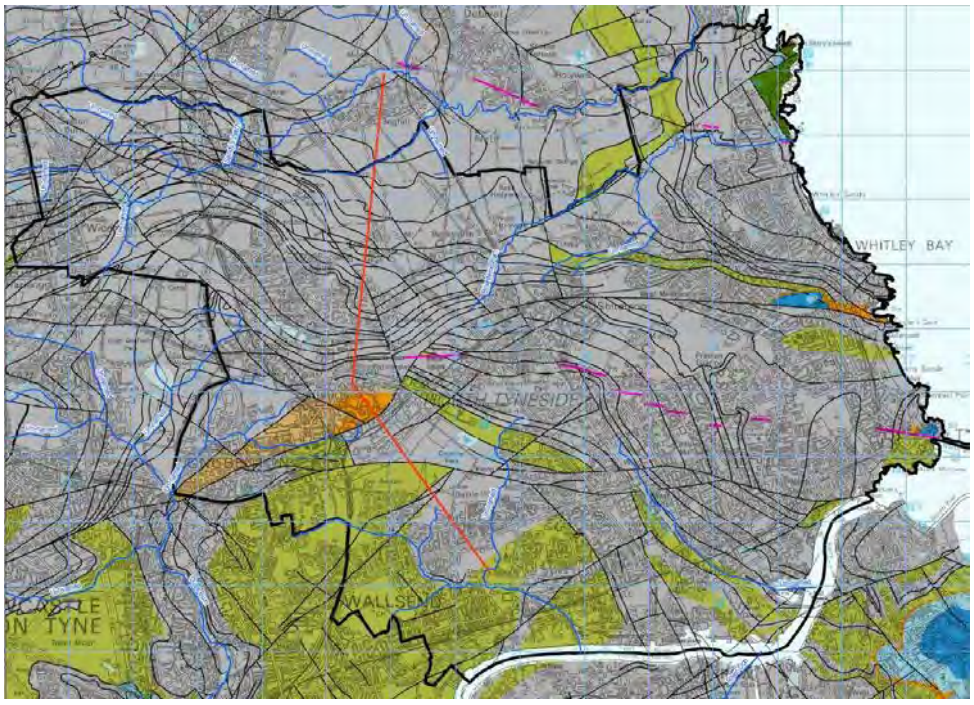
APPENDIX B – GROUNDWATER ASSESSMENT

North Tyneside Surface Water Management Plan

High Level Assessment of Groundwater Flooding Susceptibility

Phase 2
October 2011



Prepared for

North Tyneside Council

Revision Schedule

North Tyneside Council Surface Water Management Plan – High Level Assessment of Groundwater Flooding Susceptibility
October 2011

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	15 October 11	Draft	**Chris Woolhouse** Hydrogeologist	**Ryan Cox** Senior Hydrogeologist	**Jane Sladen** Technical Director

URS Scott Wilson
Scott House
Alencon Link
Basingstoke
RG21 7PP

Tel (0)1256 310200
Fax (0)1256 310201

Table of Contents

Abbreviations

ACRONYM	DEFINITION
BGS	British Geological Survey
DEFRA	Department for Environment, Fisheries and Rural Affairs
EA	Environment Agency
LiDAR	Light Detection and Ranging
SUDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

Glossary

TERM	DEFINITION
Aquiclude	Formations that may be sufficiently porous to hold water, but do not allow water to move through them.
Aquifer	Layers of rock sufficiently porous to hold water and permeable enough to allow water to flow through them in quantities that are suitable for water supply.
Aquitard	Formations that permit water to move through them, but at much lower rates than through the adjoining aquifers.
Climate Change	Long term variations in global temperature and weather patterns, caused by natural and human actions.
Flood defence	Infrastructure used to protect an area against floods, such as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floods and Water Management Act	Legislation constituting part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to help protect ourselves better from flooding, to manage water more sustainably and to improve services to the public.
Fluvial flooding	Flooding by a river or a watercourse.
Groundwater	Water that is underground. For the purposes of this study, it refers to water in the saturated zone below the water table.
Pluvial Flooding	Flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.
Risk	The product of the probability and consequence of the occurrence of an event.
Sewer flooding	Flooding caused by a blockage, undercapacity or overflowing of a sewer or urban drainage system.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. The current study refers to the 'infiltration' category of sustainable drainage systems e.g. soakaways, permeable paving.

1 Introduction

1.1 Groundwater Flooding

1.1.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels.

1.1.2 Groundwater flooding tends to occur sporadically in both location and time, and because of the more gradual movement and drainage of water, tends to last longer than fluvial, pluvial or sewer flooding. When groundwater flooding occurs, basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

1.1.3 It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, pluvial and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of pluvial and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

1.1.4 The need to improve the management of groundwater flood risk in the UK was identified through Defra's Making Space for Water strategy. The review of the July 2007 floods undertaken by Sir Michael Pitt highlighted that at the time no organisation had responsibility for groundwater flooding. The Flood and Water Management Act identified new statutory responsibilities for managing groundwater flood risk, in addition to other sources of flooding and has a significant component which addresses groundwater flooding.

1.2 The Current Report

1.2.1 North Tyneside Council commissioned URS Scott Wilson to complete its Surface Water Management Plan (SWMP). A SWMP is a plan which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and run-off from land, small water courses and ditches that occurs as a result of heavy rainfall (DEFRA, March 2010).

1.2.2 The current report provides a high level assessment of groundwater flooding susceptibility as part of the SWMP Phase 2, and provides recommendations for Phase 3. The following sections outline the geology and hydrogeology in the North Tyneside Council administrative area. From this analysis:

- Potential groundwater flooding mechanisms are identified;
- Evidence for groundwater flooding is discussed (if available);
- Areas susceptible to groundwater flooding are recognised; and
- Recommendations are provided for further investigation

2 Topography, Geology and Hydrogeology

2.1 Topography and Hydrology

2.1.1 The study area is defined by the administrative area of North Tyneside Council as shown in Figure 1, with a large proportion of the southern boundary defined by the River Tyne and the eastern boundary by the Whitley Bay coastline.

2.1.2 There are a number of watercourses within the city, including Brierdene Burn, Forest Hall Letch, Longbenton Letch, Sandy's Letch, Seaton Burn, Wallsend Burn, Willington Gut and the River Tyne. A number of un-named brooks and tributaries of the River Tyne, Seaton Burn and Brierdene Burn can also be found. No information was available as to whether these water courses are culverted.

2.1.3 North Tyneside lies more than 80m above sea level in the area of Killingworth and gradually falls to sea level (0 maOD) in the south, along the River Tyne and east at the coast. The topography also shows a gradual decline to the north towards the Seaton Burn valley, with elevations 40maOD at the council's northern boundary.

2.2 Geology

2.2.1 Figures 2 and 3 provide bedrock and superficial geological information for North Tyneside Council and the surrounding area. Figure 4 presents a geological cross section (shown on Figure 2) that has been adopted from the British Geological; 1:50,000 series map, sheet No. 15 and used to improve the conceptual understanding of the area.

Bedrock Geology

2.2.2 The bedrock geology in the study area is detailed in Table 1 in lithostratigraphical order. Based on the BGS geological sheets, 21, 14 and 15. Where available, the regional thickness of the bedrock units is also presented in Table 1, based on the cross section presented in Figure 4 and the BGS Lexicon database.

2.2.3 The Coal Measures (mudstone, siltstone and sandstone), which on Figure 2 have been subdivided into the Pennine Upper Coal Measures Formation, Pennine Middle Coal Measures Formation and Pennine Lower Coal Measures Formation, dominate the surface bedrock geology in the North Tyneside Council area beneath the superficial deposits. The Pennine Lower Coal Measures Formation can be found in the north east of the study area, near St Marys Island, and the Pennine Upper Coal Measures Formation in the south west at Forest Hall and Longbenton. The Pennine Middle Coal Measures Formation dominates the rest of the surface bedrock, covering over three quarters of the administrative area.

2.2.4 The cross section, presented in Figure 4 shows large scale deformation of the solid geology underlying North Tyneside, with small and large scale displacement. A number of faults run through North Tyneside study area, with the Burradon, Ninety Fathom, Benton Quarry and Rising Sun Faults intersecting the line of section.

2.2.5 The Pennine Middle Coal Measures Formation is around 300m thick in the area of Battle Hill in the south of the section (Figure 4).However, in the area of Forest Hall, between the Ninety Fathom Fault and the Burradon Fault, faulting has locally increased the effective thickness of the Pennine Middle Coal Measures to over 350m. From the Burradon Fault to Seghill in the

north, the cross section shows the thickness of the Middle Coal Measures thins from around 230 m to 180m.

2.2.6 The Pennine Lower Coal Measures Formation in the north east do not intersect with the line of section, but it can be estimated that deposits are up to 220m thick, from regional geological data (BGS, 1:50,000 Scale Geology Series Sheet 21). The Pennine Upper Coal Measures Formation, which does intersect the line of section, in the area of Forest Hall is found up to 120m thick.

2.2.7 In the south west of the study area, in Forest Hall Bradley, the Coal Measures are overlain by the Yellow Sands Formation (fine, medium grained sandstone), up to 60m thick at the line of section. To the east, in the area of Marden, the Yellow Sands Formation and Coal Measures are found to be overlain by the Roker and Raisby Dolomite rock Formations.

2.2.8 In the areas of Benton Square, New York, Billy Mill and Preston, trending east to west across the study area, are discontinuous small outcrops of Tholeiitic Dolerite; marking the extent of an unnamed Dyke intrusion.

2.2.9 In some areas of the study area, the Coal Measures in the South are identified as artificial ground, due to historical mining. Therefore the geology shown in these areas may be different to that shown by the maps.

Table 1 Bedrock geology

Geological Units		Description	Regional Thickness*
Permian	Rokey Formation (Dolomite)	Cream, oolitic dolostone with fine grained dolomite. Breccias are also found.	Up to 80m, but not known locally. **
	Raisby Formation (Dolomite)	Cream, brown and grey fine grained dolostone, with fine grained limestone.	Up to 40m, but not know locally.**
	Yellow Sands Formations	Weakly cemented, medium to fine grained sand or sandstone.	Up to 60m
Upper Carboniferous (Silesian)	Pennine Upper Coal Measures Formation	Interbedded grey mudstone, siltstone and pale grey sandstone. Commonly with coal seams, but not mudstones containing marine fossils are present.	Up to 120m
	Pennine Middle Coal Measures Formation	Interbedded grey mudstone, siltstone, pale grey sandstone and commonly coal seams, with a bed of mudstone containing marine fossils at the base, and several such marine fossil-bearing mudstones in the upper half of the unit	Up to 320 m
	Pennine Lower Coal Measures Formation	Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.	Up to 220m
	Unnamed Igneous Intrusion	Tholeiitic Dolerite. No further information available.	-

*Thickness of Formations from BGS sheet 15, Tynemouth, Solid & Drift Map

** Thickness of Formations from BGS, Lexicon. 2011.

Superficial Geology

2.2.10 The superficial geology of the North Tyneside Council area consists of, Blown Sand, Alluvium, Lacustrine Deposits, Tidal River or Creek Deposits, Pelaw Clay Member, Glaciofluvial Deposits and Glacial Till.

2.2.11 Glacial Till deposits present the largest surface outcrop in the North Tyneside Council area, apart from at the east coast and southern boundary along the River Tyne. The Environment Agency (2001) describes the Glacial Till as a clayey matrix with a variable sand and gravel content that generally tends to be 3 to 4 m thick, occasionally up to 6 m regionally.

2.2.12 The Pelaw Clay Member forms the second largest surface outcrop in North Tyneside, in the south east and along the north bank of the River Tyne. The BGS (2011) describes the deposits as reddish brown silty clay, with well dispersed pebbles and cobbles and is generally found up to 1m to 2m in thickness.

2.2.13 Blown Sand can be found along the east coast, near to Whitley Sands and Long Sands. The thickness of these deposits is not known.

2.2.14 The Alluvium forms the bed of the Sandy Letch and a further two un-named tributaries in the north west of the North Tyneside Council study area. The deposits comprise mainly of clay, silt, sand and gravel.

2.2.15 Lacustrine Deposits are only present at West Moor near the west boundary of the North Tyneside Council area and consists of blown silt and clay. It is not known locally how thick these deposits are.

2.2.16 The Beach Sand Deposits, composed of lose sand, are found along the eastern boundary of the study area, at Long sands and Whitley Sands. It is not known locally how thick these deposits are.

2.2.17 Glaciofluvial Deposits are found present primarily in the south along the River Tyne, at Willington Quay and Rosehill and consist of clay and silt. The Environment Agency (2001) indicates that in general the thickness of these deposits regionally is less than 5 m.

2.2.18 Tidal River or Creek Deposits are shown on Figure 3, but are only located outside the North Tyneside Council study area.

2.3 Hydrogeology

2.3.1 The hydrogeological significance of the various geological units within the study area is provided in Table 2. The range of permeability likely to be encountered for each geological unit is also incorporated in Table 2, based on BGS permeability data.

Table 2 Geological Units in the Study Area and their Hydrogeological Significance

Geological Unit		Permeability	Hydrogeological Significance
Superficial Deposits	Blown Sand	High	Secondary Aquifer (A)
	Alluvium	High to very Low	Secondary Aquifer (A)
	Lacustrine Deposits	Low to very Low	Unproductive strata
	Beach Deposits (Sand & Gravel)	Very High to High	Secondary Aquifer (A)
	Pelaw Clay Member	Low to very Low	Unproductive strata
	Glaciofluvial Deposits – clay and silt	Low to very Low	Unproductive strata
	Glacial Till	High to Low	Unproductive strata
Bedrock Geology	Rokey Formation (Dolomite)	Very High to High	Principle Aquifer
	Raisby Formation (Dolomite)	Very High to High	Principle Aquifer
	Yellow Sands Formations	High	Principle Aquifer
	Pennine Upper Coal Measures Formation	Moderate to Low	Secondary Aquifer (A)
	Pennine Middle Coal Measures (Sandstone)	High to Moderate	Secondary Aquifer (A)
	Pennine Middle Coal Measures (Mudstone, Siltstone and Sandstone)	Moderate to Low	Secondary Aquifer (A)
	Pennine Lower Coal Measures	High to Low	Secondary Aquifer (A)
	Unnamed Igneous Intrusion	Low	Secondary Aquifer (B)

'Principal Aquifer' - layers that have high permeability. They may support water supply and/or river base flow on a strategic scale.
'Secondary Aquifer (A)' - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
'Secondary Aquifer (B)' - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
'Aquitard' - allows some groundwater movement (see glossary)
'Aquiclude' - does not allow groundwater movement (see glossary)

Bedrock Hydrogeology

2.3.2 The Rockey and Raisby Dolomite Formations outcropping at surface to the North of Marden, have been classified as a principal aquifer by the Environment Agency and permit groundwater flow. The deposits are of limited lateral extent, but localised groundwater lenses may be present which may be in continuity with the underlying Coal Measures. These deposits are of interest to the current study.

2.3.3 The Yellow Sands Formation found in the area of Forest Hall, has been classified as a principal aquifer by the Environment Agency and therefore permit groundwater flow and the possibility of perched groundwater. However, where the Formation is overlain by Glacial Till (variable clay, sand and gravel) the clay content may impede Groundwater flow. These deposits are of interest to the current study.

2.3.4 The, Pennine Upper Coal Measures Formation, Pennine Middle Coal Measures Formation (sandstone), Middle Coal Measures Formation (Mudstone, Siltstone and Sandstone) and Lower Coal Measures are all classified as secondary aquifers (A) by the Environment Agency, with groundwater levels possibly existing within the sandstone horizons. Only the Pennine Middle Coal Measures Formation (sandstone) and Middle Coal Measures Formation (Mudstone, Siltstone and Sandstone) are found present at surface in the areas of Earsdon, Billy Mill, Burradon, Killingworth Village, Scaffold Hill and south of Benton Square. These units are of interest to the current study.

2.3.5 The Unnamed Igneous Intrusion is classified as a Secondary Aquifer (B) which agrees with the lower designated permeability's by the BGS. This unit is of less interest to the current study.

Superficial Hydrogeology

2.3.6 Blown Sand is found to the east coast of the North Tyneside Study area, at Long Sands and Whitley Sands. It is classified by the Environment Agency as a secondary aquifer (A). The BGS permeability shows it to be high permeability and so it's likely to store water, though its ability will vary depending on its thickness and horizontal extent. It's possible that perched groundwater may exist when found to be overlaying clay horizons of the Coal Measures.

2.3.7 The Beach Sand Deposits, composed of lose sand, are identified by the Environment Agency as a Secondary Aquifer (A), with a very high to high permeability. Groundwater will flow through these deposits and could be stored, though they are not laterally extensive.

2.3.8 Alluvium along some of the brooks and tributaries to the north west of the North Tyneside Council area is classified as secondary aquifer (A) by the Environment Agency and the BGS permeability data set suggests a high to very low permeability. It is likely that the ability of the deposits to store water will vary locally depending on the extent and thickness of the sand and gravel horizons.

2.3.9 Lacustrine Deposits are found only as a small surface outcrop at West Moor near the west boundary of the North Tyneside Council study area. The deposit is expected to behave as an aquitard, with low to very low permeability suggested by the BGS. This deposit is not of interest to the current study.

2.3.10 Glaciofluvial Deposits consisting of clay and silt found along the southern boundary of the study area and near to the River Tyne are expected to behave like aquitards. The BGS suggests they

are of low, very low permeability and so not likely to be hydraulically connected to the river or form perched groundwater. This deposit is therefore not of main interest to the current study.

2.3.11 Glacial Till deposits are generally expected to behave as aquitards, although sand and gravel horizons may locally form a secondary aquifer depending on their lateral extent and thickness. Till deposits are not classified by the Environment Agency as an aquifer, although the BGS suggest that permeabilities can range from high to low and this is due to the localise variability of sand and gravel horizons. As a consequence perched groundwater lenses could form, though they could be laterally limited.

2.3.12 In the areas marked as artificial ground, it is likely that the superficial deposits have been removed, therefore these areas should be viewed with caution.

Groundwater Levels

Bedrock Water Levels

2.3.13 Water level monitoring data has been provided by the Coal Authority for two observation boreholes; Whitley Bay and Algernon which monitor various coal mine workings in the Coal Measures strata. Unfortunately no data was available as to the construction or the drilled depth of either borehole and should therefore be viewed with caution. The borehole locations are shown on Figure 1 and the data is presented in Appendix 1. The Environment Agency does not have any monitoring boreholes in the North Tyneside Council study area.

2.3.14 The Algernon borehole located near New York, understood to monitor the main coal seam (inferred; Pennine Middle Coal Measures Formation), shows a rise in groundwater levels since 2000 (start of monitoring) in a presumed response to the reduction of groundwater abstractions. Groundwater levels rose steadily from -3.05 maOD (66.4 mbGL) in 2000 to 29.23 maOD (33.7mbGL) in August 2011, as shown in Appendix A.

2.3.15 The Whitley Bay borehole, located north of Monkseaton is believed to measure the low main seam (inferred; Pennine Middle Coal Measures Formation), but unfortunately the coal authority are not certain of the total drilled depth. The data shows a small range in water levels of 0.7m, which fluctuated between 0.8 maOD (24.2 mbGL) and 0.1 maOD (24.9 mbGL) during the period May 2006 to August 2011, as shown in Appendix A.

2.3.16 The two monitoring boreholes are understood to show the groundwater table in the Pennine Middle Coal Measures Formation to be in the range of 24 to 33 metres below ground level, and so pose little risk to causing groundwater flooding to basements. What should be noted is that to the west of North Tyneside, the Algernon Borehole near New York may be showing rebounding groundwater levels.

Superficial Water Levels

2.3.17 The Environment Agency does not monitor groundwater levels in the superficial deposits. However, borehole logs are available from the British Geological Survey and these often provide details of water strikes, providing an indication of depth to groundwater. It is recommended that under phase 3 borehole logs are obtained.

Hydraulic Relationships

Groundwater / Surface Water Interactions

2.3.18 In the north, south west and south areas of North Tyneside study area, where the river Tyne, River Briedene Burn, Sandys Letch and other tributaries are found, overflowing the Alluvium and Glacial Till deposits, it is possible that there is some superficial geology; groundwater / surface water interaction where higher sand and gravel content are found. It should be noted that in the North Tyneside study area, little is known about the amount of culverting of the surface water courses which could impede interactions.

2.3.19 Unfortunately without groundwater level data for the superficial deposits and river stage levels, it is not possible to gain a more informed understanding of groundwater / surface water interactions.

Abstractions

2.3.20 The locations of groundwater abstractions were requested from the Environment Agency and only one licensed abstraction is present in the North Tyneside study area as shown on Figures 1, 2, 3, 5 and 6. The borehole is licensed to abstract 0.35 Ml/d from the Pennine Middle Coal Measures Formation and will lower groundwater levels in the localised area.

Artificial Groundwater Recharge

2.3.21 Water mains leakage data for the North Tyneside area were not provided for this study. However it should be noted that recharge to groundwater by leaking mains could result in a local rise in groundwater levels. This rise might not prove significant under dry conditions, but could exacerbate the risk of groundwater flooding following periods of heavy rainfall.

2.3.22 The drainage/sewer network can act as a further source of artificial recharge. When pipes are installed within principal or secondary aquifers, the groundwater and drainage network may be in partial hydraulic connection. When pipes are empty, groundwater may leak into the drainage network with water flowing in through cracks and porous walls, draining the aquifer and reducing groundwater levels. During periods of heavy rainfall when pipes are full, leaking pipes can act as recharge points, artificially recharging the groundwater table and subsequently increasing groundwater levels with potential impacts on groundwater quality.

3 Assessment of Groundwater Flooding Susceptibility

3.1 Groundwater Flooding Mechanisms

3.1.1 Based on the hydrogeological conceptual understanding of the study area, the potential groundwater flooding mechanisms that may exist are:

- **Roker and Raisby Dolomite Formation outcrop in the east of the study area, near Whitley Bay where superficial deposits are absent:** Groundwater level monitoring data is not available for the Roker and Raisby Dolomite Formation and BGS borehole log groundwater strike data has not been collated for this study. Therefore, it has not been possible to confirm the presence of a shallow groundwater table. However, there is the potential for a groundwater table to exist in these formations, particularly if underlain by clay horizons within the Pennine Coal Measures. Basements / cellars in this area may be at risk from groundwater flooding particularly during periods of heavy rainfall.
- **Superficial aquifers in hydraulic continuity with open water courses:** groundwater flooding may be associated with Alluvium or Glacial Till deposits, where they are in hydraulic continuity with surface water courses. River levels may rise following high rainfall events but still remain 'in-bank', and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits. It is noted that groundwater / surface water interactions might be limited if water courses have been culverted. However, without evidence in the form of groundwater levels, this groundwater flooding mechanism cannot be ruled out.
- **Superficial aquifers not in hydraulic continuity with surface water courses:** a third mechanism for groundwater flooding is associated with the Blown Sand, Beach Deposits and to a lesser degree, the Glacial Till deposits all overlying the Pennine Upper Coal Measures Formation, Pennine Middle Coal Measures Formation (Sandstone), Pennine Middle Coal Measures Formation (Mudstone, Siltstone and Sandstone) and Pennine Lower Coal Measures Formation. Groundwater levels may rise in these deposits, through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.
- **Impermeable (silt and clay) areas down slope of superficial aquifers in various locations:** a fourth mechanism for groundwater flooding may occur where groundwater springs / seepages from minor flows and ponding over impermeable strata where there is poor drainage (artificial or natural).
- **Superficial aquifers along the coastline:** a fifth mechanism for groundwater flooding could occur where Blown Sand, Beach Deposits or Glacial Till are present behind coastline flood defences. It is possible that tidal fluctuations propagate westwards through the superficial deposits, increasing the potential for groundwater flooding. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.
- **Artificial ground in various locations but particularly in south:** a final mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this artificial ground is of substantial thickness and permeability, then a shallow water table may exist. This could potentially result in groundwater flooding at

properties with basements, or may equally be considered a drainage issue. Areas mapped by the BGS as containing artificial ground are shown in Figures 3, 5 and 6.

3.2 Evidence of Groundwater Flooding

3.2.1 No groundwater flooding incidents have been reported to the Environment Agency or North Tyneside Council. Areas of historical surface water flooding have been provided, by the Environment Agency and North Tyneside Council, but it's not known if any of these were caused by groundwater flooding.

3.3 Groundwater Flooding Susceptibility

BGS Groundwater Flooding Susceptibility Maps

3.3.2 The BGS has produced a data set showing areas susceptible to groundwater flooding on the basis of geological and hydrogeological conditions (see Figure 5).

3.3.3 Large areas of the North Tyneside study area are shown to have a very high and high susceptibility to groundwater flooding particularly where ground elevations are low. The main areas identified are, Shiremoor, Weston Chitron, Backworth and Longbenton, though susceptibility is not just confined to those areas. The BGS data set suggests this susceptibility is mostly associated with the superficial deposits (Glacial Till) as opposed to bedrock geology (largely Pennine Middle Coal Formation). However, it is noted that there is no water level data in the area and there is a need to validate the data set.

3.3.4 The BGS Groundwater Flooding Susceptibility map does indicate that there is a very high / high susceptibility to bedrock groundwater flooding where the Roker Formation and Raisby Formation outcrop to the North of Marden (Figure 3) and where superficial deposits are absent. However, as previously noted there is no available water level monitoring data for these principal aquifers and there is a need to validate the data set.

3.3.5 There may have been insufficient data available to the BGS when classifying areas mapped as artificial ground. Therefore these areas should be viewed with caution.

3.3.6 A final point is that the BGS data set does not take into account rebound of groundwater levels. The Coal Authority data (only from one borehole) (Appendix 1) indicates that groundwater rebound is still taking place, albeit to a limited degree, within the monitored secondary aquifer (A) in the western half of the study area. Therefore, there may be an increased susceptibility to groundwater flooding in the future.

3.3.7 In general, based on the available data it is thought that the approximate areas identified by the BGS as being susceptible to groundwater flooding are as expected. However, it is possible that the various categories from 'very high' to 'moderate' may not be accurate given the poor availability of groundwater level data to the BGS; the Environment Agency does not monitor superficial or bedrock groundwater levels within the study area.

4 Water Framework Directive, Flood and Water Management Act 2010 and Infiltration SUDS

4.1.1 The Water Framework Directive approach to implementing its various environmental objectives is based on River Basin Management Plans (RBMP). These documents were published by the Environment Agency in December 2009 and they outline measures that are required by all sectors impacting the water environment.

4.1.2 Improper use of infiltration SUDS could lead to contamination of the superficial deposit or bedrock aquifers, leading to deterioration in aquifer quality status or groundwater flooding / drainage issues. However, correct use of infiltration SUDS is likely to help improve aquifer quality status and reduce overall flood risk.

4.1.3 The Flood and Water Management Act 2010 states:

> *"Sustainable drainage" means managing rainwater (including snow and other precipitation) with the aim of –*
>
> *(a) reducing damage from flooding,*
>
> *(b) improving water quality,*
>
> *(c) protecting and improving the environment,*
>
> *(d) protecting health and safety, and*
>
> *(e) ensuring the stability and durability of drainage systems.*

4.1.4 Environment Agency guidance on infiltration SUDS is available on their website at: http://www.environment-agency.gov.uk/business/sectors/36998.aspx. This should be considered by developers and their contractors, and by North Tyneside Council when approving or rejecting planning applications.

Key Water Level Considerations (Figure 5)

4.1.5 The areas that may be suitable for infiltration SUDS exist where there is a combination of high ground and permeable geology. However, consideration should be given to the impact of increased infiltration SUDS on properties further down gradient. An increase in infiltration / groundwater recharge will lead to an increase in groundwater levels, thereby increasing the susceptibility to groundwater flooding at a down gradient location. This type of analysis is beyond the scope of the current report.

4.1.6 It is important to be aware of groundwater level conditions at a potential development site. The maximum likely groundwater levels should be assessed, to confirm that soakaways will continue to function even during prolonged wet conditions. The areas where there is perceived to be increased susceptibility to groundwater flooding are shown on Figure 5.

Key Geological Considerations (Figure 6)

4.1.7 The infiltration SUDS suitability assessment shown on Figure 6 is based on minimum permeability data obtained from the BGS. It is understood from the BGS guidance notes that the minimum permeability is more representative of the bulk permeability than the maximum permeability. Three permeability zones have been identified:

1) **Infiltration SUDS potentially suitable:** Minimum permeability is high or very high for bedrock (and superficial deposits if they exist).

2) **Restricted potential for infiltration SUDS:** Minimum permeability is low or very low for bedrock (and superficial deposits if they exist).

3) **Enhanced site investigation required:** Minimum permeability is low or very low for bedrock and high or very high for superficial deposits OR minimum permeability is low or very low for superficial deposits and high or very high for bedrock.

4.1.8 The third category is required because the thickness of superficial deposits is uncertain. If they are thick and impermeable, shallow soakaways may not intercept underlying higher permeability bedrock. If they are thin and permeable, overlying impermeable bedrock, they may not have the capacity to receive the additional recharge from infiltration SUDS. Under the third category, it is particularly important that the developer undertakes an appropriate site investigation to determine infiltration SUDS suitability.

4.1.9 The only areas delineated as 'infiltration SUDS potentially suitable' on Figure 6 are where the Roker and Raisby Dolomite Formations bedrock outcrop at surface. The rest of the North Tyneside study area has been delineated as 'restricted potential for Infiltration SUDS' where Glacial Till, Pelaw Clay Member and Pennine Middle Coal Measures Formation are found to outcrop at surface.

4.1.10 The Beach Deposits or Yellow Sands Formation are identified as, 'Enhanced site investigation required' to determine the thickness and the suitability for infiltration SUDS.

4.1.11 Where the Glacial Till deposits are present at surface the area has been classified as 'Restricted potential for infiltration SUDS because the minimum permeability (which is often more representative of the bulk permeability) is classified by the BGS as 'Low'. However, the maximum permeability is classified by the BGS as 'High' due to local conditions such as a higher proportion of sand and gravel. Therefore, depending on the local thickness and composition of the Glacial Till deposits and / or the permeability of the underlying Coal Measures, it is feasible that other areas than those suggested by Figure 6 may be suitable for SUDS but enhanced site investigation would be required.

4.1.12 It is noted that this is a high level assessment and only forms an approximate guide to infiltration SUDS suitability; a site investigation is required in all cases to confirm local conditions.

Key Water Quality Considerations

4.1.13 Where possible, infiltration SUDS should be located away from areas of historic landfill (shown on Figure 6) and areas of known contamination or risk of contamination. This is to ensure that the drainage does not re-mobilise latent contamination or exacerbate the risk to groundwater quality and possible down gradient groundwater receptors, such as abstractors, springs and rivers. A preliminary groundwater risk assessment should be included with the planning application.

4.1.14 Restrictions on the use of infiltration SUDS also apply to those areas within Source Protection Zones (SPZ). Developers must ensure that their proposed drainage designs comply with the available Environment Agency guidance. There are currently no Source Protect Zones present in the study area of North Tyneside.

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 The following conclusions can be drawn from the current study:

- The majority of the bedrock underlying the superficial deposits in the North Tyneside study area are classified by the Environment Agency as a secondary (A) aquifer and therefore are expected to permit groundwater flow. However the majority of the council area is covered by Glacial Till deposits, which are generally expected to behave as an aquitard;
- No Groundwater level data has been available from the Environment Agency and only limited data from the Coal Authority. The groundwater monitoring data does show groundwater levels in the Pennine Middle Coal Measures Formation to be currently 24 to 35 mbGL (August 2011). Groundwater levels in the west appear to be recovering from the cessation of historic abstractions therefore; there may be an increased susceptibility to groundwater flooding in the future;
- A number of potential groundwater flooding mechanisms have been identified. Of significance are those associated with (i) potential groundwater levels in the Roker and Raisby Dolomite Formation outcrop in the eastern part of the study area, (ii) Superficial aquifers in hydraulic continuity with open water courses (iii) superficial aquifers not in hydraulic continuity with surface water courses. Underground structures including basements and cellars are at most risk from groundwater flooding;
- Areas that may be susceptible to groundwater flooding have been identified using the BGS groundwater flooding susceptibility data set. The data indicates a high or very high susceptibility to groundwater flooding where the Glacial Till superficial deposits and Roker and Raisby bedrock Formations are present at surface. However, it should be noted that there is no groundwater level data available and so it is not possible to validate the data set in these areas.
- No groundwater flooding incidents within the study area have been reported to the Environmental Agency or North Tyneside Council. The lack of reported groundwater flooding incidents suggests that whilst perched aquifers may exist, groundwater levels are sufficiently low and/or there are a lack of receptors (e.g. basements), such that groundwater flooding has not been an issue. However, it is important to note that increased discharges to these aquifers through infiltration SUDs or / and groundwater rebound may lead to future groundwater flooding issues. Therefore, use of infiltration SUDs should be carefully managed;
- Only one licensed groundwater abstraction has been identified in the study area, abstracting from the Pennine Middle Coal Formation. There are currently no groundwater source protection zones.

5.2 Recommendations

5.2.1 The following recommendations are made based on the current study. These will allow a more detailed assessment of potential for high or rising groundwater levels and suitability for infiltration SUDS:

- The superficial deposit thickness data set could be purchased from the BGS to provide additional information on the potential thicknesses of the superficial deposits across the study area; and
- Borehole logs should be obtained from the BGS to provide more information on the superficial / bedrock composition and presence of groundwater if groundwater strikes are documented;
- The areas identified as having increased potential for high groundwater levels should be compared with those areas identified as being susceptible to other sources of flooding e.g. fluvial, pluvial and sewer. An integrated understanding of flood risk will be gained through this exercise;
- Data identifying properties with basements / cellars should be used to improve the understanding of susceptibility to groundwater flooding, if available;
- Historic maps of mined areas should be obtained to help better conceptualise the flow of groundwater through these old workings;
- Consideration should be given to the installation of monitoring boreholes in the Pennine Upper and Middle Coal Measures Formation to better quantify rebounding groundwater levels across the study area.
- The installation of monitoring boreholes within the Roker, Raisby Dolomite and Yellow Sands Formation should also be considered, particularly where they outcrop at surface. These monitoring boreholes could be fitted with automatic level recording equipment so that responses to significant rainfall events can be analysed and site monitoring visits could be reduced;
- Water level data collected as part of the planning application process should be collated to inform future assessments. Longer term monitoring of water levels is encouraged and this could be included as a condition when granting planning permission
- Site investigation reports for historic development sites could be reviewed to obtain additional groundwater level information, to improve the conceptual understanding of the area;
- The impact of infiltration SUDS on water quality and quantity with respect to the Water Framework Directive should be considered when approving planning applications.

6 References

- British Geological Survey. 1:50,000 Scale Geology Series [Geological Map] Sheet 14 Morpeth: Bedrock and Superficial Deposits.
- British Geological Survey. 1:50,000 Scale Geology Series [Geological Map] Sheet 15 Tynemouth: Bedrock and Superficial Deposits.
- British Geological Survey. 1:50,000 Scale Geology Series [Geological Map] Sheet 21 Sunderland: Bedrock and Superficial Deposits.
- BGS, Lexicon. August 2011. WWW.BGS.AC.UK.
- DEFRA, March 2010. Surface Water Management Plan Technical Guidance.
- Environment Agency, 2010. Areas Susceptible to Groundwater Flooding. Guidance Document
- Jones, H K, Morris, B L, Cheney, C S, Brewerton, L J, Merrin, P D, Lewis, M A, MacDonald, A M, Coleby, L M, Talbot, J C, McKenzie, A A, Bird, M J, Cunningham, J, and Robinson, V K., 2000. The physical properties of minor aquifers in England and Wales. British Geological Survey Technical Report, WD/00/4. 234pp. Environment Agency R&D Publication 68.

Limitations

URS Scott Wilson Ltd ("URS Scott Wilson") has prepared this Report for the sole use of North Tyneside Council in accordance with the Agreement under which our services were performed. No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by URS Scott Wilson. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of URS Scott Wilson.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by URS Scott Wilson has not been independently verified by URS Scott Wilson, unless otherwise stated in the Report.

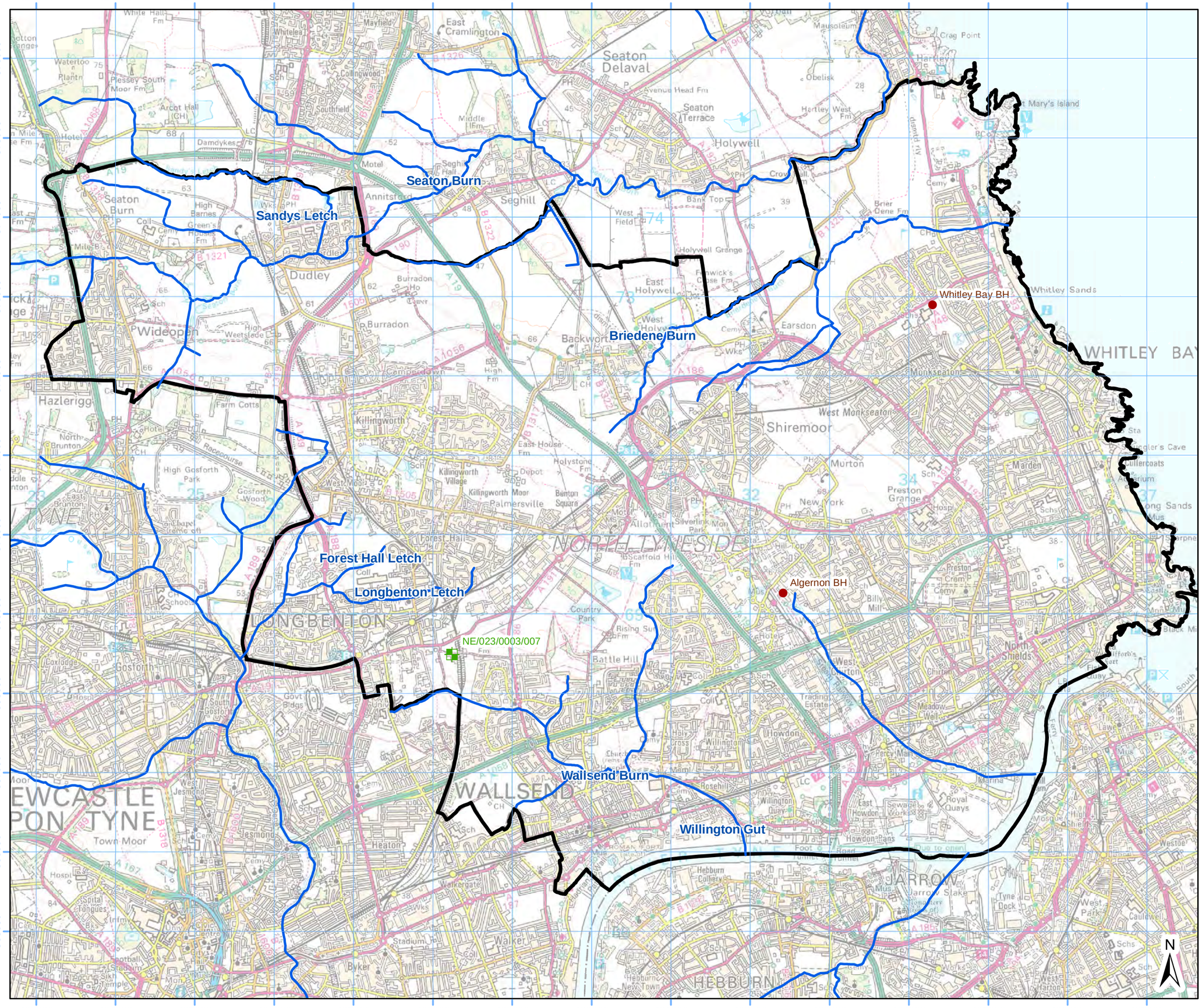
The methodology adopted and the sources of information used by URS Scott Wilson in providing its services are outlined in this Report. The work described in this Report was undertaken in October 2011 and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

URS Scott Wilson disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to URS Scott Wilson's attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. URS Scott Wilson specifically does not guarantee or warrant any estimate or projections contained in this Report.

Copyright



Legend

- North Tyneside City Council
- Main Rivers
- Coal Authority Groundwater Monitoring Bh

Licensed Groundwater Abstractions

- Licensed Groundwater Abstractions

Revision Details	By / Check	Date	Suffix

Drawing Status: FINAL

Job Title: NORTH TYNESIDE SURFACE WATER MANAGEMENT PLAN

Drawing Title: LOCATION MAP

Scale at A3: 1:45,000

0 0.45 0.9 1.8 Kilometers

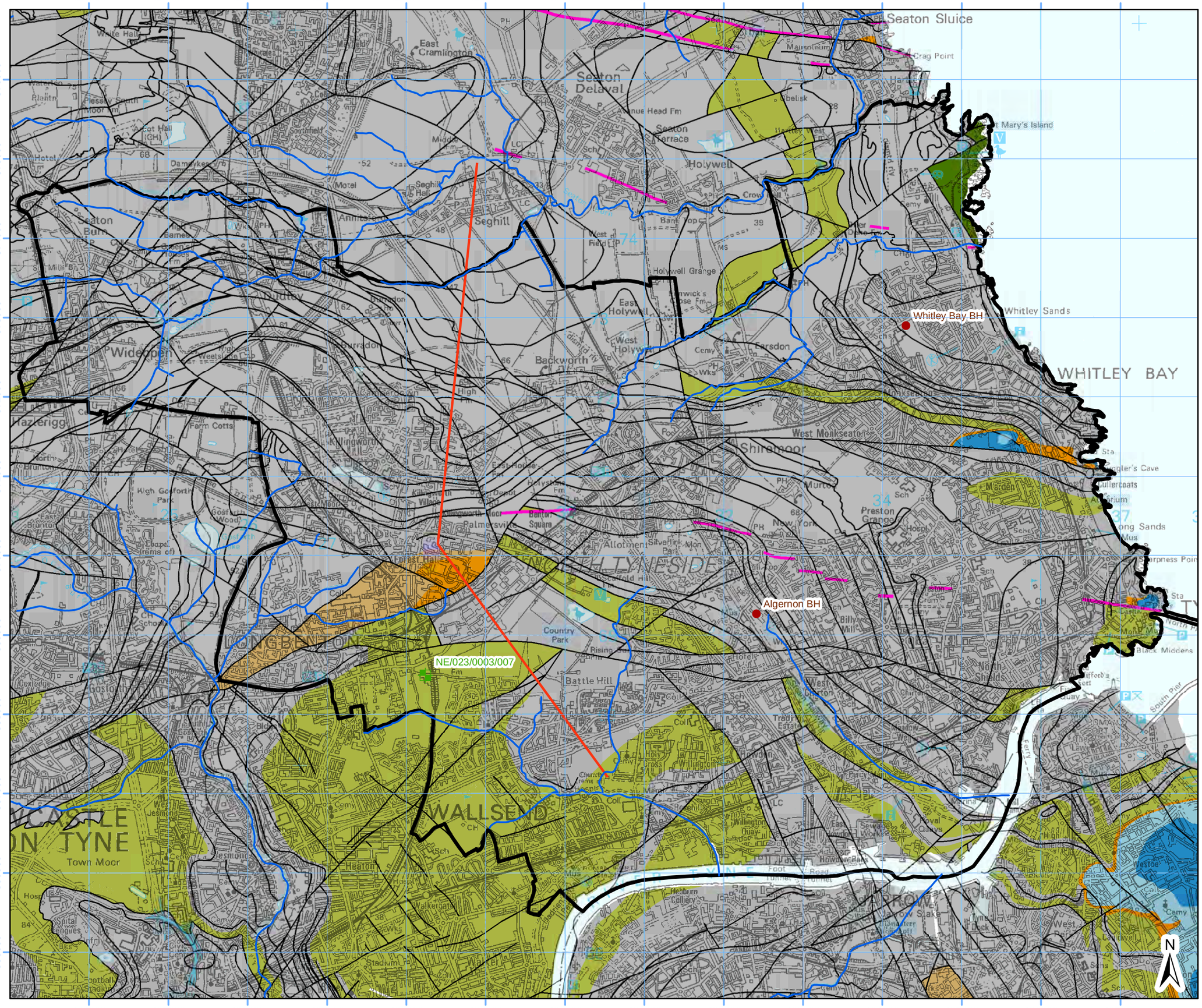
Drawn	Approved
CW	SJC

Stage 1 check	Stage 2 check	Originated	Date
			28/09/2011

URS Scott Wilson Ltd
Scott House
Alençon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
www.urs-scottwilson.com

Drawing Number: **FIGURE 1** Rev

Date: 24th August 2011
Filepath: K:\jobs\47050194\ North Tyneside\700 Technical\711 GIS\01 Layout



Legend

- North Tyneside City Council
- Coal Authority Groundwater Monitoring Bh
- Licensed Groundwater Abstractions

Bedrock Geology

- Roker Fm (Dolomite Rock)
- Raisby Fm (Dolomite Rock)
- Yellow Sands Fm (Sst)
- Pennine Upper CM Fm (MdSt, Sist & Sst)
- Pennine Middle CM Fm (Sst)
- Pennine Middle CM Fm (MdSt, Sist & Sst)
- Pennine Lower CM Fm (Sst)
- Unnamed Dyke
- Cross Section
- Fault

Notes
CM = Coal Measures
Fm = Formation, Sst = Sandstone
Sist = Siltstone, MdSt = Mudstone

Revision Details	By / Check	Date	Suffix

Drawing Status: FINAL

Job Title: NORTH TYNESIDE SURFACE WATER MANAGEMENT PLAN

Drawing Title: BEDROCK GEOLOGICAL MAP

Scale at A3: 1:45,000

Kilometers
0 0.45 0.9 1.8

Drawn	Approved
RAC	SJC

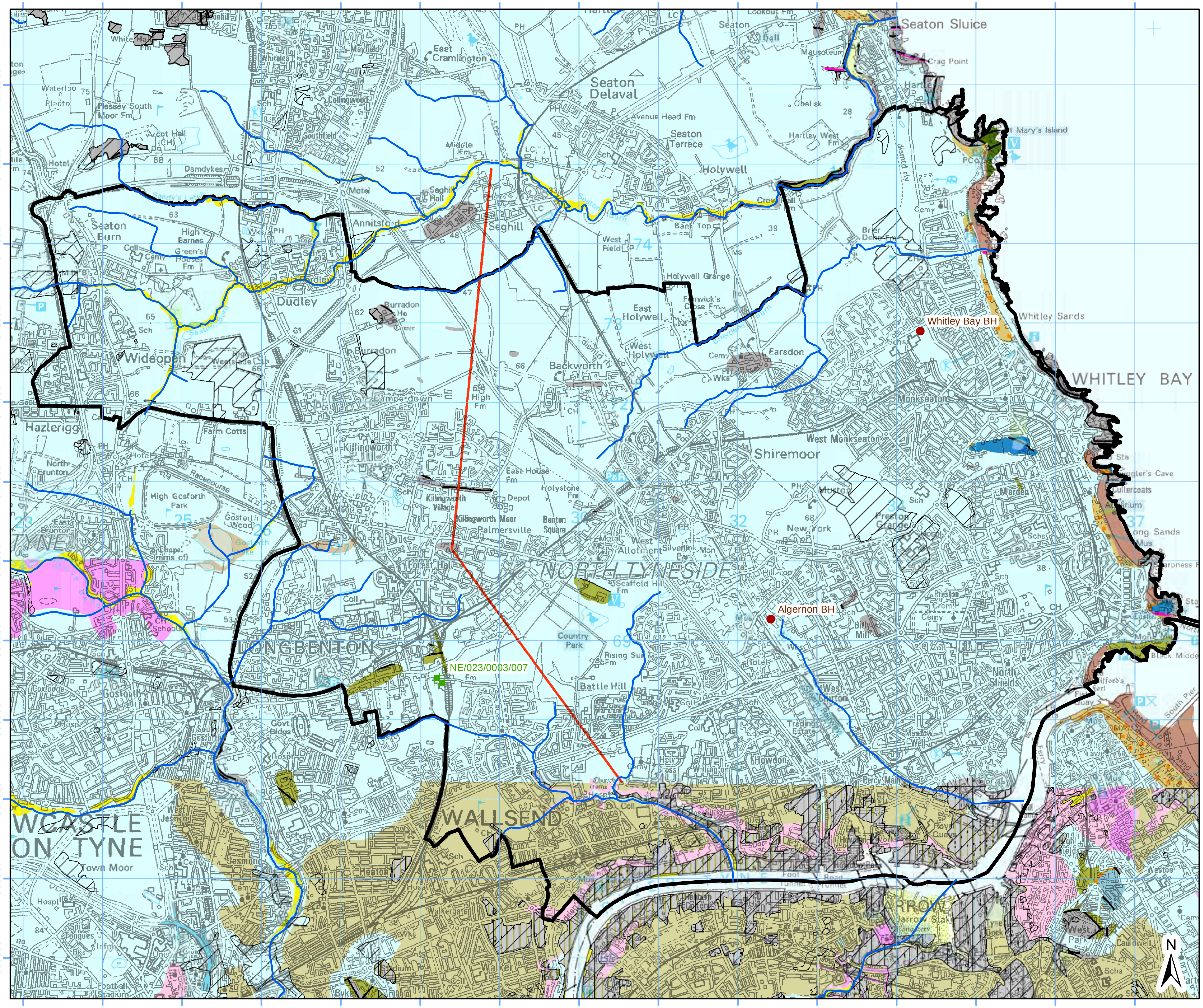
Stage 1 check	Stage 2 check	Originated	Date

URS Scott Wilson Ltd
Scott House
Alençon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
www.urs-scottwilson.com

Drawing Number: **FIGURE 2**

Rev

Date: 24th August 2011
Filepath: K:\jobs\47050194\ North Tyneside\700 Technical\711 GIS\01 Layout



423000 424000 425000 426000 427000 428000 429000 430000 431000 432000 433000 434000 435000 436000 437000

576000 575000 574000 573000 572000 571000 570000 569000 568000 567000 566000 565000

Legend

- North Tyneside City Council
- Coal Authority Groundwater Monitoring Bh
- Licensed Groundwater Abstractions
- Cross Section
- Artificial Ground

Superficial Geology

- Blown Sand (sand)
- Alluvium (Clay, Silt, Sand & Gravel)
- Lacustrine Deposits (clay silt & sand)
- Beach Deposits (sand & gravel)
- Tidal River or Creek Deposits (clay & silt)
- Tidal River or Creek Deposits (clay, silt & sand)
- Tidal River or Creek Deposits (clay, silt, sand & gravel)
- Pelaw Clay Member
- Glaciofluvial Deposits Undiff (sand & gravel)
- Glaciofluvial Deposits (clay & silt)
- Glacial Till (Devensian)
- Superficial Deposits not mapped

Bedrock Geology

- Roker Fm (Dolomite Rock)
- Raisby Fm (Dolomite Rock)
- Yellow Sands Fm (Sst)
- Pennine Upper CM Fm (MdSt, Sist & Sst)
- Pennine Middle CM Fm (Sst)
- Pennine Middle CM Fm (MdSt, Sist & Sst)
- Pennine Lower CM Fm (Sst)
- Unnamed Dyke
- Fault

Notes
CM = Coal Measures, Dep = Deposits,
Fm = Formation, Sst = Sandstone,
Sist = Siltstone, MdSt = Mudstone,
Undiff = Undifferentiated

Revision Details	By / Check	Date	Suffix

Drawing Status
FINAL

Job Title
NORTH TYNESIDE
SURFACE WATER
MANAGEMENT PLAN

Drawing Title
BEDROCK & SUPERFICIAL
GEOLOGY

Scale at A3
1:45,000

0 0.5 1 2 Kilometers

Drawn	Approved
RAC	SJC

Stage 1 check	Stage 2 check	Originated	Date

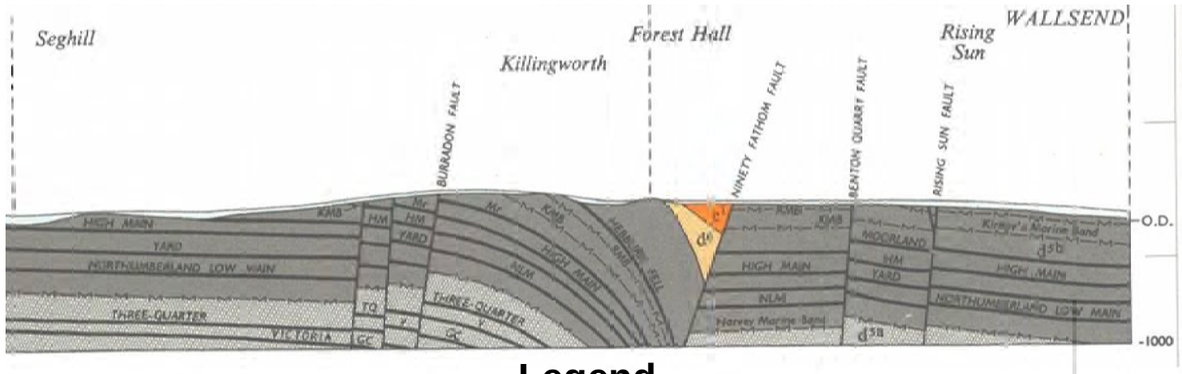
URS Scott Wilson Ltd
Scott House
Alencon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
www.urs-scottwilson.com

Drawing Number
FIGURE 3
Rev

Date: 24th August 2011
Filepath: K:\jobs\47050194 North Tyneside\700 Technical\711 GIS\01 Layout

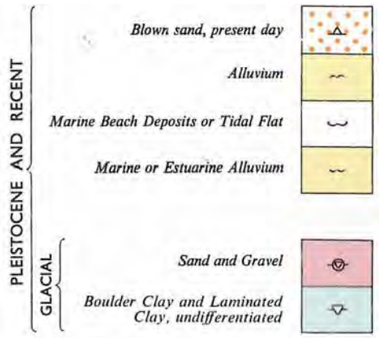
North

South

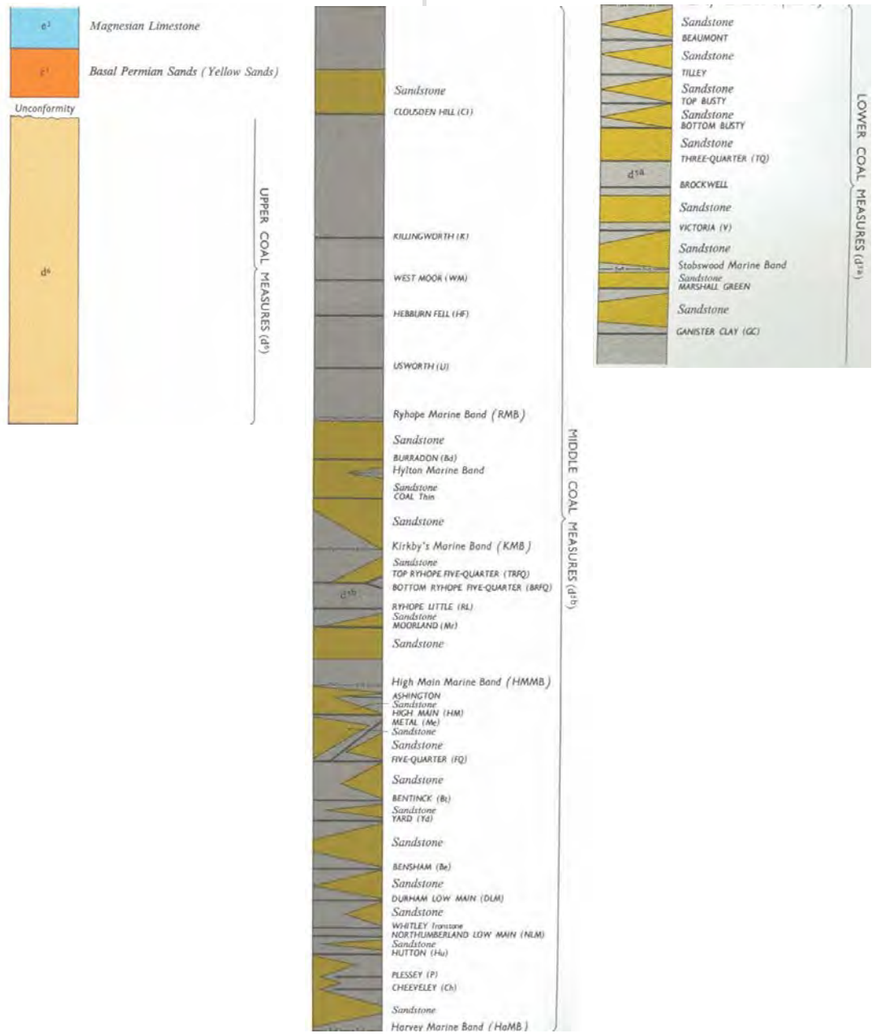


Legend

Drift Geology



Solid Geology



Horizontal Scale: One Inch to One Mile

1 ½ 0 1 2 3 Miles

Vertical Scale three times the horizontal

1000 500 0 1000 2000 Feet

Date: 24th August 2011
Filepath: K:\jobs\47050194\ North Tyneside\700 Technical\711 GIS\01 Layout

Revision Details	By / Check	Date	Suffix

Drawing Status

FINAL

Job Title

NORTH TYNESIDE SURFACE WATER MANAGEMENT PLAN

Drawing Title

GEOLOGICAL CROSS SECTION

Drawn	Approved
CW	SJC

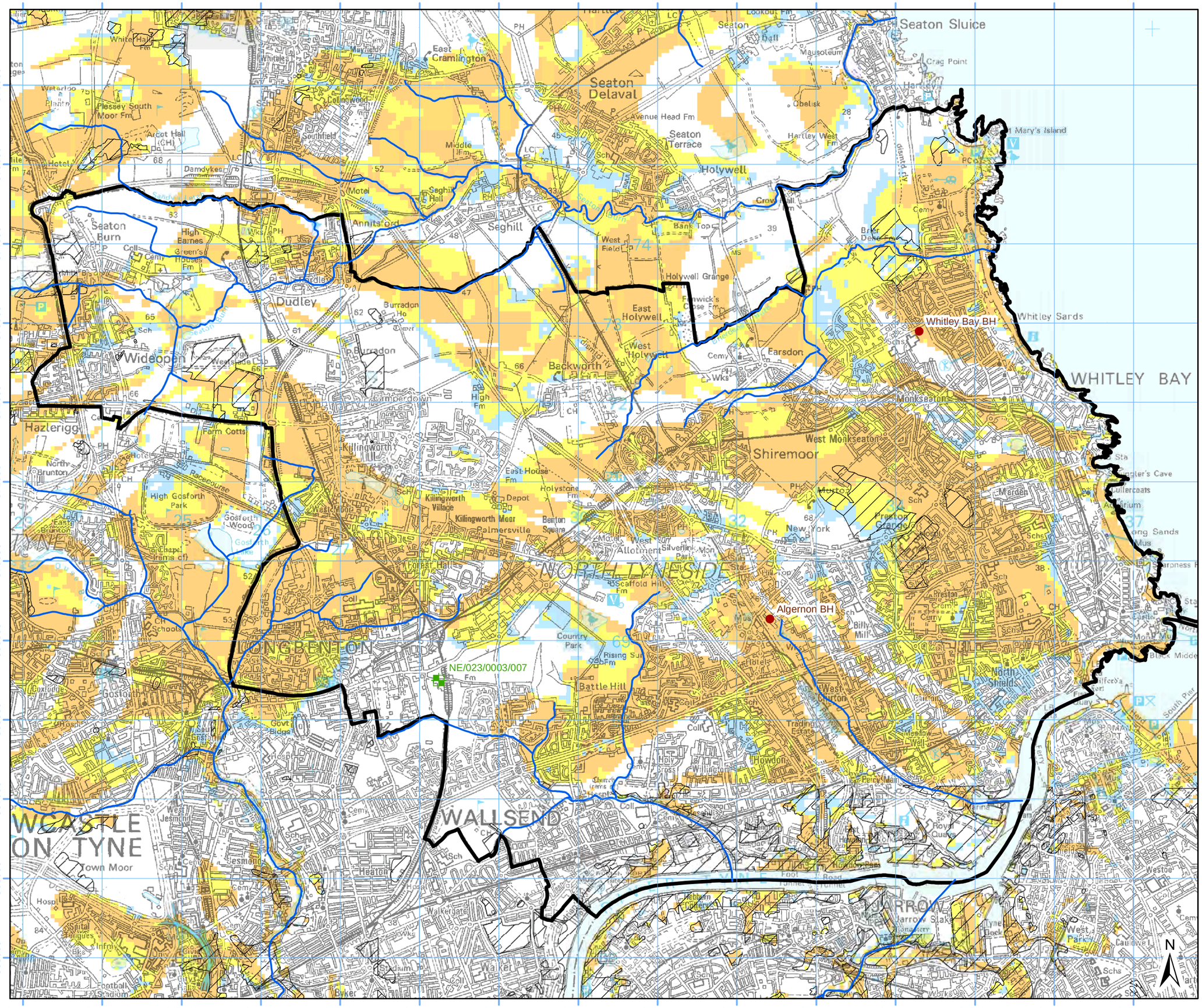
Stage 1 check	Stage 2 check	Originated	Date

URS Scott Wilson Ltd
Scott House
Alençon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
www.urs-scottwilson.com

Drawing Number

FIGURE 4

Rev



Legend

- North Tyneside City Council
- River
- Coal Authority Groundwater Monitoring Bh
- Licensed Groundwater Abstractions
- Artificial Ground

BGS Groundwater Flooding Susceptibility

- Very High
- High
- Moderate

Notes:

This map forms an approximate guide to areas that may be susceptible to groundwater flooding. However, for all new developments, site investigation is required to confirm local groundwater levels and therefore risk of groundwater flooding.

Revision Details	By / Check	Date	Suffix

Drawing Status: FINAL

Job Title: NORTH TYNESIDE SURFACE WATER MANAGEMENT PLAN

Drawing Title: BGS GROUNDWATER FLOODING SUSCEPTIBILITY MAP

Scale at A3: 1:45,000

0 0.5 1 2 Kilometers

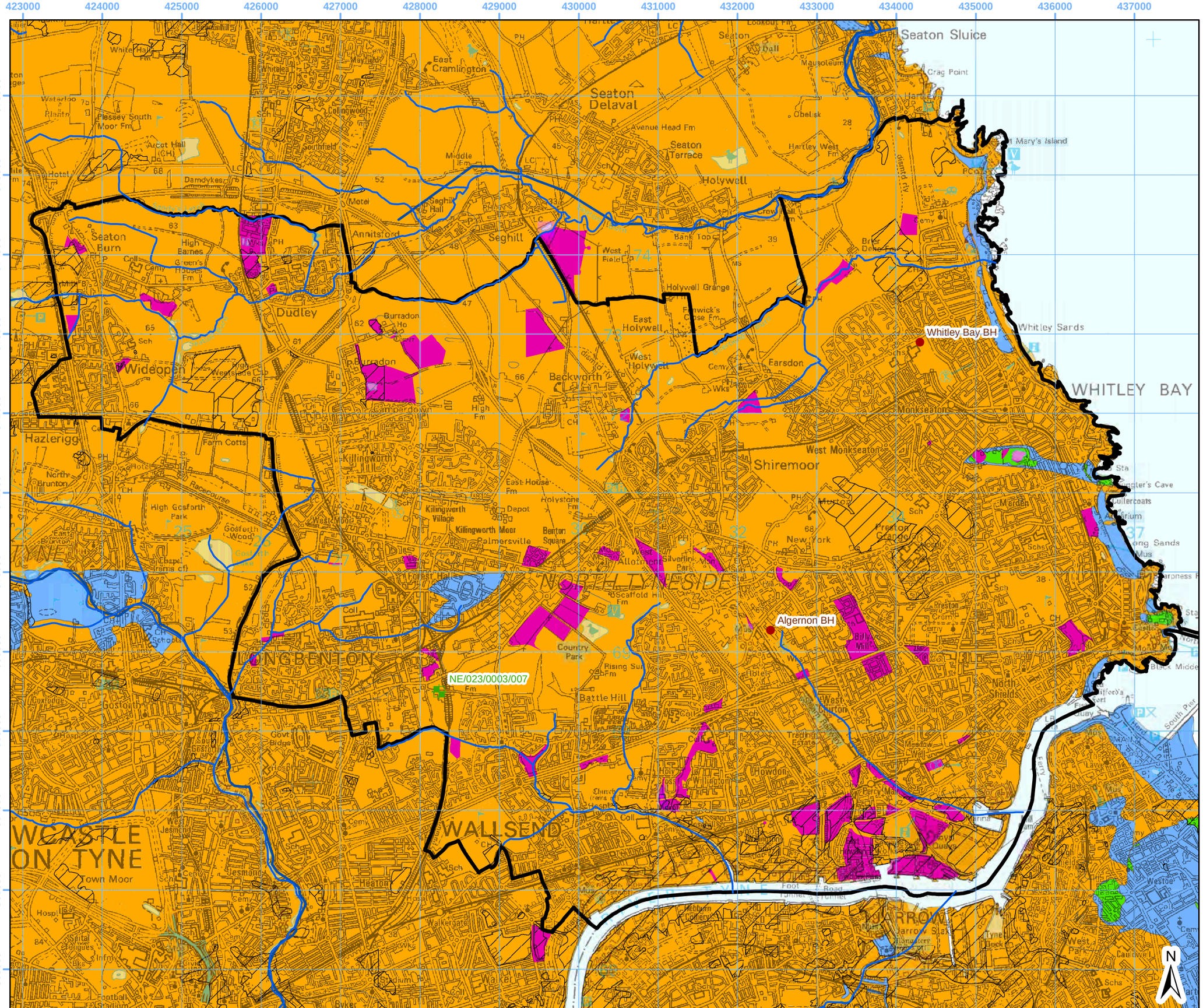
Drawn	Approved
RAC	SJC

Stage 1 check	Stage 2 check	Originated	Date

URS Scott Wilson Ltd
Scott House
Alencon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
www.urs-scottwilson.com

Drawing Number: **FIGURE 5** Rev

Date: 24th August 2011
Filepath: K:\jobs\47050194\ North Tyneside\700 Technical\711 GIS\01 Layout



Legend

- North Tyneside City Council
- Main River
- Coal Authority Groundwater Monitoring Bh
- Licensed Groundwater Abstractions

Artificial Ground

- Artificial Ground

Infiltration SUDS & Geological Suitability

- Enhanced site investigation required
- Infiltration SUDs potentially suitable
- Restricted potential for infiltration SUDS

Historic Landfill Sites

- Historic Landfill Sites

Source Protection zones

No Source Protection Zones in the area of study

Notes:

This map forms an approximate guide to permeability. However, for all new developments, site investigation is required to confirm local permeabilities and infiltration rates.

Areas identified as having 'restricted potential' for infiltration SUDS are probably unsuitable where high infiltration rates are required. However, it is possible that low infiltration rate SUDS can be used in conjunction with attenuation SUDS.

Revision Details	By	Check	Date	Suffix

Drawing Status: FINAL

Job Title: NORTH TYNESIDE SURFACE WATER MANAGEMENT PLAN

Drawing Title: INFILTRATION SUDS SUITABILITY

Scale at A3: 1:45,000

0 0.5 1 2 Kilometers

Drawn	Approved
BTV	SJC

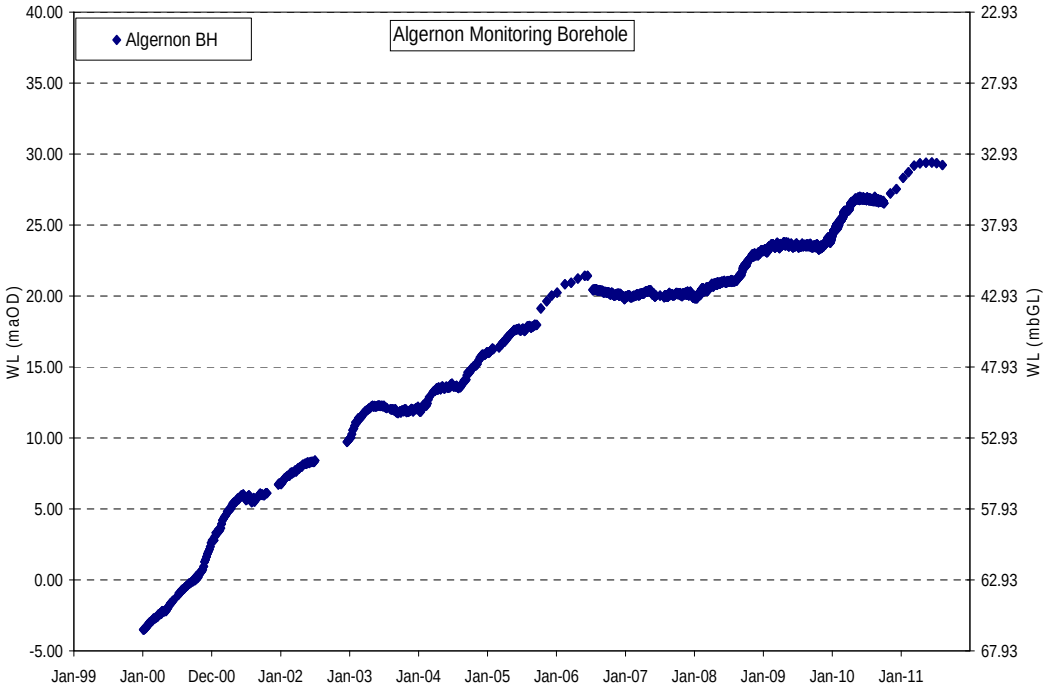
Stage 1 check	Stage 2 check	Originated	Date

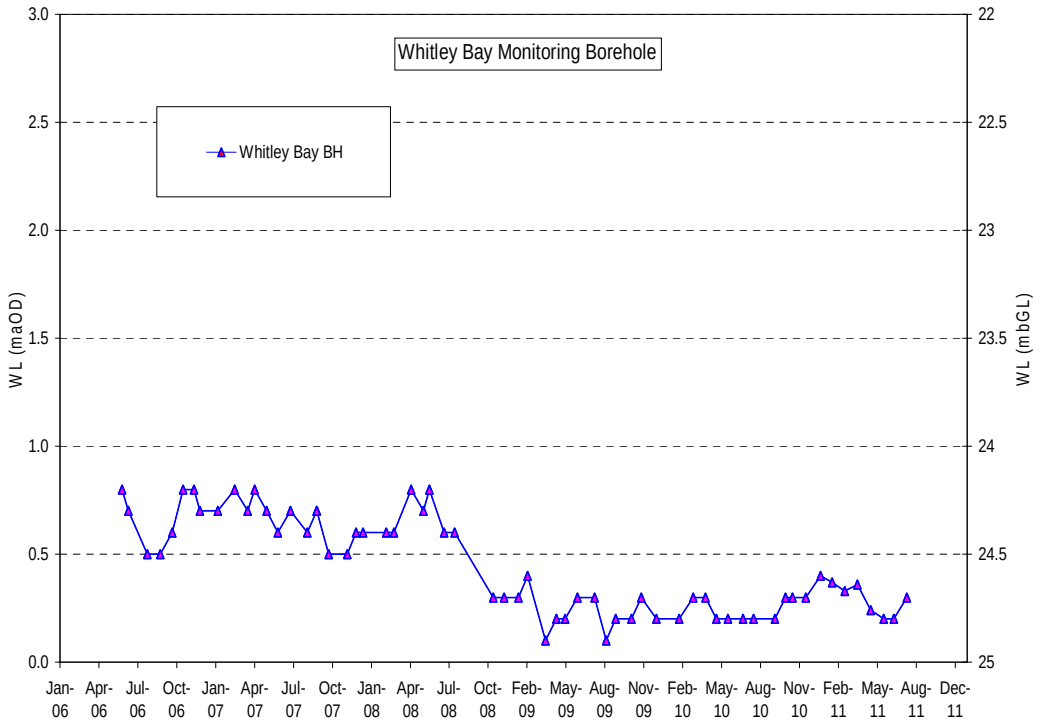
URS Scott Wilson Ltd
Scott House
Alençon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
www.urs-scottwilson.com

Drawing Number: **FIGURE 6** Rev

Date: 24th August 2011
Filepath: K:\jobs\47050194\ North Tyneside\700 Technical\711 GIS\01 Layout

APPENDIX A


Algernon Monitoring Borehole
Algernon BH
WL (maOD)
WL (mbGL)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
22.93
27.93
32.93
37.93
42.93
47.93
52.93
57.93
62.93
67.93
Jan-99
Jan-00
Dec-00
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11


Whitley Bay Monitoring Borehole
Whitley Bay BH
WL (maOD)
WL (mbGL)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
22
22.5
23
23.5
24
24.5
25
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Dec-11