there can be in the source location so that the concentration at the compliance point does not exceed the target concentration.

6.5.4 Compliance Point

(112) The Compliance Point (CP) is "the point along the contaminant pathway where the target concentration should not be exceeded as this would represent an unacceptable risk of harm to the receptor" (Environment Agency, 2006).

(113) The location of the CP can change and depends primarily on the "Level" of hydrogeological risk assessment being undertaken. Both EA (2006) guidance and CONSIM use 4 assessment levels. At each Level, the compliance point moves further from the source. Table 5 summarises the Levels.

Table 5 Location of Compliance Point at Levels 1-4

Level	Contaminants in soil which may enter groundwater	Contaminants in groundwater which may migrate to an identified receptor
1	CP is the soil in the source area	No Level 1
2	CP is the groundwater immediately below the source Level 2 takes account dilution by groundwater flow beneath the source. It may also consider attenuation in the unsaturated zone (this is not included within the Remedial Targets Spreadsheets but is present in CONSIM).	CP is the groundwater immediately below the source Therefore RT = TC (and no calculations are required).
3	CP is the groundwater downgradient of the source e.g. river, water abstraction. Level 3 takes account of attenuation in the saturated zone.	CP is the groundwater downgradient of the source e.g. river, water abstraction. Level 3 takes account of attenuation in the saturated zone.
4	CP is at the receptor. Level 4 takes into account dilution within the receptor. Level 4 equations are in the remedial target methodology but not in the spreadsheet provided or in CONSIM.	CP is at the receptor. Level 4 takes into account dilution within the receptor. Level 4 equations are in the remedial target methodology but not in the spreadsheet provided or in CONSIM.

(114) The location of the CP needs to be agreed with NIEA.

(115) Guidance on locating a compliance point for hydrogeological risk assessment is provided by Environment Agency (Environment Agency, 2006) p28. Scottish guidance (Position Statement WAT-PS-10-01 Assigning groundwater assessment criteria for pollutant inputs, Version: 2.1 June 2011) describes the Scottish approach.

6.5.5 Target Concentration

(116) The Target Concentration "is the concentration at the compliance point that should not be exceeded" (Environment Agency, 2006). In principle, the target concentration remains constant during the assessment process and is normally based on a relevant environmental standard or background water quality. (There are occasions when the Target Concentration may be changed but this is usually a policy decision such as selecting a less stringent value as a result of cost/benefit analysis)

(117) The Target Concentration selected is based on the current intended use of the water and plausible, proposed or planned future uses of the water and nearby waters (Environment Agency, 2006). For example at sites where groundwater is used for drinking water, a suitable value would be the UK Drinking Water Quality Standard. At sites where groundwater provides base-flow to rivers / streams, an Environmental Quality Standard (such as The Water Framework Directive (Priority Substances and Classification) Regulations (Northern Ireland) 2011) would be used.

6.5.6 Remedial Target

(118) Once the target concentration (TC) has been identified and the compliance point (CP) agreed (i.e. where the TC should be achieved) the Remedial Target (RT) is calculated. The RT takes into account the decline in contaminant concentration with distance along the flow path. The RT provides the maximum concentration there can be at the source area without exceeding the target concentration at the CP.

(119) There are two approaches to this:

a. A "Forward calculation" from source to compliance point. Estimate the concentration in water at the compliance point based on measured concentrations at the source and compare directly with the target concentration. COMSIM uses a forward calculation.

b. A "Backward calculation" from compliance point to source. Estimate the concentration at the source that will give a concentration in water at the compliance point equal to the target concentration and compare this with measured source concentrations. The backward calculation is used by Environment Agency 2006.

(120) Remedial Targets can be derived for:

a. Contaminants sorbed to soils above the water table in the unsaturated zone. (if there is the potential for pollution of surface water or groundwater)

b. Contaminants dissolved in groundwater at or below the water table in the saturated zone; (if contamination has already occurred)

(121) The RT decreases from Level 1 to Level 4; this may mean that less costly risk management options are required. The amount of data required to derive an RT (and hence the cost of the risk assessment) increases from Level 1 to Level 4.

6.5.7 Cost Benefit Analysis

Based on (Environment Agency, 2006) the final part of waters risk assessment includes consideration of the costs of the proposed remediation against the anticipated environmental benefits.

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7 REMEDIATION STRATEGIES

7.1 Introduction

(122) This section summarises potentially appropriate remediation strategies for the Site. It also discusses past remedial works conducted at similar sites with pollutant linkages similar to those identified in the PCSM.

7.2 Relevant Pollutant Linkages (RPLs)

(123) The design of a remediation strategy starts with identifying the RPLs (Environment Agency, 2004) based on the updated conceptual site model. There are still many uncertainties to address on the CSM. Therefore this discussion of possible remediation strategies is based on the pathways likely to need consideration, which are;

- Vapour intrusion
- Ingestion, dermal uptake, inhalation of dust
- Migration via unsaturated zone
- Migration via saturated zone
- Migration via preferential pathways in the boulder clay

7.3 Remediation Strategies for Human Health

7.3.1 Dermal uptake, Ingestion and dust inhalation pathways

(124) There are elevated concentrations of contaminants in the soils which could affect future users of the site via dermal uptake, ingestion and inhalation of dust.

(125) If future development will result in the site being almost entirely covered by buildings and hardstanding, further remedial action in respect of these pathways would not be required. Measures may be required locally to address soft landscaped areas, but would probably be limited to breaking the pathway by use of a barrier.

(126) Should future development, including any interim development, comprise soft landscaping or reprofiling of existing materials, a risk assessment will be needed to determine the need for any remediation works.

7.3.2 Vapour intrusion pathways: Marriot and Northern Fringe

(127) The major issue of potential concern in respect of human health is the presence of contaminants in soil and groundwater which could result in vapour intrusion into the proposed buildings. It includes the possibility of upward migration of volatile contaminants from DNAPLs in the sandstone aquifer via holes in the Boulder Clay.

(128) Remediation options are:

- Removal of hotspots of soil contamination, OR
- Installation of vapour barriers into the design of any buildings, AND
- Foundation design that does not create new pathways for downward migration of liquid pollutants and upward migration of vapours.

(129) Removal of soil hotspots may not be practical in some locations and also depends on having identified all such locations.

(130) In any event, as there is a second possible source of vapours from DNAPLs in Sandstone migrating upwards via holes in Boulder Clay and possibly other preferential pathways, the pathway into buildings need to be broken. Any design to protect against vapour intrusion should allow for an increase in vapour as a result of piling which could create additional vapour migration pathways. The most likely solution to be adopted by a developer is to break the pathway by the installation of vapour barriers.

7.3.3 Vapour Intrusion Pathways Developed Area

(131) In the event that there was sufficient evidence to suggest that the vapour pathway had not been broken, and there were legal, or other, drivers to address it, risk management options include:

- Long term air monitoring
- Gas alarms

- Retrofitting membranes
- Installation of air blanket

7.4 Remediation Strategies for Groundwater and Surface Water

7.4.1 Unsaturated zone pathways

(132) Residual contamination present in the soils could migrate via the unsaturated zone into the underlying perched aquifer. Identified hotspots can be dealt with by excavation and disposal.

(133) Covering the site in buildings and hardstanding will reduce the amount of infiltration and thereby reduce migration via the unsaturated zone. The efficacy of this option can be assessed using the remedial targets methodology (Environment Agency, 2006) as described in Section 6.5. In respect of the Northern Fringe, soil contamination data which could be used for this risk assessment is already available in RPS 2009a.

7.4.2 Saturated zone pathways

(134) The pathway to the Lagan has not been proven in any of the reports reviewed and to date no other surface water receptors or abstractions have been identified. However, it is possible that measures to address contamination already in the saturated zone might be required. It is known that the contamination in the sandstone aquifer appears as a tar and almost certainly includes a dense non aqueous phase liquid (DNAPL). DNAPLs are difficult to remove from groundwater.

(135) There has been limited success in removing all DNAPL from below the water table (Environment Agency, 2003) at sites, particularly in fractured rock. Remediation strategies may comprise source zone containment or stabilisation, partial mass removal, plume management or plume interception.

(136) Separate approaches are often warranted for the DNAPL source zone and any associated aqueous phase plume.

(137) The design of any remediation option in respect of the DNAPLs in the saturated zone will require considerable site investigation and data analysis in order to understand the location of the source zone and migrating plume.

(138) Table 5 lists DNAPL remediation techniques suggested in (Environment Agency, 2003) with comments on their possible applicability at the site.

(139) **Table 5** *DNAPL Remediation Technologies*

Technique	Summary Description	Likely feasibility	Comment
Groundwater Pump and Treat	Groundwater is pumped from wells and treated off-site. Mature technology but treatment times are long. Many sites experience rebound (i.e. return of contaminant if treatment stops)	Low	Long (indefinite?) treatment times makes this unlikely as a treatment option. Might be used as a temporary process if it becomes necessary to protect an identified receptor.
Permeable reactive barriers (PRB)	Groundwater is guided towards a treatment zone by the construction of subsurface vertical barriers.	Low	Aquifer needs to be accessible so unsuitable for sandstone aquifer. Also need consistent groundwater flow direction which may not be present at this site.
Physical barriers	Vertical barriers such as sheet piles used to isolate DNAPL from groundwater.	Moderate	Typically limited to unconsolidated deposits. Requires good delineation of DNAPL extent.
Enhanced biodegradation	Addition of nutrients and other agents to create the right geochemical conditions to biodegrade contaminants in site. Partial mass removal.	Moderate	Might be applicable. Would require good delineation of DNAPL and plume extent and pilot tests before implementation.
Thermally enhanced technologies	A range of technologies using heat to vaporise and mobilise contaminants. Requires SVE to remove vapours.	Moderate	Limited track record in UK. Risk of mobilising contamination to unimpacted areas. Can work below water table but may not be feasible at depth of sandstone aquifer.
Chemical Flushing	Chemicals introduced to subsurface to mobilise and remove residual and pooled DNAPL.	Moderate	Variable results. Risk of mobilising contamination to unimpacted areas
Excavation	Physical excavation of residual and pooled DNAPL from soil. Does not treat groundwater.	Low	Whilst residual soil contamination could be excavated once it had been delineated, this does not address contamination in the perched and sandstone aquifer.
In situ chemical oxidation (ISCO)	Use of chemicals to destroy contaminants in situ by oxidation. Partial mass removal.	Low	Might be applicable but good delineation of DNAPL and pilot study would be required. Stoichoimetry requires good characterisation of contaminant mass.
Soil vapour extraction (SVE)	SVE extracts air from the unsaturated zone which encourages volatilisation (and a degree of biodegradation) of volatiles in residual and pooled DNAPL.	Low	As SVE is essentially for the unsaturated zone it is unlikely to be the main technology on this site, except to treat areas of residual contamination.
Water Flooding	An increase in hydraulic gradient is used to mobilise and remove pooled DNAPL. A source zone stabilisation technology which can halt DNAPL migration and remove potentially mobile pools.	Low	Requires much higher degree of hydraulic control than current understanding of groundwater regime.
Air sparging	A similar process to SVE but operating below the water table to encourage volatilisation of dissolved phase contaminants.	Low	DNAPL handbook (Environment Agency, 2003) notes air.sparging has not been very successful at DNAPL sites.

7.4.3 Preferential pathways via holes in Boulder Clay

(140) Much downward migration into the aquifer has already happened. There is unlikely to be a feasible method of blocking the holes in the Boulder Clay. Surface sealing or diversion of percolating rainwater will reduce downward migration of remnant shallow contaminants.

(141) The upward migration of vapours from contamination in the sandstone through holes in the Boulder Clay remains a possibility.

7.5 Remedial works at similar sites

(142) There is a long history of remediation of former gasworks in the UK and around the world. Former gasworks sites have been redeveloped for housing, commercial, leisure and industrial uses. In some cases former gas works structures have been retained and included in the redevelopment.

(143) Most remediation involved conventional engineering techniques such as excavation and offsite disposal of contaminated soils. However process based techniques have also been used. The former Basford Gasworks, Nottingham, was remediated using soil washing. A permeable reactive barrier is being used to remediate polluted groundwater at a gasworks in Exeter. Bioremediation has been used at the Hull Gasworks. A hydraulic barrier has been installed at the former St Helier Gasworks, Jersey as part of the creation of a new Town Park.

(144) However remediation of fractured bedrock is only rarely possible for the sort of contaminants encountered during the driving of the Belfast Sewer Tunnel. This is both due to the difficulty of locating all the contamination and then of either recovering or destroying the contaminants reliably.

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8 CONCLUSIONS

(145) No risks to current receptors warranting immediate remedial action were identified.

(146) Many uncertainties were identified in the PCSM. The major uncertainties relate to:

- The extent of coal tar contamination in the sandstone aquifer
- Groundwater conditions;
    - depth to groundwater (minimal data) and
    - contradictions in the data on groundwater flow direction for the Marriot and Northern Fringe parts of the Site.
- The absence of specific consideration of the potential for vapours entering buildings in the Developed Area.
- Impact of existing piled foundations in respect of upward vapour migration and possibly also downward migration of contaminants to the underlying aquifer.

(147) Other uncertainties have been identified in Table 2, together with suggested actions to address each uncertainty. Stakeholders need to be aware of these to assist in their decisions on the site.

(148) Legal drivers have been identified requiring protection to:

- Current and future users (planning)
- Surface water (under the Water Order 1999)
- The Sandstone Aquifer (under the Water Order 1999 and Groundwater Regulations 2009)

(149) It is not clear whether there is a legal driver to address the contamination already present in the sandstone aquifer.

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9 RECOMMENDATIONS

(150) This report outlines likely risk assessment strategies (Section 6) and possible methods of risk management/ remediation (Section 7) and may be a useful reference when evaluating submitted proposals relating to contamination issues at the site. Its findings, if not the whole report, should be made available to potential developers of the Northern Fringe.

9.1 Short Term Actions

(151) There is a great deal of information (listed in Table 2) which might be inexpensively obtained to address the identified uncertainties. Gaining this sooner rather than later (or finding out and documenting that is does not exist) will assist in subsequent decision making.

(152) As described in Section 5.2 monitoring of existing wells for groundwater depth should begin to be carried out as soon as possible as it will provide valuable data for designing a groundwater quality monitoring strategy.

9.2 Liaison with NIEA

(153) NIEA should be briefed on the findings of this report at the earliest opportunity as they can assist both with some of the uncertainties identified in the preliminary CSM and with formulating a plan to comply with existing (and perhaps future) legislation.

(154) Uncertainties in the PCSM which may be able to be addressed by NIEA are listed in Table 2. It will also be useful to confirm the legislation that they will be addressing this site under, e.g. the Water Order 1999 and Groundwater Regulations 2009.

(155) There is evidence of significant quantities of contamination in the sandstone aquifer. NIEA's view in relation to existing groundwater contamination should be sought. At present, it is not clear any of the existing legislation would require BCC to deal with it nor that a technically feasible economically viable means of doing so can be developed.

(156) NIEA have raised the issue of risk relating to the creation of this pathway due to piling. This is a valid concern and the Environment Agency of England and Wales (EAEW) has issued guidance on how piling through contamination ought to be carried out (Environment Agency, 2001). It would be useful to confirm whether this approach meets with their approval.

(157) It would also be useful to establish :

- Whether a river basin management plan has been (or is due to be) published for the Lagan as specified in the Groundwater Regulations II (1).
- That the WQS in the Water Framework Directive (Priority Substances and Classifications regulations (Northern Ireland) 2011) is the appropriate WQS to apply to the Lagan.

9.3 Groundwater and surface water monitoring

(158) It is likely that BCC will need to commission a groundwater (and possibly surface water) monitoring programme. Details are in Section 5.2.

9.4 Possible vapour pathway to current users in the Developed Area

(159) The uncertainties around possible vapour pathways in the Developed Area may be resolved by obtaining the relevant information listed in Table 2. If this is not possible an air monitoring programme may be required. Details are in Section 5.3.

9.5 Proposed future development

(160) This relates to the Northern Fringe and the Marriot site.

(161) The Stage 2 report identified contractual actions (see Section 4.3).

(162) As, there is contamination in the soils and groundwater at the site it is likely risk assessment and remediation will be required. Methodologies are described in Sections 6 and 7. It is almost certain that risk assessment will need to include a foundation works risk assessment as described by the Environment Agency (Environment Agency, 2001). It may be useful to draw this to the attention of the developers at an early stage to allow them to incorporate likely suitable foundations into their design and the need for the foundations work risk assessment could be included in any planning conditions where appropriate. Stakeholders should also be made aware of some remaining uncertainties, listed in Table 2.

(163) Any planning permission granted will need to ensure that the proposed development is compatible with this contamination by:

- Preventing the creation of new pathways.
- Interrupting pathways to new receptors, especially direct and vapour exposure to contaminants.
- Breaking pollutant linkages causing pollution of groundwater.
- Ensuring that verification reports demonstrating pollutant linkages have been broken are required in the planning condition.

(164) In addition to imposing planning conditions to address contamination it is essential to ensure that the planning conditions are complied with and hence discharged. This applies to all development on the Northern Fringe and on the Marriot site. It is understood that the Planning Department have up to four years to check for compliance with, and to discharge, planning conditions.

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10 LIMITATIONS

LQM obtained, reviewed and evaluated information from the client. LQM's conclusions, opinions and recommendations are based solely on this information.
The conclusions and recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices at this time and location and as such are not a guarantee that the Site is free from hazardous materials or conditions.

This report was prepared by LQM for our client. Any third party using this report does so entirely at their own risk. LQM makes no warranty or representation whatsoever, express or implied, with respect to the use by a third party of any information contained in this report or its suitability for any purpose. LQM assumes no responsibility for any costs, claims, damages or expenses (including any consequential damages) resulting from use of this report or any information contained within this report by a third party.
This report was prepared by

13 November 2012

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For and on behalf of Land Quality Management Ltd

Date

This report was reviewed by

13 November 2012

Paul Nathanail
Director
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11 REFERENCES

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APPENDIX 1

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Report ID	Authors	Date	abc	Title	Report Number	Commissioned by	Prepared for	Site Area	Zone
1a	Industrial Science Centre	1991	a	Site Investigation at Belfast Gasworks	TI/1989/90		DED, Belfast	South of Blackstaff River excluding Phase1	
1b	Industrial Science Centre	1989	a	The sampling and analysis of soils from Belfast Gasworks site (purifier area)	TI/1915/89	McAdam Design	DED, Belfast	Two areas' former purifiers	
1c	Industrial Science Centre	1989	b	Site Investigation at Belfast Gasworks (Phase 1)	TI/1818/90		DED, Belfast	Immediately south of Blackstaff River	
1d	Industrial Science Centre	1992	a	Site Investigation at Belfast Gasworks	TI/2904/91		DED, Belfast	Areas not prviously included; south of Blackstaff River	
1e	Industrial Science Centre	1991	b	Site Investigation at Belfast Chemical works	TI/2927/91		DED, Belfast	Former Chemical Works	
1f	Industrial Science Centre	1990	a	Site Investigation at Belfast Gasworks	TI/1924/90		DED, Belfast	North east of River Blackstaff	
2	Parkman N I Ltd	1993	a	Belfast Gasworks Physical Site Appraisal, Feasibility Study Report:- Post Demolition	2966/OR/1/C	Laganside Corporation		Gas Works north and south of Blackstaff River	
3	Parkman N I Ltd	1993	b	Belfast Gasworks Physical Site Appraisal, Feasibility Study Report:- Post Demolition - Appendices	2966/OR/1/C	Laganside Corporation		Gas Works north and south of Blackstaff River	
4	Parkman N I Ltd	1997	a	Belfast Gas Works Stage 1 Closing Report for Remediation	14101/OR/10F		Belfast City Council	South of Blackstaff River	
5	Parkman N I Ltd	1998	a	Belfast Gas Works Stage 2 Closing Report for Remediation	14128/OR/10E		Belfast City Council	North of Blackstaff River	
6	Geotechnical and Environmental Services	2009	a	Former Belfast Gas Works Ormeau Road, Belfast. Geo-Environmental Ground Investigation Factual Report	021/NI/09	RPS Consulting Engineers	Belfast City Council	Northern Fringe	3

Report ID	Authors	Date	abc	Title	Report Number	Commissioned by	Prepared for	Site Area	Zone
7	RPS Consulting Engineers	2008	a	Northern Fringe Masterplan - Belfast Gasworks. Ground Conditions Survey Phase 1 Desk Study Report	IPB0082		Belfast City Council	Northern Fringe	3
8	RPS Consulting Engineers	2009	a	Northern Fringe Masterplan - Belfast Gasworks. Phase II Contamination Assessment Report	IPB0082		Belfast City Council	Northern Fringe	3
9	RPS Consulting Engineers	2008	b	Proposed New Marriot 'Courtyard Hotel' Site 4 Gasworks, Belfast. Ground Condition Survey Phase 1 Desk Study Report. February 2008	IBP0009/Reports/Phase1	N/A	Culzean Estates	Land for proposed Marriot Hotel	2
10	RPS Consulting Engineers	2008	c	Proposed New Marriot 'Courtyard Hotel' Site 4 Gasworks, Belfast. Ground Condition Survey Phase II Desk Study Report. February 2008	IBP0009/Reports/PhaseII		Culzean Estates	Land for proposed Marriot Hotel	2
11	RPS Consulting Engineers	Jan-09	b	Letter Report: Proposed Courtyard Hotel at 22 Cromac Place, Belfast BT7	RP\IB0009/NIEA Response	N/A	Northern Ireland Environment Agency	Land for proposed Marriot Hotel	2
12	RPS Consulting Engineers	Jan-09	c	Proposed New Marriott 'Courtyard Hotel', Site 4 Gasworks, Belfast. Remedial Strategy. January 2009 - Revision 1. Planning Ref: F/2008/0518/F	IBP0009/Reports/Rev1	N/A	Culzean Estates	Land for proposed Marriot Hotel	2
13	RPS Consulting Engineers	Apr-09	d	Letter Report: Groundwater Risk Assessment	HLEC4679/001 L-RG			Land for proposed Marriot Hotel	2
14	RPS Consulting Engineers	Aug-09	e	Marriot Hotel Site, Former Belfast Gasworks - Groundwater Contamination	HLEC4679/002 L-RG		Culzean Estates	Land for proposed Marriot Hotel	2
15	RPS Consulting Engineers	Jan-10	a	Letter Report: Marriot Hotel - Additional Site Investigation	HLEC4679/004 L-RG			Land for proposed Marriot Hotel	2

Report ID	Authors	Date	abc	Title	Report Number	Commissioned by	Prepared for	Site Area	Zone
16	NIEA	Jul-10	a	Assessment of the Land Contamination Issues WRT Planning Application A/2008/0518/F - Proposal for Development of a Courtyard Hotel at 22 Cromac Place Belfast	Plan 1/2003/6			Land for proposed Marriot Hotel	2
17	Hydrogeological & Environmental Services Ltd	May-98	n/a	Site Contamination Survey of 51-57 McAuley Street, Belfast BT7 2BX	HIS/89-1	Napier & Sons	McAuley Street Metals	51-57 McAuley Street	4
18	Parkman N I Ltd	Jun-98	n/a	Gasworks Environmental Liability - McAuley Street Metals	17277/0R/2B		Belfast City Council	53 McAuley Street	4
19	Kirk McClure Morton	Dec-00	n/a	Proposed Development McAuley Street Belfast Contaminated Land Survey	4707.77		H&J Martin	3 sites McAuley Street	4
20	Kirk McClure Morton	Aug-04	n/a	Proposed Development McAuley Street Belfast Remediation Report	4707.77		H&J Martin	3 sites McAuley Street	4
21	Golder Associates	Apr-08	a	Phase 1 Preliminary Risk Assessment McAuley Street Belfast	8514320010	JNP Architects	BIH Housing Association	McAuley Street Apartments	4
22	Golder Associates	Aug-08	b	Phase 1 Site Investigation and Risk Assessment McAuley Street Belfast	08514320010.502		BIH Housing Association	McAuley Street Apartments	4
23	Golder Associates	Mar-09	n/a	Consultation Response McAuley Street Belfast	08514320010.503		BIH Housing Association	McAuley Street Apartments	4
24	JNP Architects	Sep-09	n/a	Apartment Development at McAuley Street Belfast - Design and Verification Statement	4343		BIH Housing Association	McAuley Street Apartments	4
25	Golder Associates	May-10	n/a	Indoor Air Quality Monitoring - McAuley Street Apartments	09514320055.500/A.0		Helm Housing (formerly BIH Housing Association)	McAuley Street Apartments	4
26	Enviros Consulting Ltd	Octover 2006	n/a	River Terrace, River's Edge, Belfast: Technical Note 1: Ground Condition Report DRAFT	BE0050015A		Belfast City Council	disused land off River Terrace	5