M60/M62/M66 Simister Island Interchange

TR010064

ENVIRONMENTAL STATEMENT APPENDICES

APPENDIX 13.5 GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS ASSESSMENT REPORT

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ENVIRONMENTAL STATEMENT APPENDICES

APPENDIX 13.5 GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS ASSESSMENT REPORT

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Appendix 13.5 Groundwater dependent terrestrial ecosystems assessment report

1 Introduction

1.1 Purpose of the report

1.1.1 This appendix follows the UK Technical Advisory Group (UKTAG) guidance (UKTAG, 2005), to identify, prioritise, and assess the impacts of the Scheme on groundwater dependent terrestrial ecosystems (GWDTE).

1.1.2 The report informs the assessment presented in Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1).

1.2 Assessment methodology

Site identification

1.2.1 A screening assessment was carried using the datasets and information listed in paragraph 1.2.7, to identify sites that lie within 250m of the Order Limits for the Scheme. This includes:

- Statutory designated sites of international importance, such as Special Areas of Conservation (SAC)
- Statutory designated sites of national importance, such as Sites of Special Scientific Interest (SSSI) and Local Nature Reserves (LNR)
- Non-statutory designated sites, such as Sites of Biological Importance (SBI)
- Sites that are considered important for ecological conservation but that do not have a statutory or non-statutory designation (i.e. non-designated sites), such as Habitats of Priority Importance (HPI).

1.2.2 From this initial screening, three potential GWDTE were identified: Hazlitt Wood SBI, Hollins Vale LNR, SBI and Hollins Plantation SBI. Following the preliminary assessment reported in the Preliminary Environmental Information Report (contained in Annex L of the Consultation Report Annexes (TR010064/APP/5.2)), UK Habitat Classification (UKHab) survey data (see Appendix 8.1: UK Habitat Classification Report of the Environmental Statement Appendices (TR010064/APP/6.3) for full details) have also been incorporated into the assessment to identify further potential GWDTE within the study area. Sites have been identified within 250m of the Scheme where UKHab survey data describes a terrestrial habitat type and/or vegetation community which could be indicative of a wetland habitat.

1.2.3 As shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report, there are three nature conservation sites that could potentially be impacted because of the Scheme, along with six additional sites identified through the UKHab surveys undertaken by ecologists.

1.2.4 The distance of 250m from the Order Limits for the Scheme was chosen based on Scottish Environmental Protection Agency (SEPA) guidance (SEPA, 2017), which recommends an initial screening distance of:

- 100m for all excavations less than 1m deep
- 250m for all excavations that are more than 1m deep.

1.2.5 For this assessment, a distance of 250m was chosen as an appropriate screening buffer, in cognisance of the specific construction methods and excavation requirements that would be adopted for the Scheme. It is within this distance that potentially significant impacts would occur and are not expected to reach beyond this.

1.2.6 Sites supporting potential GWDTE identified for this assessment are shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report. GWDTE have been colour-coded based on their groundwater dependency classification (see Conceptual Site Model section below), and cross-hatched to highlight their nature conservation designation (if designated).

Data sources

1.2.7 For each potential GWDTE, land use, soil, topographic, geological, coal mining, hydrogeological, hydrological, and ecological information was gathered, comprising:

- Ordnance Survey (OS) mapping and aerial imagery (Google Earth, 2023)
- Historical maps

- Light detection and ranging (LiDAR) digital terrain model
- Ground Investigation (GI) data for the Scheme (Appendix 9.3: Ground Investigation Report of the Environmental Statement Appendices (TR010064/APP/6.3))
- Geological maps (1:10,000 and 1:50,000 scale), borehole logs, and permeability index/aquifer properties datasets (where required) available at the British Geological Survey (BGS) GeoIndex website (BGS, 2023) or via an information request (BGS, 2021a).
- BGS Susceptibility to Groundwater Flooding mapping (BGS, 2021b)
- Environment Agency data obtained from their website or via an information request (Environment Agency, 2021)
- Statutory and non-statutory designated site boundaries (excluding SBIs), and HPI boundaries, available on Department for Environment, Food and Rural Affairs (Defra) Multi-Agency Geographic Information for the Countryside (MAGIC) Map application (Defra, 2023)
- Sites of Biological Importance register (Greater Manchester Ecology Unit (GMEU), 2017)
- Ecological information from nature conservation designation descriptions or from planning application documents comprising baseline ecological surveys that are freely available online.
- National soils mapping (Cranfield University, 2023)
- Soil survey results presented in Appendix 9.2: Agricultural Land Classification Survey Report of the Environmental Statement Appendices (TR010064/APP/6.3)
- Review of returned Private Water Supply (PWS) questionnaires sent out to landowners in both January 2022 and March 2023
- Coal Authority data obtained from their Interactive Map Viewer (Coal Authority, 2023).

Conceptual site model

1.2.8 A Conceptual Site Model (CSM) was developed for the potential GWDTE sites. The CSM describes the relative importance of water sources supporting the GWDTE identified, conceptual supply mechanisms, water flows, levels and quality, and the main physical factors determining these. The CSM is based on a detailed review of available geological and hydrogeological information derived from the draft factual GI data for the Scheme, as well as historical BGS borehole information and topography. The CSM is also supported by site-specific survey data collected during hydrogeological walkover surveys, which complemented and refined the ecological information obtained from the UKHab surveys. For the three nature conservation sites identified, this has allowed their groundwater dependencies to be reviewed.

1.2.9 As part of the CSM, the groundwater dependency of each site scoped in is determined based on professional judgement using the following categorisations:

- Not groundwater dependent
- Low groundwater dependency
- Moderate groundwater dependency
- High groundwater dependency

1.2.10 The CSM was then used to assess potential changes in groundwater levels, flows, and quality, which could result from the Scheme. The assessment of potential changes was made considering specific construction method and type of development (e.g. cutting, widening, embankment, piled foundations and drainage infrastructure).

Assessment criteria

Value

1.2.11 The prioritisation of sites is reflected in the determination of the value of each GWDTE. As per UKTAG guidance (UKTAG, 2005), the value attribution is a combination of nature conservation designation and the degree of groundwater dependency determined in the CSM.

1.2.12 The value classifications outlined in the Environmental Scoping Report (TR010064/APP/6.6) and listed below for GWDTE, are based on the Water Framework Directive; and align with UKTAG guidance. The UKTAG guidance brings together the degree of groundwater dependency (low, moderate, and high), and the level of ecological designation / protection of a site, to determine the overall importance of each potential GWDTE. This deviates from the value (importance) definitions identified in Table 3.70 of DMRB LA 113.

1.2.13 The value of the potential GWDTE is defined in Table 13.20 of Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1), with a summary given below:

- **Very High:** Water feeding GWDTE with a high or moderate groundwater dependency, with a high environmental importance and international or national value, such as Ramsar sites, SAC, SPA and SSSI.
- **High:** Water feeding GWDTE of low groundwater dependency, with a high environmental importance and international or national value, such as Ramsar sites, SAC, SPA and SSSI. Water feeding GWDTE with a high or moderate groundwater dependency, with a national non-statutory UK Biodiversity Action Plan (BAP) priority.
- **Medium:** Water feeding GWDTE of low groundwater dependency, with a national non-statutory UK BAP priority. Water feeding GWDTE with a high or moderate groundwater dependency, with no conservation designation.
- **Low:** Water feeding GWDTE of low groundwater dependency, with no designation. Groundwater that supports a wetland not classified as a GWDTE, although may receive some minor contribution from groundwater.

Magnitude of change

1.2.14 The CSM is used to assess potential changes in groundwater levels, flows, and quality, which could impact on the GWDTE because of the Scheme. To ensure that no impact is overlooked, irrespective of the likely construction sequence, each activity / potential impact is assessed systematically. Where the construction sequence could affect the impact assessment, this is clearly stated in the relevant assessment of effects section for each GWDTE.

1.2.15 The magnitude of change is assessed based on the criteria set out in Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1).

Significance of effect

1.2.16 The resultant potential significance of effect, combining value of the GWDTE, and magnitude of change, is based on the significance matrix in Table 4.7 of Chapter 4: Environmental Assessment Methodology of the Environmental Statement (TR010064/APP/6.1).

Assumptions, limitations and data gaps

1.2.17 Specific to this GWDTE assessment, assumptions, limitations and data gaps include:

- There are no Environment Agency or BGS groundwater monitoring locations available close to any of the GWDTE sites to provide an indication of groundwater seeps, strikes, or rest water levels.
- Ecology surveys supporting the development of the CSM comprise the UKHab surveys, and not more detailed National Vegetation Classification (NVC) surveys (see Chapter 8: Biodiversity of the Environmental Statement (TR010064/APP/6.1) for a detailed description of the ecology data collected, and methodologies used for the ecology surveys carried out for the Scheme).
- It has been assumed that only HPI classified as wetlands (i.e., those including swamp, marsh, bog, and/or fen habitats) would support potential GWDTE. HPI such as dry broadleaved deciduous woodlands were excluded from the assessment.
- Access was restricted in certain locations due to landowners not responding to access requests/ refusing access, which prevented complete hydrogeological site walkover surveys from being undertaken for Parkwood Cottages South and parts of Philips Park LNR and SBI. See Figure 13.5.2 in Annex A of this report for areas that access was agreed/ not agreed.
- Draft and factual GI data (hereafter referred to as ‘GI data’) contained in Appendix 9.3: Ground Investigation Report of the Environmental Statement Appendices (TR010064/APP/6.3) have been used for the GWDTE assessment. A data freeze was set in May 2023, with no new or revised GI data (such as groundwater level monitoring data) collected / edited after this date having been incorporated into the assessment.
- In some cases (described in Section 1.2 on a site-by-site basis), lithology and groundwater level information are limited to geological logs and groundwater strikes and seeps noted in historical borehole records provided by the BGS.

- Consideration of embedded and essential mitigation measures referred to in Section 13.9 of Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1) for the determination of potential effects.
- This section only discusses potential effects on groundwater levels, flows, and quality that support ecosystems. Other impacts on vegetation and habitats, such as partial or total loss of a GWDTE, are discussed in Chapter 8: Biodiversity of the Environmental Statement (TR010064/APP/6.1).

1.2.18 The general assumptions, limitations and data gaps relating to the groundwater environment, and that are listed in Appendix 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement Appendices (TR010064/APP/6.3), also apply to this appendix.

2 Site-specific GWDTE assessments

2.1 Introduction

2.1.1 This section provides assessments for each GWDTE within the study area. Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report shows the location and groundwater dependency classification for each GWDTE discussed in this section.

2.2 Hazlitt Wood SBI

Site setting, topography and hydrological catchment

2.2.1 Hazlitt Wood SBI is located immediately south-west of the existing M60 carriageway and comprises a narrow, wooded valley in the north of Heaton Park. The site is protected by fencing on all sides. Heaton Park Golf Course borders the eastern boundary of the site.

2.2.2 An unnamed Ordinary Watercourse ‘issues’ in the north-west corner of the site as shown on OS maps. A second unnamed Ordinary Watercourse issues 100m north. Both watercourses flow south-east, in and out of culvert through the centre of the site, and merge upstream and discharge into Hazlitt Pond. The outflow from Hazlitt Pond, flows southwards, and exits the site via its southern boundary, where it discharges into Blackfish Pond located in Heaton Park Golf Course.

2.2.3 The elevation of the site ranges from 100m above ordnance datum (AOD) in the north-east, at the head of the valley, to around 75mAOD in the south-east corner, where the watercourse exits the site. Ground to the east and west reaches approximately 100mAOD. This marks the limit of the hydrological catchment which stretches 180m east, and 250m west. The embankment for the existing M60 carriageway may limit the extent of the surface water catchment to the north.

Soils and geology

2.2.4 There are no historical borehole records located within the site itself. A series of boreholes were drilled to the north of the site for the existing M60 carriageway, one of the deepest of which was drilled approximately 25m north (SD80NW701). A single historical borehole was also drilled 35m east of the site (SD80NW19) (BGS, 2023) In addition, the GI data provides geological information for two boreholes drilled 25m north of the site (BH-P03 and WS-P09). Relevant information extracted from all borehole logs is provided in Table 2.1.

2.2.5 Soils at the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023).

2.2.6 Made ground was encountered in all three boreholes to the north of the site (see Table 2.1), to depths ranging from 1.7mbgl to 3.4mbgl (likely associated with the existing M60 carriageway). The made ground predominantly comprised a gravelly sandy clay lithology, except for at SD80NW701, which recorded an upper sand horizon overlying the sandy gravelly clay. Given the lack of GI data within the site itself, it is difficult to determine if any made ground extends within the site boundary, although geological maps suggest that the made ground extends as far south as the northern site boundary (BGS, 2023).

2.2.7 The mapped superficial geology comprises head deposits of clay, silt, sand, and gravel across most of the site (BGS, 2023). Hummocky glacial deposits of sand and gravel are shown on geological maps located on the edge of the site, on high ground, mainly in the west and north. This is consistent with the alternating layers of clay and sand identified in all four borehole records. The borehole located to the east of the site (SD80NW19) recorded the base of the superficial deposits as 43.56mbgl.

2.2.8 Bedrock at the site is the Chester Formation, comprising sandstone (BGS, 2023). The borehole record located 35m east of the site (SD80NW19) describes the bedrock as a soft red sandstone, with alternating units of hard red sandstone and red marl (see Table 2.1).

Table 2.1 Borehole records for Hazlitt Wood SBI

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
BH-P03	0	2.8	Grass over slightly gravelly, slightly sandy to sandy CLAY with roots and gravel of sandstone, flint, mudstone, concrete, limestone and brick (MADE GROUND)	No groundwater strike recorded
	2.8	6.26	Slightly gravelly, slightly sandy, silty CLAY, overlying slightly gravelly, slightly sandy to sandy, slightly silty CLAY, and very silty, fine to coarse SAND	
WS-P09	0	1.7	Grass over slightly gravelly, slightly sandy to sandy CLAY with occasional rootlets and gravel of sandstone, limestone, flint, mudstone, brick and concrete, overlying gravelly, clayey, very silty, fine to coarse SAND (MADE GROUND)	No groundwater strike recorded

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	1.7	5.04	Slightly sandy, slightly gravelly CLAY to 3.60m, overlying slightly gravelly, slightly silty, fine to coarse SAND	
SD80NW701	0.00	1.20	Grass over dark brown slightly clayey gravelly SAND (MADE GROUND)	Not recorded*
	1.20	3.40	Stiff dark brown sandy slightly gravelly clay (MADE GROUND)	
	3.40	3.80	Brown slightly clayey slightly gravelly SAND	
	3.80	4.10	Stiff dark brown slightly sandy slightly gravelly CLAY	
SD80NW19	0.00	43.56	Alternating layers of SAND, sandy CLAY, SAND and GRAVEL and gravelly CLAY	Not recorded
	43.56	>150.00	Alternating units of soft and hard red SANDSTONE with marl bands (tens of metres thick)	
*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered.				

Groundwater

2.2.9 Groundwater level monitoring information for the period January 2022 to May 2023 for BH-P03 and WS-P09 is summarised in Table 2.2. The data show that during this period, the highest groundwater levels recorded 25m north of the site ranged from 0.11mbgl to 4.40mbgl, just 50m to the west.

2.2.10 Except for the far south-east corner of the site, the BGS susceptibility to groundwater flooding dataset classifies Hazlitt Wood SBI as having limited potential for groundwater flooding to occur (BGS, 2021b). The south-east corner of the site is classified as having either potential for groundwater flooding of property situated below ground level, or potential for groundwater flooding to occur at surface level.

2.2.11 There are no springs, sinks, sources, collects, or spreads shown within the site boundary or its immediate vicinity on OS maps or historical maps. A hydrogeological walkover survey was undertaken at the site in December 2021, which identified groundwater seepages along the western valley sides, discharging into the unnamed Ordinary Watercourse in the centre of the site. One particular groundwater discharge was observed entering the site from a source that was situated upgradient of the western site boundary. The source could not be visited due to the presence of dense vegetation restricting access to this location. The ground was also found to be saturated throughout the base of the valley, with ponded water observed in topographic lows adjacent to the watercourse.

2.2.12 OS maps show the presence of a well on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report. No licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021), but the well could indicate the presence of a Private Water Supply (PWS), and potentially shallow groundwater levels in this location. This well was visited during the hydrogeological walkover survey in December 2021 and was assessed to still be in use. However, at the time of writing, no PWS questionnaire results were available for the site to confirm this.

2.2.13 It should be noted that a possible ocherous discharge was also observed during the hydrogeological walkover survey. This was located just south of Hazlitt Pond (where the culverted watercourse emerges), outside of an area of Coal Measures and adjacent to the ‘Land at Heaton Park’ historic landfill site. On the eastern bank of the watercourse, there was an area of orange-stained deposits, with a visible flow coming out of the ground and from an adjacent corrugated plastic drainage pipe, that discharged into the unnamed Ordinary Watercourse.

Table 2.2 Groundwater level monitoring information for Hazlitt Wood SBI

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min. Depth (mbgl)	Max Depth (mbgl)
BH-P03	1 to 2.5	Made ground	12/01/2022 – 02/05/2023	17	0.11	1.37
WS-P09	3.6 to 4.7	Clay and sand (Superficial deposits)	12/01/2022 – 02/05/2023	6	4.40	’Damp’ (no water level recorded)

2.2.14 The GI data includes groundwater quality information for one sample collected from BH-P03 on 02/02/2022 at a depth of 1.5mbgl. All groundwater sample results for the Scheme have been compared to available freshwater Environmental Quality Standards (EQS). EQS exceedances were detected for heavy metals (copper and chromium as Cr^{3+}), phenol, and ammoniacal nitrogen as N. Detectable concentrations of Total Petroleum Hydrocarbons (TPH) and Total Polycyclic Aromatic Hydrocarbons (PAH) were also found. The source of the heavy metals, TPHs and PAHs in the made ground at this location could be associated with the M66, or its construction, which is located 75m upgradient of BH-P03 (although this is not certain). The presence of ammoniacal nitrogen as N (0.81mg/l) exceeding an EQS of 0.3mg/l, could be a result of agricultural activity in proximity to the site.

Habitats and vegetation

2.2.15 Hazlitt Wood is designated a SBI based on the following key features; woodland, reedbed, swamp, fen, ponds and small lodges, and aquatic invertebrates (GMEU, 2017).

2.2.16 Three separate areas in the south of the site are also classified as HPI, where the main habitats comprise lowland fen (described as swamp, fen and flushes). These areas are confined to the western spur of the site, and two narrow corridors, surrounding the path of the merged unnamed Ordinary Watercourse in the south, before it discharges into Blackfish Pond.

2.2.17 A UKHab survey was undertaken for most of Hazlitt Wood SBI, except for the southern part of the site. The surveyed part of the site was classified as a lowland mixed deciduous woodland habitat type, surrounding an area of eutrophic standing waters in the centre (Hazlitt Pond) (see Table 2.3). The UKHab survey notes did not record the presence of any groundwater features, wet ground conditions, or species indicative of shallow groundwater levels. However, during the hydrogeological walkover survey undertaken in December 2021, the southern part of the site (where no UKHab surveys were undertaken), was found to be wet and boggy underfoot, particularly surrounding the Ordinary Watercourse and in the lower western part of the site. GWDTE at the site are therefore likely to be present in this southerly location.

Table 2.3 UKHab survey data for Hazlitt Wood SBI

UKHab Classification	Description	Relation to Site (Location)	Survey Notes	Potential for GWDTE
w1f	Lowland mixed deciduous woodland	Within most of site	Large expanse of woodland with variable woodland communities. Large area of beech dominated woodland in centre with little diversity in canopy and secondary woodland growth. Understory very sparse with bare ground layer	No
r1a	Eutrophic standing waters	Within the centre of the site	Waterbody	No

Conceptual site model

2.2.18 Plate 2.1 shows a conceptualised cross-section running north-west to south-east through the centre of the site. The CSM highlights the indicative movement of groundwater and surface water through the site, and derived groundwater dependencies supporting vegetation and habitats present.

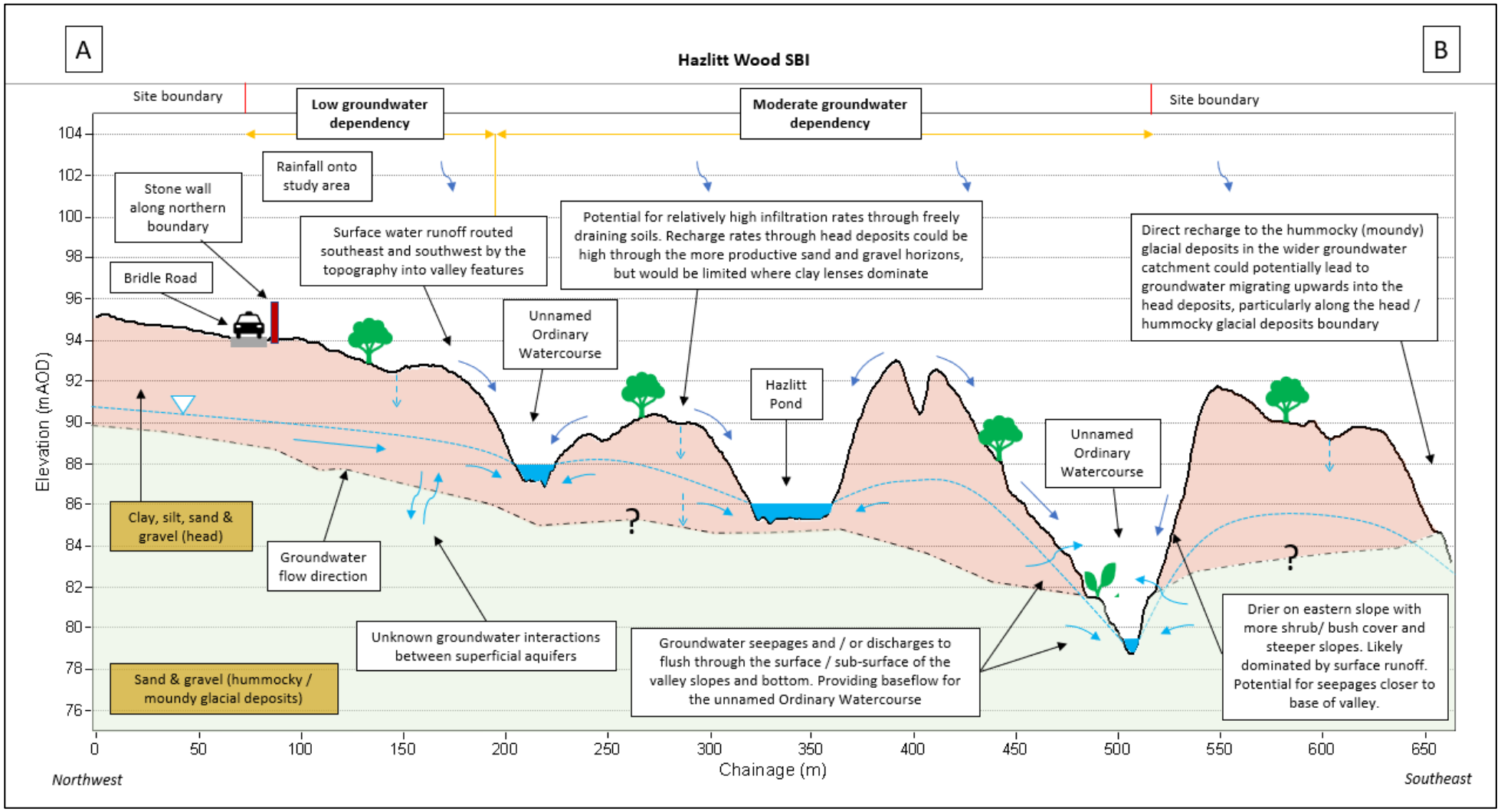
2.2.19 Seepages and groundwater emergence were observed within the site during the hydrogeological walkover along the western slopes of the valley and were feeding into a saturated area along the banks of the unnamed watercourse, where trees and woodland were less abundant. In this area the soils were fully saturated and conditions swamp like.

2.2.20 The presence of groundwater seepages flushing through the surface / sub-surface of the valley areas surrounding the unnamed Ordinary Watercourses, correlates well with the presence of the above-mentioned wetland habitats and the areas of highest groundwater flooding susceptibility. The well located 20m north-west could also be indicative of shallow groundwater conditions. The western spur, central, and southern areas of the site, are therefore classified with a **moderate groundwater dependency**.

2.2.21 However, as indicated by the absence of springs, sinks, sources, collects and issues within the site boundary, the groundwater table is generally not expected to be close to the ground surface throughout the remainder of the site. The hydrogeological walkover survey confirmed this with drier conditions found in the north. Although groundwater level monitoring data recorded shallow groundwater at BH-P03 (25m north of the site), groundwater levels for the same period were >4mbgl at WS-P09 – just 50m west of BH-P03 and still 25m north of the site. This indicates the potential presence of a localised, discontinuous perched groundwater lens rather than widespread shallow groundwater in this location. For these reasons, the remainder of the site is classified as having a **low groundwater dependency**.

2.2.22 Given the presence of the SBI designation, the value of the GWDTE is medium to high. The variation is due to different groundwater dependencies within the site.

Plate 2.1 Conceptual site model for Hazlitt Wood SBI



Assessment of effects

2.2.23 The northern boundary of the site lies immediately adjacent to, and down-gradient of the Order Limits.

Construction

2.2.24 The site lies outside of the estimated dewatering zones of influence for the nearest cutting and drainage connections. No dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted from these assets (see Table 2.4). However, groundwater could be slightly intercepted by approximatively 0.6m during excavation of Pond 5, which lies 15m north of the site. In this instance, it is not applicable to attribute a dewatering zone of influence but rather expect that groundwater level disruption would be extremely localised (i.e., expected to extend no more than 5m from the edge of the excavation). This would result in a **slight adverse** significance of effect in the far north of the site. The remainder of the site would experience negligible or no impacts.

2.2.25 There could also be short-term disturbances to groundwater flows at the GWDTE, because of compaction-related construction activities and earthworks (such as soil stripping), that would not need dewatering. Soil stripping is assumed to take place up to a maximum of 0.5m depth and located 10m north of the site at its closest point. Considering the limited excavation depth, proximity of the earthworks to the site, and groundwater flow directions in the area, minor magnitude impacts to groundwater flows and levels could occur in the far north of the site, resulting in **slight adverse** significance of effect. Negligible or no impacts are expected throughout the remainder of the site. No impacts are predicted to the GWDTE from the construction of cuttings, embankments, bridges, or gantries, given their distance from the site.

2.2.26 Ground disturbance due to the above-mentioned activities could also lead to changes in groundwater quality, due to the mobilisation of suspended solids and / or accidental leaks and spills of fuels and chemicals. As described in Chapter 13: Road Drainage and the Water Environment (TR010064/APP/6.1), there are several best-practice mitigation measures contained within the First Iteration EMP (TR010064/APP/6.5) for pollution prevention including managing silt pollution (for suspended solids transport). These measures would significantly reduce the likelihood of contaminating groundwater, but do not affect the severity or consequence of an event occurring. Considering the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), the proximity of the earthworks to the site, and groundwater flow directions in the area, minor magnitude impacts to groundwater quality could occur in the far north of the site, resulting in a **slight adverse** significance of effect. Negligible to no impacts on groundwater quality are expected throughout the remainder of the site. In addition, no impacts on groundwater quality are predicted at the site from the creation of new vertical contaminant pathways in the superficial aquifers, i.e., from the construction of cuttings, embankments, bridges, or gantries, given their distance from the site.

Operation

2.2.27 The presence of below ground structures 15m north of the site (Pond 5), could permanently alter local groundwater flows and levels in the superficial aquifer. Given the proximity of the pond to the site, and groundwater flow directions in the area, minor magnitude impacts to groundwater levels and flows could occur in the far north of the site, resulting in a **slight adverse** significance of effect. Negligible to no impacts are expected throughout the remainder of the site.

2.2.28 There is potential for local groundwater recharge rates to be permanently disrupted from the increased interception of overland flows. This could be due to an increase in impermeable surface areas, permanent highway drainage, reprofiled ground etc. However, the relative contribution of groundwater inputs from the north of the site is negligible compared to the wider groundwater catchment in recharging the superficial aquifers. As a result, no noticeable impacts are expected to recharge rates sustaining the GWDTE.

2.2.29 Considering the distance of the Scheme from the GWDTE, no impacts on groundwater quality are expected to the site during the operation phase from accidental leaks / spills of fuels and chemicals (i.e., due to road collisions), and / or routine runoff associated with the new highway.

Summary

2.2.30 A summary of the effects to the site is provided in Table 2.4.

Table 2.4 Summary of effects to Hazlitt Wood SBI

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect
Low	SBI	Medium	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Minor	Slight adverse
Moderate		High			Negligible	Neutral
Low		Medium	Mobilisation of suspended solids (groundwater quality)	Construction	Minor	Slight adverse
Moderate		High			Negligible	Neutral
Low to moderate		Medium to high	Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	No impact	N/A
Low		Medium	Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	Minor	Slight adverse
Moderate		High			Negligible	Neutral
Low to moderate		Medium to high	Cutting dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
Low		Medium	Pond dewatering (groundwater levels / flows / quality)	Construction	Minor	Slight adverse
Moderate		High			No impact	N/A
Low to moderate		Medium to high	Drainage connection dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
Low to moderate		Medium to high	Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	Negligible	Neutral

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect
Low to moderate		Medium to high	Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	No impact	N/A
Low to moderate		Medium to high	Ground settlement in superficial deposits (groundwater levels / flows)	Operation	No impact	N/A
Low		Medium	Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	Minor	Slight adverse
Moderate		High			Negligible	Neutral
*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.						

2.3 Hollins Vale LNR, SBI, and Hollins Plantation SBI

Site setting, topography and hydrological catchment

2.3.1 Most of the area shown as Hollins Vale on OS maps is designated as an LNR. Two discrete areas within the LNR are also designated as SBIs. This includes the north of the LNR, which comprises Hollins Vale SBI, and the south-east of the LNR, which forms Hollins Plantation SBI. The largest extents of both the LNR and the two SBIs are used for this assessment and are referred to generally as “the site”, unless specified otherwise.

2.3.2 The south of the LNR and Hollins Plantation SBI are situated in an area of relatively high ground to the west of the M66. The elevation in this part of the site ranges from 105m AOD in the south and south-east, to 90m AOD further north. The north of the site, which also forms Hollins Vale SBI, comprises a narrow valley through which Hollins Brook Main River flows west towards the River Roch (also designated Main River status), and the elevation drops to around 75m AOD. North of Hollins Brook lies a lodge, shown by OS maps to be hydrologically connected to Hollins Brook, which spans most of the width of the site. Further north, and higher up the valley side, the elevation increases to around 85m AOD along the northern boundary of Hollins Vale LNR and SBI.

2.3.3 The southern boundary of the site (Hollins Vale LNR and Hollins Plantation SBI) lies at a topographic divide. This marks the boundary between two hydrological catchments; that for Hollins Brook in the north of the site, and that for Parr Brook Main River, which flows 380m to the south. Much of the site itself therefore forms the hydrological catchment for Hollins Brook. The catchment is also likely to be limited to the east by the highway embankment for the M66.

2.3.4 A spring is shown on historical maps along the southern boundary of the LNR, north of Haweswater Crescent. An unnamed Ordinary Watercourse is also shown to “issue” in the south of Hollins Plantation SBI, and flows north-east, where it enters culvert underneath the existing M66 carriageway.

2.3.5 Hydrogeological walkover surveys were undertaken at Hollins Vale in December 2021 and April 2023, with the December 2021 survey only covering the southwestern corner (Hollins Plantation SBI). During the December 2021 visit the “issue” to the southeast could not be identified due to flooding in that part of the site. However, the area was generally found to be waterlogged and comprised a topographic low. The April 2023 walkover could not ground truth the presence of the spring which was identified on historical mapping as there were no signs of active spring discharge observed on the day of the survey.

Soils and geology

2.3.6 Twelve historical borehole records are available for the site (BGS, 2023), albeit confined to the north and east (Hollins Vale SBI). Relevant information extracted from two of these borehole records (SD80NW217 and SD80NW453; considered representative of the geology in this location) is provided in Table 2.5. A borehole was also drilled just outside of the site boundary in the north-west (SD80NW237). This borehole encountered bedrock, unlike the boreholes within the north and east of the site. In addition, the GI data provides geological information for a single borehole drilled 50m east of the site (see Table 2.5).

2.3.7 Soils in the western half of the site are described as naturally wet, very acid sandy and loamy soils (Cranfield University, 2023). Soils in the east of the site comprise slowly permeable seasonally wet acid loamy and clayey soils with impeded drainage. The hydrogeological walkover survey confirmed the presence of clay rich soils in the southeast of the site (Hollins Plantation SBI). Several areas of made ground are mapped across the site, including two small patches in the south and southeast, and multiple patches in the north, to the north of Hollins Brook. The borehole record located just north-west of the site boundary (SD80NW237) encountered made ground to a depth of 5.60mbgl, comprising a soft grey sandy clay. The made ground deposits appear to be associated with the lodges situated throughout the north of the site. GI borehole (BH-G09), located to the east of the site also recorded a 0.74m thick layer of made ground, which comprised asphalt overlying a sandy, silty gravel layer. This is likely to be associated with the M66 embankment.

2.3.8 Superficial geology across most of the site (in the south, centre, and far north) comprises hummocky sand and gravel deposits (BGS, 2023). Head deposits, overlain by alluvium in parts, both comprising clay, silt, sand and gravel, are shown to be present in the north of the site, across a large proportion of the area designated an SBI. Table 2.5, which summarises borehole records, shows that generally, alternating layers of clay and sand with varying thicknesses were recorded in boreholes in the north-west and east of the site. The GI borehole (BH-G09) to the east encountered gravel, overlying layers of clay and sand. Given that head, alluvium, and glacial deposits typically comprise varying lithologies, it is unclear if these borehole records correlate with published geological mapping. Landslide deposits have also been recorded in the north-east of the site, to the south of Hollins Brook (BGS, 2023).

2.3.9 Bedrock at the site can be broadly split into three regions (BGS, 2023). Most of the site is underlain by the Pennine Lower Coal Measures Formation, comprising mudstone, siltstone, and sandstone. A unit of sandstone, belonging to the Trencherbone Rock member, underlies the north-west of the site. This member forms part of the Pennine Lower Coal Measures Formation. The Pennine Lower Coal Measures and Trencherbone Rock is inferred to be fault bounded across the site. Bedrock in the far south of the site also comprises the Pennine Middle Coal Measures Formation.

2.3.10 Bedrock was encountered in the borehole located just outside of the site boundary, in the north-west (SD80NW237). This was described as a highly weathered purple/grey mudstone. Published geological mapping, however, shows this area to be underlain by a sandstone unit belonging to the Trencherbone Rock member (BGS, 2023). Bedrock was not encountered in the GI borehole.

2.3.11 One fault bisects the site at its centre, trending east-west, and marks the southern extent of the Trencherbone Rock sandstone member (BGS, 2023). Further north, two north-west-south-east trending faults cut across the site. The northernmost fault marks the boundary between the Trencherbone Rock member and the Pennine Lower Coal Measures.

Table 2.5 Borehole records for Hollins Vale LNR, SBI and Hollins Plantation SBI

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
BH-G09	0	0.74	Asphalt overlying slightly sandy to sandy, slightly silty GRAVEL of limestone (MADE GROUND)	No groundwater strikes recorded

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	0.74	30.45	Sandy, slightly clayey, fine to coarse GRAVEL, overlying slightly gravelly, slightly sandy, silty CLAY, very silty CLAY, gravelly, clayey, fine to coarse SAND, slightly gravelly CLAY, laminated slightly sandy to sandy, very silty CLAY, slightly gravelly, sandy, silty to very silty CLAY and laminated CLAY	
SD80NW217	0.00	0.30	TOPSOIL	Seep at 2.40. Standing water level was 5.40 after 20 minutes
	0.30	2.40	Firm brown and grey mottled very silty sandy CLAY with sand bands	
	2.40	3.10	Medium dense brown fine silty SAND	
	3.10	5.50	Firm grey brown very silty CLAY with fine gravel	
	5.50	7.00	Dense brown silty SAND with fine and medium GRAVEL	
SD80NW453	0.00	0.20	TOPSOIL	Not recorded*
	0.20	2.80	Stiff dark brown CLAY with occasional roots and mottling to 1.00mbgl	
	2.80	12.00	Loose slightly clayey silty SAND with occasional gravel and silt bands	
SD80NW237	0.00	5.60	Soft grey sandy CLAY (MADE GROUND)	Seep at 14.40. Standing water level was 13.90 after 15 hours
	5.60	5.80	Brown SAND	
	5.80	8.40	Firm grey brown very silty CLAY with some laminations and sand bands	
	5.80	10.10	Stiff brown very silty friable CLAY with some gravel	
	10.10	14.20	Stiff grey brown sandy gravelly CLAY with cobbles	
	14.20	19.80	Highly weathered purple/grey MUDSTONE	

*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered

Groundwater

2.3.12 The nearby GI borehole does not provide any groundwater level information. Groundwater level information for the twelve historical borehole records located within the north-east and northwest of the site, and single historical borehole record (SD80NW237) located just northwest of the site boundary, is provided in Table 2.6. During the hydrogeological walkover in April 2023, seepages were observed to the north / centre of the site, south of Hollins Brook, which created a small tributary in the marshy grassland flowing towards Hollins Brook. Ground conditions in this area and in the central part of the site were also observed to be very wet underfoot, with small dry areas at higher elevations in the southwest and southeast. Ponding of water around paths, and in the centre of the LNR was also observed.

2.3.13 The BGS susceptibility to groundwater flooding dataset classifies the southern half of the site (including Hollins Plantation SBI) as having limited potential for groundwater flooding to occur (BGS, 2021). The north of the site, however, is classified as either having potential for groundwater flooding to occur at surface level, or as having potential for groundwater flooding of property situated below ground level. The area with the highest susceptibility to groundwater flooding is in the valley bottom, where Hollins Brook is located. The area of highest susceptibility to groundwater flooding also correlates with observed seepages and wet ground conditions from the hydrogeological walkover.

2.3.14 Groundwater was encountered in seven out of the eight historical boreholes drilled in the north-west of the site, including the single borehole located just outside of the site boundary (SD80NW237). Groundwater seeps were encountered at depths of between 2.40mbgl (SD80NW217) and 14.40mbgl (SD80NW237). Groundwater strikes were recorded at depths ranging from 4.80mbgl (SD80NW219) to 10.00mbgl (SD80NW238). One borehole remained dry at the time of drilling, to a depth of 9.00mbgl (SD80NW239).

2.3.15 In the east and north-east of the site, groundwater was only encountered in one out of the five borehole records, but at the shallow depth of 0.50mbgl (SD80NW454). All other boreholes were dry at the time of drilling. The groundwater table was therefore more than 3.00mbgl (SD80NW450) and 12.00mbgl (SD80NW453), depending on the exact location of the borehole.

Table 2.6 Groundwater level information extracted from borehole records for Hollins Vale LNR, SBI and Hollins Plantation SBI

Borehole ID	Groundwater Level Information	Date
SD80NW215	Seep at 5.30mbgl	02/12/1980
SD80NW216	Seep at 3.40mbgl	02/12/1980 – 03/12/1980

Borehole ID	Groundwater Level Information	Date
SD80NW217	Seep at 2.40mbgl and 5.80mbgl. Standing water level was 5.40mbgl after 20 minutes. A piezometer was installed in the borehole, which recorded a water level of 1.90mbgl on 4/12/1980	03/12/1980
SD80NW218	Strike at 5.00mbgl. Standing water level was 4.60mbgl after 20 minutes	3/12/1980
SD80NW219	Strike at 4.80mbgl. Standing water level was 2.50mbgl after 1 hour	4/12/1980
SD80NW237	Seep at 14.40mbgl. No rise after 1 hour but standing water level was 13.90mbgl after 15 hours	10/11/1980
SD80NW238	Strike at 10.00mbgl. Standing water level was 8.20mbgl after 20 minutes	7/12/1980 – 9/12/1980
SD80NW239	Not encountered (borehole terminated at 9.00mbgl)	6/10/1980
SD80NW454	Strike at 0.50mbgl with no rise after 20 minutes	1/2/1995
SD80NW453	Not encountered (borehole terminated at 12.00mbgl) – sand was wet below 8.00mbgl but no temporary standing water level present	31/1/1995
SD80NW452	Not encountered (borehole terminated at 3.50mbgl)	1/2/1995
SD80NW451	Not encountered (borehole terminated at 4.00mbgl)	2/2/1995
SD80NW450	Not encountered (borehole terminated at 3.00mbgl)	2/2/1995

2.3.16 The spring shown on historical mapping located along the southern site boundary, is likely to be indicative of shallow groundwater levels in this location. An “issues” is also shown on OS maps in the south-east of the site, along with a well in the north-west which is shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report. This is also potentially indicative of shallow groundwater emergence in these areas. No licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). At the time of writing, no PWS questionnaire results were available for the site and so the presence of PWSs cannot be ruled out.

2.3.17 As mentioned previously, the “issues” shown on OS maps could not be verified during the hydrogeological walkover survey of Hollins Plantation SBI in December 2021, due to flooding in this part of the site. However, a wooden board (acting as a damming structure) was identified approximately 5m north of this area placed in the topographic low. This was observed to be restricting forward flows in the Ordinary Watercourse and causing water to back up behind the board in this area. Additionally, during the April 2023 walkover, the spring was not observed to be actively discharging and hence could also not be verified.

2.3.18 No groundwater quality information from the GI data is available for this site.

Habitats and vegetation

2.3.19 Most of Hollins Vale LNR (south and central parts) is grazing land with relatively low ecological interest (Bury Metropolitan Borough Council, 2003). Other habitats, however, include marginal habitats adjacent to Hollins Brook, old woodland, old and new hedgerows, bramble and gorse scrub, and more recently planted woodland.

2.3.20 Hollins Plantation SBI, in the south-east of the site, comprises approximately two hectares of old woodland, with the oldest trees planted between 1848 and 1893, on the slopes of a tributary of Hollins Brook (Bury Metropolitan Borough Council, 2003). The large willows (many of which are now dead or dying), pre-date the oaks that now characterise the plantation.

2.3.21 In the north of the site, which forms Hollins Vale SBI, the most diverse flora occurs where water springs from the steep scarp forming a boggy flush. This habitat is described in the LNR designation as a wet meadow.

2.3.22 Approximately half of Hollins Vale SBI is also listed as an HPI, where the main habitat comprises lowland fen, swamp and flushes (Natural England, 2010), which coincides with the areas of “boggy flush” described above. There are also several canal-like lodges in this part of the site. The SBI designation in this area is primarily due to the diversity of waterside plants.

2.3.23 A UKHab survey was undertaken for the eastern half of the site (see Table 2.7). The centre of the site was classified as a modified grassland habitat type, with a significant component of rushes identified moving northwards. Patches of wet woodland, lowland fen, dense scrub, lowland dry acid grassland and other neutral grassland habitat types were observed in the north/north-east of the site, with the wetland areas situated immediately to the south of Hollins Brook. The southeast of the site (Hollins Plantation SBI) was classified as a lowland mixed deciduous woodland habitat type.

Table 2.7 UKHab survey data for Hollins Vale LNR, SBI and Hollins Plantation SBI

UKHab Classification	Description	Relation to Site (Location)	Survey Notes	Potential for GWDTE
g4	Modified grassland	Within centre of the site (southern part)	Grassland	No
g4,15	Modified grassland with a significant component of *Juncus* (rush) species	Within centre of the site (further north)	Grassland secondary code 15 likely	Yes (due to dominance of rush)
w1f	Lowland mixed deciduous woodland	Within the southeast of the site	Pedunculate oak dominated woodland. Understory includes hawthorn, ask saplings etc. Ground flora is dominated by bramble, native bluebell, rough meadow grass, pendulous sedge, etc.	Yes (due to vegetation species present)
g3c	Other neutral grassland	Small area north of Hollins Brook in north of site	Grassland	No
r2b	Other rivers and streams	Within the north of the site	Hollins Brook	No
r1a	Eutrophic standing waters	Within the north-east of the site	Large mitigation pond area with scrub on banks	No
w1d	Wet woodland	Within the north of the site	Wetland habitat mosaic including lowland fen with interspersed areas of wet woodland habitat	Yes
f2a	Lowland fens	Within the north of the site	Fen within acid grassland. Area on valley slope representing M27	Yes
h3	Dense scrub	Within the north of the site	Mixed scrub on valley bank	No

UKHab Classification	Description	Relation to Site (Location)	Survey Notes	Potential for GWDTE
		Within the north-east of the site	Woodland plantation currently better represents scrub. Willow, alder, and birch dominant. Ground layer dominated by cultivated pendulous sedge	Yes (due to vegetation species present)
g1a	Lowland dry acid grassland	Large area within the north and east of the site	SBI grassland, acid grassland on slopes, transitioning to more neutral grassland towards the motorway. Acid grassland dominated by spring turf moss, common bent, etc. Neutral grassland dominated by rushes	Yes (due to dominance of rushes)

Conceptual site model

2.3.24 Plate 2.2 shows a conceptualised cross-section running south-west to north-east through the centre of the site.

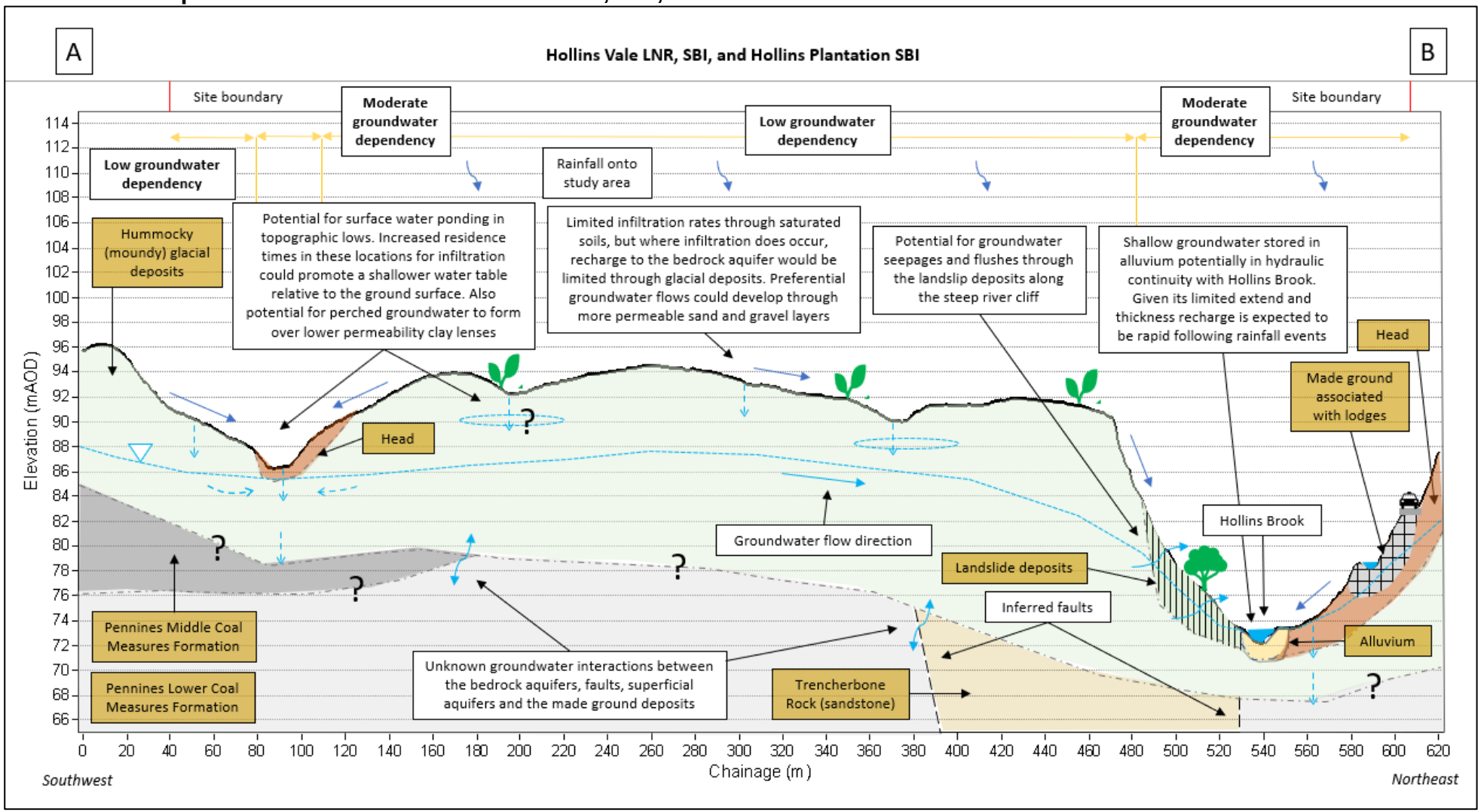
2.3.25 The area of grazing land in the south of the site is classified as having a **low groundwater dependency**. This is based on the BGS groundwater flooding susceptibility mapping, which identifies this part of the site as having limited potential for groundwater flooding to occur, the absence of springs or issuing watercourses, generally high elevation, and the fact that the south of the site marks the head of the groundwater catchment. All of which suggest that groundwater levels are not expected to be close to the ground surface in this location. There is potential for surface water ponding to occur in topographic lows in the centre of the site, which with increased residence times for infiltration, could lead to perched groundwater horizons (where downwards moving groundwater flows are impeded by lower permeability clay lenses in the glacial deposits).

2.3.26 The north of the site which forms Hollins Vale SBI, is described as a boggy flush, where springs and groundwater seepages emerge along the steep valley sides. Despite groundwater being encountered at the shallow depth of less than 1m in only one historical borehole record in the north of the site, groundwater levels in this area are anticipated to be high, due to the sudden drop in topography likely allowing the water table to intersect with the ground surface. During the hydrogeological walkover in April 2023 the presence of very wet ground conditions and groundwater seepages arising along the scarp edge were confirmed, especially where higher permeability landslide deposits are located. These have the potential to support groundwater dependent vegetation to the north and north-east of the site, which are therefore attributed as having a **moderate groundwater dependency**.

2.3.27 Hollins Plantation SBI has areas of wet, boggy ground where the issue was indicated on OS mapping. However, during the hydrogeological walkover in December 2021 no evidence of shallow groundwater was identified in this area, with the issue likely to be sourced from surface water ponding in this location rather than groundwater. The rest of the SBI was relatively dry indicating that groundwater levels are likely to be deeper and not particularly close to the surface. This part of the site is therefore classified as having a **low groundwater dependency**.

2.3.28 Given the presence of the LNR and SBI designations, the value of the GWDTE is medium to high.

Plate 2.2 Conceptual site model for Hollins Vale LNR, SBI, and Hollins Plantation SBI



Assessment of effects

2.3.29 The far south-east corner of the site lies 30m west and partially down-gradient of the Order Limits at its closest point, and on the opposite side of the existing M66 southbound carriageway.

Construction

2.3.30 The site lies outside of the estimated dewatering zones of influence for the nearest cutting, pond and drainage connections. No dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted (see Table 2.8).

2.3.31 The nearest ground disturbance associated with ground compaction, soil stripping, vegetation clearance and construction of the gantry within the Order Limits is situated 50m east of the far south-east corner of the site. Given, the works position on the opposite side of the existing M66 southbound carriageway and groundwater flow directions in the area, impacts to groundwater flows and levels in the south-east of the site are expected to be attenuated up-gradient of the site boundary and would be negligible. This would result in a **neutral effect**. No impacts to groundwater flows and levels are expected throughout the remainder of the site. Similarly, no impacts are predicted to the GWDTE from the construction of the embankments, bridges, or drainage assets, given their distance from the site.

2.3.32 The magnitude of change on existing groundwater quality in the south-east of the site, due to the mobilisation of suspended solids and/or accidental spills and leaks of fuels and chemicals is expected to be negligible. That is, considering the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), which would result in a **neutral** significance of effect in this location. No impacts to groundwater quality are expected throughout the remainder of the site.

Operation

2.3.33 There are no permanent below ground structures or embankments within the vicinity of the site to locally alter groundwater levels and flows supporting GWDTE. No operational impacts to groundwater flows and levels at the site are therefore predicted.

2.3.34 Considering the distance of the Scheme from the GWDTE, the existing M66 infrastructure, likely groundwater flow directions in the area, and the filtering effect of aquifer material, no impacts on groundwater quality are expected to the site during the operation phase.

Summary

2.3.35 A summary of the effects to the site is provided in Table 2.8.

Table 2.8 Summary of effects to Hollins Vale LNR, SBI, and Hollins Plantation SBI

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Low to moderate	LNR / SBI	Medium to high	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Negligible	Neutral
			Mobilisation of suspended solids (groundwater quality)	Construction	Negligible	Neutral
			Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	Negligible	Neutral
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	Negligible	Neutral
			Cutting dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
			Pond dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
			Drainage connection dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
			Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	No impact	N/A
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	No impact	N/A

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	No impact	N/A
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	No impact	N/A
			Intercept contaminated groundwater in long-term, or mixing of different groundwater chemistries (groundwater quality)	Operation	No impact	N/A

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

2.4 Philips Park LNR and SBI

Site setting, topography and hydrological catchment

2.4.1 Philips Park is designated as both an LNR and an SBI, the extents of which differ slightly along the site's margins. Philips Park SBI also includes a second LNR, known as Mere Clough, which runs south-west to north-east along most of the site's eastern boundary. The largest extents of both LNRs and the SBI are used for this assessment.

2.4.2 The site is separated into two parts by the existing M60 carriageway. The smaller part, North Wood, lies to the north of the highway embankment and forms a narrow, steep sided valley. An unnamed Ordinary Watercourse issues along the northern boundary of this part of the site, flows southwards through the valley bottom in the site's centre, and enters a culvert underneath the M60 carriageway, at the southernmost part of the woodland.

2.4.3 The elevation of North Wood ranges from approximately 105mAOD in the north, to around 65mAOD in the south-east, where the watercourse exits the southern boundary.

2.4.4 Most of Philips Park lies to the south of the existing M60 carriageway. The River Irwell bounds the site to the south, and Bradley Brook flows south-west, within the site, close to the entire eastern boundary of this part of the site. Several ponds (former reservoirs) are located in the south, and the watercourse which flows in a culvert beneath the M60 embankment from North Wood, discharges into the River Irwell in the south of the site. A hydrogeological walkover survey was undertaken at this larger part of the site in December 2021. Access was restricted to North Wood, and consequently no hydrogeological walkover survey has been carried out in this location.

2.4.5 The elevation of this larger part of the site ranges from approximately 100mAOD in the north, to around 30mAOD in the south, adjacent to the River Irwell.

2.4.6 The hydrological catchment for the site extends approximately 600m north, towards the A667 Ringley Road West, where the ground reaches around 130mAOD.

2.4.7 Two springs are shown on historical maps towards the centre of the southern part of the site as shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report, along with two “sinks” in the east, close to Bradley Brook. Historical maps also show two “issues” close to the eastern boundary of the southern part of the site, and three more “issues” in North Wood.

Soils and geology

2.4.8 No GI data were available close to the site at the time of writing. However, several historical borehole records are available for the site (BGS, 2023). Relevant information extracted from four of these historical borehole records (considered to be representative of the geology in each part of the site) is provided in Table 2.9.

2.4.9 Soils across most of the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023). Soils in the south-east of the site are described as freely draining slightly acid loamy soils. Slowly permeable seasonally wet acid loamy and clayey soils are shown to be present in the north and north-east. During the hydrogeological walkover survey wet clayey/ silty soils with sand were identified along the course of Bradley Brook.

2.4.10 Four areas of made ground are mapped across the site (BGS, 2023). Two small areas lie in the west, a small strip of made ground is shown in the centre of North Wood, and the largest expanse is associated with an underpass beneath the existing route of the M60 in the west. There is no lithological information provided for any of the mapped areas of made ground, but two of the historical borehole records summarised in Table 2.9 describe layers of brick, ash, clay, and sand as made ground deposits (SD70SE159 and SD70SE530).

2.4.11 The superficial geology across most of the site comprises glaciofluvial sand and gravel deposits, interspersed with glacial till (BGS, 2023). River terrace sand and gravels are mapped in the south-west of the site, and a thin, south-west-north-east trending unit of hummocky glacial deposits, also comprising sand and gravel, are mapped along most of the eastern boundary. Layers of sands, sandy gravels and clays are described in the historical borehole records provided in Table 2.9, which is broadly consistent with the mapped superficial geology. Large expanses of landslide deposits are shown along most of the southern and eastern edges of the southern part of the site (through Mere Clough), along with the southern half of the North Wood (BGS, 2023).

2.4.12 Bedrock comprises several individual formations which trend north-west to south-east (BGS, 2023). Individual bedrock units at the site include the Pennine Middle Coal Measures Formation (mudstone, siltstone and sandstone) – including a unit of sandstone belonging to the Newton Heath Sandstone member, the Pennine Upper Coal Measures Formation (mudstone, siltstone and sandstone - including a unit of sandstone belonging to the Worsley Delf Rock member, the Manchester Marls Formation (mudstone), and the Chester Formation (sandstone).

2.4.13 The mapped geology is consistent with the bedrock lithology identified in the historical borehole records for the Coal Measures, which describe alternating layers of mudstone and coal (see Table 2.9).

2.4.14 A north-west-south-east trending fault cutting across the east of the site. This fault marks the boundary of the Pennine Lower/Middle Coal Measures Formation and the Manchester Marls/Chester Formation.

Table 2.9 Borehole records for Philips Park LNR and SBI

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike* (mbgl)
SD70SE159	0.00	1.20	Brick and clinker (MADE GROUND)	Not encountered
	1.20	3.05	Clay and sand (MADE GROUND)	
SD70SE530	0.00	0.20	Ash (MADE GROUND)	Strike at 5.80mbgl. Standing water level rose to 4.40mbgl after 20 minutes
	0.20	4.50	Grey/black sandy clay with ash/glass (MADE GROUND)	
	4.50	5.80	Soft to firm grey slightly sandy silty CLAY	
	5.80	6.10	Loose grey brown sandy GRAVEL	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike* (mbgl)
	6.10	8.00	Soft clayey SAND with clay bands	
SD70SE42	0.00	39.00	Alternating layers of CLAY and SAND	Not recorded*
	39.00	42.00	Grey MUDSTONE with coal layers	
SD80SW71	0.00	33.53	-	Not recorded
	33.53	38.10	MUDSTONE with layers of coal, seatearth and ironstone	
*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered				

Groundwater

2.4.15 The BGS susceptibility to groundwater flooding dataset classifies the south-eastern part of the site as having potential for groundwater flooding to occur either at surface level, or to property situated below ground level (BGS, 2022b). This is also the case for the lower part of the valley in North Wood, adjacent to the watercourse that flows south. The north-east of the site, however, is classified as having limited potential for groundwater flooding to occur.

2.4.16 One of the historical borehole records located in the south of the site (SD70SE530) encountered groundwater at a depth of 5.80mbgl, with standing water recorded at 4.40mbgl. Groundwater levels could therefore be at, or close to ground level, in certain parts of the site, following periods of sustained or significant recharge.

2.4.17 The presence of the springs, sinks, the “issues” and wells in the south and east of the site are also indicative of shallow groundwater emergence in these locations, along with the two wells in the north-west, and the three issues shown in and around the edges of North Wood. No licenced groundwater abstractions were identified within the site and its vicinity (Environment Agency, 2021). At the time of writing, no PWS questionnaire results were available for the site and so the presence of PWSs cannot be ruled out.

2.4.18 During a hydrogeological walkover survey in December 2021, both the springs were identified, along with a new spring located in Mid Wood in the north-east of the site. The new spring (hereafter referred to as the 'Mid Wood' spring), was observed discharging into Bradley Brook at Ox Gap. The "issue" marked in the north-east part of the site was found to be further north-east than the location shown by OS maps. A culvert outlet is also thought to be present where Bradley Brook enters the site from underneath the M60. However, this could not be accessed (and therefore verified) due to the presence of thick vegetation.

2.4.19 The sinks were found to be culvert inlets, conveying overland flows beneath the footpath into Bradley Brook. Groundwater seepages were identified along the valley sides of Bradley Brook, with flows seen to pond along the northern edge of the footpath. The ponded water drains into the watercourse via the mapped 'sinks' under the footpath. OS maps also show a marked "issue" in this location. Although the ground in this area was found to be wet underfoot, with water seen to flow into a ditch at the side of the pathway, the issue itself could not be identified due to the presence of dense vegetation.

2.4.20 No groundwater quality information from the GI data is available for this site.

Habitats and vegetation

2.4.21 The SBI designation lists the key features of Philips Park as woodland, grassland, ponds, and small lodges (GMEU, 2017). The site also includes a series of HPI, with the main habitats comprising lowland fen (Natural England, 2010).

2.4.22 The units mapped as lowland fen habitat comprise several discrete areas, dispersed across the site, and which occupy approximately one quarter of the site as a whole.

2.4.23 A Phase 1 habitat survey was carried out for Bury Metropolitan Borough Council in 2001, for the HPI unit situated in the east of the site. The HPI unit was classified as having an F1 vegetation type (Bury Metropolitan Borough Council, 2001). F1 vegetation is described as swamp vegetation (Joint Nature Conservation Committee (JNCC), 2010). That is, tall emergent vegetation, typical of the transition between open water and exposed land.

2.4.24 A UKHab survey was subsequently undertaken for the eastern part of the site. Most of the surveyed area was classified as a lowland mixed deciduous woodland habitat type (see Table 2.10). Lesser areas of modified grassland and other neutral grassland habitats were identified in the north, with a thin strip of other broadleaved woodland habitat situated along the northern site boundary, and a small area of dense shrub vegetation in the north-east.

2.4.25 During the hydrogeological walkover survey, small 'marshy' areas with rushes were identified surrounding a marked "issue" (as shown on OS maps) in the north-east of the site.

Table 2.10 UKHab survey data for Philips Park LNR and SBI

UKHab Classification	Description	Relation to Site (Location)	Survey Notes	Potential for GWDTE
w1f	Lowland mixed deciduous woodland	Large expanse within the east of the site	Woodland (beech, silver birch, etc.) with ground layer (lesser celandine, wood anemone, remote sedge etc.)	No
g4	Modified grassland	Small area in north of site	Grassland	No
g3c	Other neutral grassland	Small area in north of site	Grazing field holding slightly higher diversity than g4	No
w1g	Other woodland; broadleaved	Thin strip along northern site boundary	Highway soffit estate screening woodland	No
h3	Dense scrub	Small area in north-east of site	Scrub regeneration area under power line	No

Conceptual site model

2.4.26 Plate 2.3 shows a conceptualised cross-section running north to south through the east of the site.

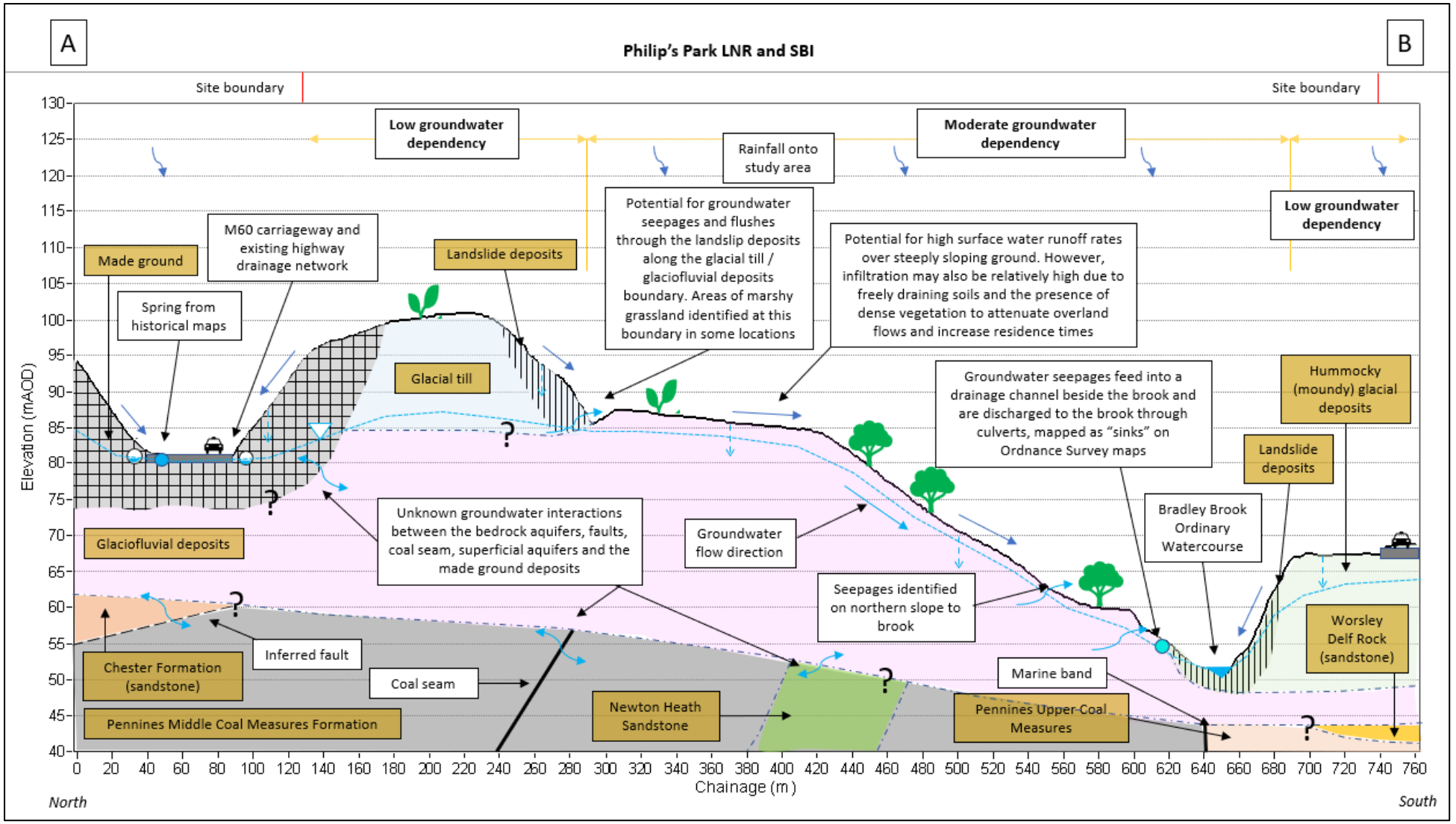
2.4.27 GWDTE could be present at the site and would most likely be in the areas of fen, swamp, and flushes described above. These habitats are shown to be dispersed across the site, with the largest expanses located in the far west, and in the south and east of the site. More than half of the area located to the north of the existing M60 carriageway is also classified as lowland fen habitat.

2.4.28 The identified hydrological features in the southern half of the site, and its eastern and western edges, confirms the presence of shallow groundwater levels in these locations, as does the number of issuing watercourses in North Wood and the correlation with the mapped areas of highest groundwater flooding susceptibility. For these reasons, most of the site is classified as having a **moderate groundwater dependency**.

2.4.29 Towards the centre of Philips Park, and in the north-east of the site (in its southern part), localised areas of high ground are expected to have deeper groundwater levels. Recharge rates through the glacial till in these areas are likely to be lower than in other parts of the site. Groundwater stored within the glaciofluvial deposits may be confined by the overlying till in these locations, although this is not certain. With the limited hydrological catchment areas and steep slopes present in the centre and north-east of the site (southern part), likely limiting recharge potential, a **low groundwater dependency** classification has been initially attributed to these areas. This is consistent with the absence of springs and associated hydrological features in these locations.

2.4.30 Given the presence of the LNR and SBI designations, according to Table 13.15 of Chapter 13: Road Drainage and the Water Environment (TR010064/APP/6.1), the value of the GWDTE is medium to high.

Plate 2.3 Conceptual site model for Philips Park LNR and SBI



Assessment of effects

2.4.31 The Order Limits are located 200m north-east of the site at their closest point and on the opposite side of the existing M60 J17.

Construction

2.4.32 The site lies outside of the estimated dewatering zones of influence for the nearest cutting, Pond and drainage connections. No dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted (see Table 2.11).

2.4.33 Given that the Order Limits are located 200m north-east of the site, and the likely groundwater flow directions in the area, no impacts to groundwater flows and levels because of ground disturbance (associated with ground compaction, soil stripping and vegetation clearance etc. within the Order Limits) are predicted at the site. Similarly, no impacts are predicted to the GWDTE from the construction of the cuttings, embankments, bridges, gantries, or drainage assets given their distance from the site.

2.4.34 No impacts to existing groundwater quality are also predicted to the site during the construction of the Scheme.

Operation

2.4.35 There are no permanent below ground structures or embankments within the vicinity of the site to locally alter groundwater levels and flows supporting GWDTE. No operational impacts to groundwater flows and levels at the site are therefore predicted.

2.4.36 Considering the distance of the Scheme from the GWDTE, and likely groundwater flow directions in the area, no impacts on groundwater quality are expected to the site during the operation phase.

Summary

2.4.37 A summary of the effects to the site is provided in Table 2.11.

Table 2.11 Summary of effects to Philips Park LNR and SBI

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect
Low to moderate	LNR / SBI	Medium to high	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	No impact	N/A
			Mobilisation of suspended solids (groundwater quality)	Construction	No impact	N/A
			Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	No impact	N/A
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	No impact	N/A
			Cutting dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
			Pond dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
			Drainage connection dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
			Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	No impact	N/A
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	No impact	N/A
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	No impact	N/A

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	No impact	N/A
			Intercept contaminated groundwater in long-term, or mixing of different groundwater chemistries (groundwater quality)	Operation	No impact	N/A

2.5 Cowl Gate Farm

Site setting, topography and hydrological catchment

2.5.1 The site lies adjacent to, and northwest of the M60 J18, with the M66 to the east and the M60 (and its slip road) to the south. The western site boundary backs on to the rear end of residential properties located off Marston Close and Rothay Close. To the north, Mode Hill Lane and Pole Lane form the northern site boundary, with Cowl Gate Farm situated immediately north-east of the site.

2.5.2 OS maps show a small pond in the north-east of the site. No other hydrological features are shown on OS maps or historical maps. A hydrogeological walkover survey was undertaken at the site in December 2021, which confirmed the presence of the pond, and identified wet ground conditions elsewhere throughout the site, including patches of standing water in localised topographic lows.

2.5.3 The elevation at the site ranges from 101mAOD in the southeast, to 93mAOD in the centre and southwest. The hydrological catchment for the site extends approximately 350m south to Simister Lane and reaches an elevation of 108mAOD. The M60 embankment and associated drainage infrastructure likely limits a proportion of the natural hydrological inputs to the site from the south.

Soils and geology

2.5.4 There is one historical borehole record located in the south of the site (SD80NW255). In addition, the GI data provides geological information for 19 boreholes drilled within the site. Relevant information extracted from all borehole records is provided in Table 2.12. Their locations are shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report.

2.5.5 Soils at the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023).

2.5.6 Made ground associated with the existing M60 and M66 carriageways is present in the far south of the site, and adjoining the site to the east (BGS, 2023). Made ground was encountered in six out of the 19 boreholes within the site. Depths ranged from 0.15mbgl along the eastern site boundary (WS-N14), to 8mbgl in the south (BH-N03). The made ground is heterogenous and varies from sandy gravelly clays with silt/sand and gravel layers at its base, to silty, gravelly sands overlying clay, to gravel layers with a sand matrix.

2.5.7 The superficial geology at the site is mapped as glaciofluvial sands and gravels in the north and east, with glaciolacustrine deposits (clays and silts) covering the northern, central and western parts of the site (BGS, 2023). Glacial till is expected to be present throughout the entire site footprint and is shown at surface level on geological maps in the south and east.

2.5.8 Superficial deposits were encountered in 16 out of 20 of the boreholes (refer to Table 2.12). The base of the superficial deposits was not proven in any of these locations but was recorded to depths of greater than 2.4mbgl and 30mbgl. The lithology of the superficial deposits comprised predominantly alternating sand, clay, silt, and gravel layers and interbeds (i.e., the deposits are embedded among or between others and are discontinuous).

2.5.9 Peat was encountered in WS-N13, WS-P12B and BHNO03A, to depths of 6.35mbgl, 8mbgl and 7.2mbgl, respectively, in the south and central part of the site. The peat was described as silty, sandy, amorphous, and fibrous peat (WS-N13), as well as spongy and plastic (WS-P12B), and amorphous with wood fragments (BHNO03A). A review and interpretation of soil survey results (see Appendix 9.2: Agricultural Land Classification Survey Report of the Environmental Statement Appendices (TR010064/APP/6.3)) has been undertaken, concluded that Cowl Gate Farm is one of three GWDTE sites where peat/peaty soils were identified. It is indicated that isolated pockets of thin peat and remnant buried peat layers occur but are not continuous across the site.

2.5.10 Moving from north to south, the bedrock comprises the Pennine Middle Coal Measures Formation comprising mudstone, siltstone, and sandstone; the Chester Formation in the centre and far south of the site comprising sandstone; and the Manchester Marls Formation comprising mudstone in the south (BGS, 2023). Two northwest-southeast trending faults cut across the bedrock in the north and south of the site, separating the three formations.

Table 2.12 Borehole records for Cowl Gate Farm

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
BH-G08B	0	0.4	Sandy CLAY with frequent rootlets (TOPSOIL)	Not recorded*
	0.4	16.9	Slightly sandy, very silty, slightly organic CLAY, overlying slightly sandy, slightly gravelly CLAY with infrequent black flecks of carbonaceous material, clayey, very silty, fine to medium SAND, gravelly, slightly clayey, silty, fine to coarse SAND, very gravelly, silty, clayey, fine to coarse SAND, slightly silty, fine to coarse SAND and fine to coarse GRAVEL including sandstone, mudstone and mixed metamorphic lithologies, very gravelly, medium and coarse SAND with high cobble content, slightly sandy, slightly gravelly CLAY, very sandy GRAVEL including sandstone, mudstone and mixed metamorphic lithologies	
BH-N04	0	30	Gravelly, clayey, very silty, fine to coarse SAND, overlying very sandy, slightly clayey, slightly silty GRAVEL, very sandy, slightly clayey, silty GRAVEL, slightly gravelly, slightly silty, fine to coarse SAND, slightly sandy, silty CLAY, slightly gravelly, sandy, silty CLAY, slightly gravelly, slightly silty, fine to coarse SAND and slightly gravelly, slightly sandy, silty CLAY	Strikes at 11 and 19.3, the latter of which rose to 17.2 after 20 minutes
WS-P02	0	0.4	Grass over slightly sandy SILT with abundant rootlets (TOPSOIL)	Strike at 1
	0.4	3	Silty, fine to coarse SAND, overlying gravelly, slightly clayey, silty, fine to coarse SAND	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
WS-P03A	0	0.5	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	Seepage at 1.4
	0.5	6.45	Slightly sandy CLAY, overlying very silty, fine to coarse SAND with occasional pockets of clayey, fine to coarse sand, slightly sandy, slightly clayey SILT, gravelly, clayey, very silty, fine to coarse SAND, and very silty, fine and medium SAND with occasional very sandy clay pockets	
WS-N03	0	0.15	Grass over silty, fine to coarse SAND with rootlets (TOPSOIL)	Not recorded
	0.15	6.45	Slightly gravelly, silty, fine to coarse SAND, overlying slightly gravelly, clayey, silty, fine to coarse SAND with occasional pockets of soft clay	
WS-P05	0	0.4	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	Not recorded
	0.4	6	Silty, fine and medium SAND, overlying sandy CLAY, slightly sandy, very silty CLAY, very clayey, very silty, fine to coarse SAND, slightly sandy CLAY and fine to coarse SAND	
WS-P12A	0	0.6	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	Strike at 0.25. Hole terminated at 0.60m due to water seepage
WS-G08A	0	7.8	Slightly sandy, gravelly, slightly silty CLAY with angular to rounded, fine to coarse gravel of brick, slate, sandstone etc., overlying slightly gravelly, slightly sandy, very silty CLAY, slightly sandy, very silty CLAY with black, organic streaks, very soft CLAY, slightly clayey, fine to coarse SAND, and sandy, very clayey GRAVEL (MADE GROUND)	Strike at 5.50
	7.8	9.38	CLAY, overlying sandy CLAY and fine to coarse SAND	
WS-N13	0	1.4	Sandy, gravelly CLAY with roots and angular to subrounded, fine to coarse gravel of limestone, sandstone, siltstone, mudstone and brick, overlying slightly gravelly, sandy, slightly clayey SILT with sand lenses (MADE GROUND)	Not recorded

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	1.4	6.45	Slightly silty, slightly sandy, amorphous PEAT, overlying slightly silty, fibrous PEAT, and slightly clayey, silty, fine to coarse SAND	
WS-N02B	0	5.88	Grass over very gravelly, clayey, silty, fine to coarse SAND, with abundant rootlets and wood fragments, overlying gravelly, clayey, silty, fine to coarse SAND, slightly gravelly, slightly silty, fine to coarse SAND, and slightly gravelly, sandy, slightly silty CLAY with coal fragments (MADE GROUND)	Strike at 1.2, rose to 0.65 after 20 minutes
WS-P02A	0	0.5	Grass over slightly sandy CLAY with abundant rootlets (TOPSOIL)	Strike at 1.2
	0.5	6.45	Silty, fine to coarse SAND, overlying slightly gravelly, fine to coarse SAND with gravel including coal, thinly bedded, slightly clayey, fine to coarse SAND, fine to coarse SAND with occasional pockets (5-15mm) of slightly gravelly sand, and slightly silty, clayey, fine to coarse SAND	
BH-N03	0	8	Grass over slightly silty, slightly gravelly, fine to coarse SAND with roots and gravel of sandstone, siltstone, mudstone, brick, and limestone, overlying gravelly, clayey, very silty, fine to coarse SAND, slightly gravelly, sandy, silty CLAY with occasional silt laminations, slightly gravelly, sandy, slightly silty CLAY with bands of fine to coarse sand, and slightly gravelly, slightly sandy, slightly silty CLAY (MADE GROUND)	Strike at 8, rose to 7.3 after 20 minutes
	8	9	VOID. No returns	
WS-P04	0	0.3	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	No groundwater strikes recorded
	0.3	6.45	Slightly sandy, silty CLAY, overlying sandy CLAY with occasional pockets of fine and medium sand, slightly sandy, very silty CLAY, firm CLAY / SILT, very silty, fine to coarse SAND with rare pockets of black organic material and fine to coarse slightly gravelly sand, slightly sandy CLAY, and clayey, very silty, fine and medium SAND	
WS-N14	0	0.15	Slightly gravelly, slightly silty, fine to coarse SAND with rootlets and gravel of sandstone, siltstone, pottery and quartz (MADE GROUND)	Not recorded

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	0.15	6.45	Slightly gravelly, slightly silty, fine to coarse SAND, overlying slightly gravelly, fine to coarse SAND and slightly gravelly, silty, fine to coarse SAND	
WS-P12B	0	0.6	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	Strikes at 0.6 and 6.4
	0.6	8	Spongy, fibrous PEAT, overlying spongy, pseudo-fibrous PEAT, slightly sandy CLAY, spongy, slightly clayey, pseudo-fibrous PEAT, slightly sandy CLAY, plastic, clayey PEAT, and slightly sandy, silty CLAY with thin beds of fine and medium sand	
WS-P03	0	0.6	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	Not recorded
	0.6	4.43	Slightly sandy SILT, overlying slightly sandy CLAY, fine to coarse SAND, slightly sandy, very silty CLAY and fine to coarse SAND	
BH-N02A	0	0.4	Grass over slightly sandy, organic CLAY (TOPSOIL)	Not recorded
	0.4	18.5	Slightly sandy CLAY, overlying slightly sandy, silty CLAY with weak laminations, fine and medium SAND, sandy, slightly SILT/CLAY with thin, sandy clay bands, fine and medium SAND, gravelly, clayey, silty, fine to coarse SAND, sandy GRAVEL, gravelly, silty, fine to coarse SAND, slightly sandy SILT, gravelly, medium and coarse SAND, and very sandy GRAVEL	
WS-P12	0	0.6	Grass over slightly sandy CLAY with frequent rootlets (TOPSOIL)	Strike at 0.25. Hole terminated at 0.60m due to water seepage
BHNO03A	0	3.10	Topsoil comprising slightly sandy clay with moderate rootlets, underlain by sandy, slightly gravelly clay with gravel of sandstone, coal and brick (MADE GROUND)	Not recorded
	3.10	5.50	Sandy slightly gravelly CLAY, gravel is sandstone and coal.	
	5.50	7.20	Amorphous PEAT with wood fragments	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	7.20	8.10	Very organic sandy CLAY with fragments of wood	
	8.20	9.20	Slightly sandy GRAVEL with cobbles.	
SD80NW255	0	0.2	Gravelly sandy silty CLAY (topsoil)	Damp from 1.95
	0.2	1.05	Fine to coarse sub-angular GRAVEL, cobbles and occasional boulders with silty clayey fine to coarse sand matrix (made ground)	
	1.05	1.3	Sandy sub-angular fine to coarse GRAVEL. Occasional pockets of sandy clay (made ground)	
	1.3	2.4	Silty fine to medium and occasionally coarse sand with clay pockets (MADE GROUND?)	
*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered				

Groundwater

2.5.11 Groundwater level monitoring information for the site is provide in Table 2.13. Groundwater level monitoring data were collected between January 2022 and May 2023. Three boreholes (WS-N13, WS-N02B, and WS-P12B), all located in the south of the site, recorded a piezometric head of less than 1mbgl. One of these locations (WS-N02B) was found to be artesian (up to 0.23m above ground level) on all monitoring visits undertaken. Elsewhere within the south and east of the site, the highest groundwater levels recorded ranged from 0.10mbgl to 9.52mbgl.

2.5.12 The artesian borehole (WS-N02B) was terminated at 5.88mbgl (in the Made Ground) and is screened within the upper sand dominated beds of the Made Ground deposits, with no overlying clay beds, and a 1.88m thick (at least) clay layer below. The source of the artesian groundwater is therefore not caused by the confinement of the sand bearing strata within the Made Ground. Alternatively, it is possible that this could be the location of a spring. It is also possible that the artesian conditions are caused by groundwater upwelling along the geological boundary between the Manchester Marls and Chester Formations which directly underlies the borehole's location.

2.5.13 The BGS susceptibility to groundwater flooding dataset classifies the entire site as having potential for groundwater flooding to occur at surface level, or to property situated below ground level (BGS, 2021b). A small, raised area in the southeast is classified as having limited potential for groundwater flooding to occur. It should be noted that while no data are shown in the southwest part of the site, the BGS susceptibility to groundwater flooding dataset does not provide coverage for areas underlain by peat, which is present to the west of the site. Inferred groundwater levels from the site's groundwater flooding susceptibility are therefore not available in this location.

2.5.14 During the hydrogeological walkover survey undertaken at the site in December 2021, no groundwater features were identified. However small areas towards the centre of the site, especially in small topographical lows were found to be very wet underfoot, including around the pond margins to the east. There was one area, in the centre of the site towards the north, which was slightly raised from the surrounding land and was very wet underfoot. Overall, the eastern part of the site was found to be marginally wetter than the west.

2.5.15 There are no springs, sinks, sources, issues, collects, or spreads within the site boundary, as shown on OS maps and historical maps. However, the above suggests that in some parts of the site, groundwater levels could be close to the ground surface following periods of sustained or significant recharge.

2.5.16 No licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). PWS questionnaire results received in February 2022 indicated that there is a well associated with Cowl Gate Farm. However, the landowner had yet to locate and use this supply. OS maps show a well located 65m north of the GWDTE, which could be the Cowl Gate Farm PWS (albeit currently unused).

Table 2.13 Groundwater level monitoring information for Cowl Gate Farm

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min. Depth (mbgl)	Max Depth (mbgl)
BH-G08B	12.5 to 16.5	Clay, sand and gravel (superficial deposits)	14/01/2022 – 02/05/2023	16	6.92	7.35
BH-N04 (1)*	10 to 13	Sand, gravel and clay (superficial deposits)	14/01/2022 – 06/04/2022	11	7.92	8.84
BH-N04 (2)*	22 to 22.5	Sand, gravel and clay (superficial deposits)	14/01/2022 – 06/04/2022	4	9.52	10.41

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min. Depth (mbgl)	Max Depth (mbgl)
WS-P03A	2.5 to 3.5	Clay, sand and silt (superficial deposits)	14/01/2022 – 06/04/2022	4	2.98	3.49
WS-P05	2.5 to 4	Sand and clay (superficial deposits)	14/01/2022 – 02/05/2023	5	1.03	3.01
WS-G08A	6 to 8	Made ground / clay and sand (superficial deposits)	14/01/2022 – 06/04/2022	4	6.16	Dry
WS-N13	1.5 to 2.8	Peat and sand (superficial deposits)	14/01/2022 – 06/04/2022	13	0.10	1.06
WS-N02B	2 to 4	Made ground	14/01/2022 – 14/04/2022	11	-0.23 (Artesian)	0.00
WS-P02A	2 to 6	Sand (superficial deposits)	14/01/2022 - 02/05/2023	5	0.64	Dry
BH-N03	1 to 7	Made ground	14/01/2022 - 02/05/2023	11	5.48	6.24
WS-P04	3 to 6	Clay, silt and sand (superficial deposits)	14/01/2022 - 02/05/2023	12	2.87	4.5
WS-P12B	2 to 6	Peat and clay (superficial deposits)	14/01/2022 - 02/05/2023	11	0.53	0.96
BH-N02A (1)*	11 to 13	Clay, silt, sand and gravel (superficial deposits)	14/01/2022 - 02/05/2023	11	5.83	Dry
BH-N02A (2)*	17 to 18		14/01/2022 - 02/05/2023	5	5.46	5.79
BHN03A	8.20 to 9.20	Sandy gravel with cobbles (superficial deposits)	24/03/2023	1	6.65	6.65
*(Number) denotes where there are multiple standpipes installed within one borehole.						

2.5.17 The GI data includes groundwater quality information for eight out of 19 GI locations. EQS exceedances of various heavy metals and / or ammoniacal nitrogen as N were identified in samples collected at all eight locations (see Table 2.14). Four locations also recorded detectable concentrations of total PAHs. The source of the heavy metals and PAHs in the superficial deposits and / or made ground at these locations could be associated with the construction of M60 J18, or associated drainage, which lies adjacent to and upgradient of the GI locations (although this is not certain). The presence of ammoniacal nitrogen as N could be the result of agricultural activity at the site. Concentrations of nitrates as NO_3 have also been screened against a threshold value of 26mg/l for a healthy GWDTE (UKTAG, 2012). The highest nitrate value recorded was 1.9mg/l at BH-N03, which is below the threshold value for the wet grassland habitat type present.

Table 2.14 Groundwater quality information for Cowl Gate Farm

GI Location	Sample depth	Sample date	EQS exceedances
BH-G08B	12.5	01/02/2022	Ammoniacal Nitrogen as N, iron, manganese, nickel, zinc
BH-N04*	10.5	01/02/2022	Chloride, iron, manganese, nickel
WS-N13	2	01/02/2022	Ammoniacal Nitrogen as N, aluminium, iron, manganese, nickel
WS-N02B*	2.5	01/02/2022	Chloride, ammoniacal Nitrogen as N, iron, manganese, nickel
BH-N03	6.5	01/02/2022	Copper
WS-P04	4.5	01/02/2022	Ammoniacal Nitrogen as N, iron, manganese, nickel
WS-P12B*	3	01/02/2022	Ammoniacal Nitrogen as N, aluminium, iron, manganese, nickel
BH-N02A*	11.5	01/02/2022	Iron, manganese, nickel
*Denotes where there are detectable concentrations of total PAHs			

Habitats and vegetation

2.5.18 A UKHab survey was undertaken for Cowl Gate Farm. The site was classified as a neutral grassland habitat type, with scattered scrub and trees for the most part, and scrub and ruderal vegetation in a small area to the southwest (see Table 2.15). The UKHab survey notes recorded the presence of soft rush throughout the site, which could be indicative of wet ground conditions and the presence of GWDTE. During the hydrogeological walkover survey boggy ground conditions were noted in the areas dominated by rushes.

Table 2.15 UKHab survey data for Cowl Gate Farm

UKHab Classification	Description	Relation to Site (Location)	Survey Notes	Potential for GWDTE
g3c10,11	Other neutral grassland, with scattered scrub and trees	Within most of site	Horse grazed field comprising grassland with soft rush	Yes (due to presence of rush)
g3c10,17	Other neutral grassland with scattered scrub and ruderal vegetation	Small area in southwest of site	Slope towards motorway has greater diversity, with orchids and soft rush	Yes (due to presence of orchids and rush)

2.5.19 There are no ecological designations present within the site.

Conceptual site model

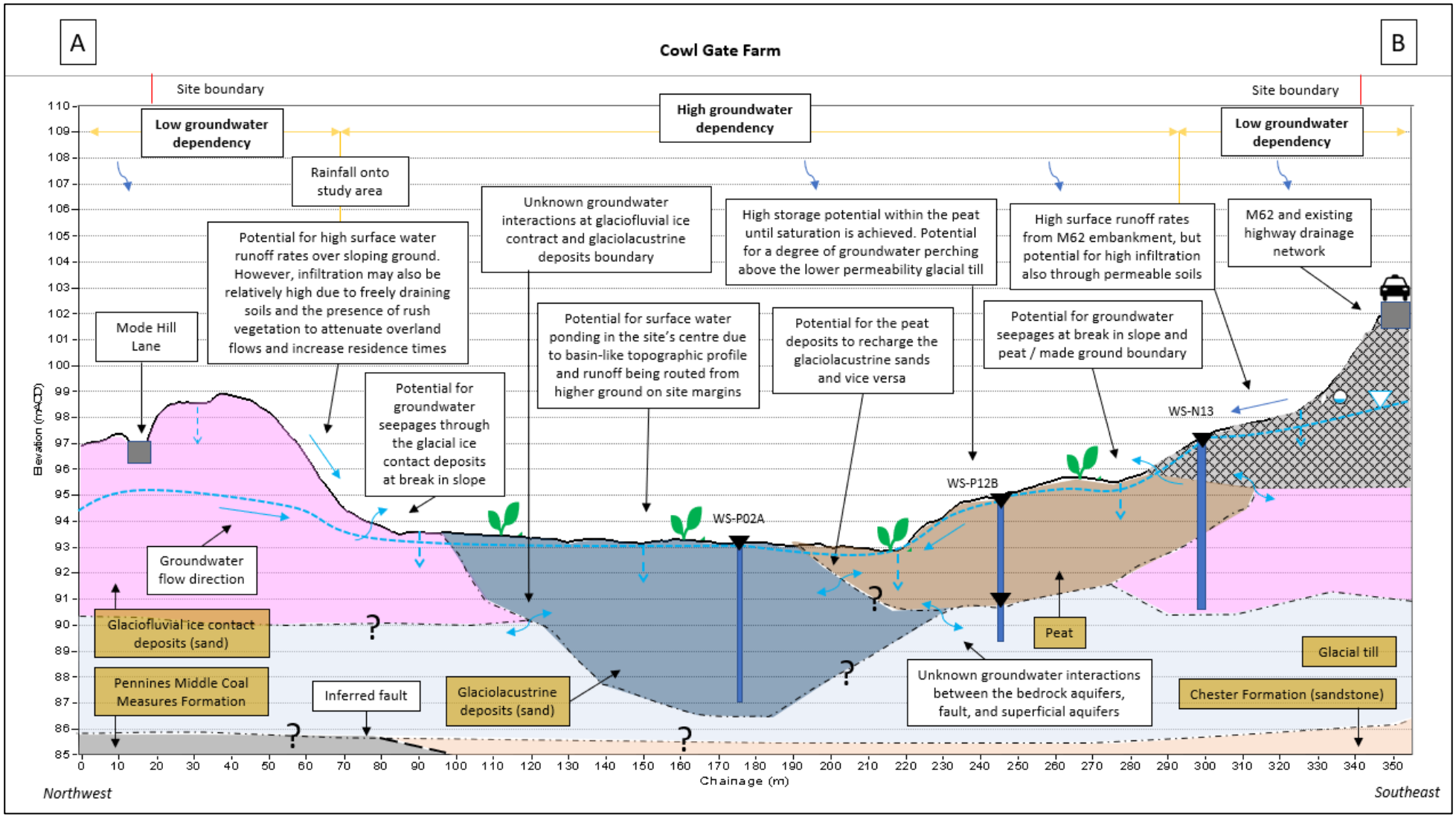
2.5.20 Plate 2.4 shows a conceptualised cross-section running northwest to southeast through the centre of the site.

2.5.21 Shallow groundwater stored within the various superficial deposits is generally expected to follow the topography and flow towards the centre of the site. That is, from the higher ground present along the site's margins and surrounding areas. This is consistent with monitored groundwater levels, which were found to be shallow (less than 1mbgl) within the centre, south, and southwest of the site, and suggest a degree of groundwater accumulation in these areas. Artesian groundwater was also encountered in the southwest, just 20m north of the existing M60 carriageway. This could be indicative of an unmarked spring, and / or groundwater upwelling from the deeper bedrock aquifers at the geological boundary between the Manchester Marls (mudstone) and Chester (sandstone) formations. Considering this, along with the potential for groundwater flooding to occur at surface level, and the wet and boggy ground conditions encountered during the hydrogeological walkover survey, most of the site, (including its centre, and parts of the north, south, east, west, and south-west), is classified as having a **high groundwater dependency.**

2.5.22 Locally, the steeper topography along the edges of the site likely promotes higher surface water runoff rates and limited infiltration and recharge potential to the Made Ground deposits and underlying superficial aquifers in these locations. This is consistent with the deeper monitored groundwater levels and generally drier ground conditions encountered in these parts of the site during the hydrogeological walkover survey. As a result, the margins of the site, situated on higher ground, in the north, east, southeast, and southwest are classified as having a **low groundwater dependency**.

2.5.23 Given that the site has no ecological designation, the value of the GWDTE is medium to low.

Plate 2.4 Conceptual site model for Cowl Gate Farm



Assessment of effects

2.5.24 The Order Limits for the Scheme cover the entire site, with both temporary working areas and assets, and permanent infrastructure located within the site boundary (see Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report).

Construction

2.5.25 The site lies outside of the estimated dewatering zone of influence for the nearest cutting. Therefore, no cutting-related dewatering impacts on groundwater flows, levels or quality at the site are predicted. However, Pond 7 and its associated new drainage connections are in the southwest of the site. The 25m estimated dewatering zones of influence for these assets extend into in an area classified as having a high groundwater dependency. Given the direct nature of the impacts expected, a localised major magnitude change in groundwater levels is anticipated in the southwest of the site, which would result in a **large adverse** or **moderate adverse** significance of effect (depending on the groundwater dependency of different parts of the site).

2.5.26 Ground disturbance (associated with ground compaction, soil stripping, vegetation clearance, and construction of haul roads, compounds, and temporary works areas) would occur across the entire site. Given the direct nature of the impacts expected, a major magnitude change in groundwater levels is anticipated throughout the GWDTE, which would result in a **large adverse** or **moderate adverse** significance of effect (depending on the groundwater dependency). In addition, localised, direct and therefore major magnitude impacts are predicted in the far southeast of the site from the construction of the Simister Pike Fold Viaduct due to its associated piling requirements. In the south of the site, this would result in a **moderate adverse** significance of effect. Potential moderate magnitude impacts on groundwater flows and levels could propagate downgradient into the centre of the site in an area of high groundwater dependency, resulting in a **moderate adverse** significance of effect. It should also be noted that soil stripping and vegetation clearance would lead to a complete loss of GWDTE habitat. This is assessed separately in Chapter 8: Biodiversity of the Environmental Statement (TR010064/APP/6.1).

2.5.27 Ground disturbance due to the above-mentioned activities could also impact on groundwater quality, due to the mobilisation of suspended solids and/or accidental spills and leaks of fuels and chemicals. Implementation of the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5) would significantly reduce the likelihood of an incident occurring. However, given the consequence of such an event, the risk remains high, and contaminants could directly enter shallow groundwater from the works area resulting in a moderate magnitude impact on groundwater quality across the site, leading to a **moderate adverse** significance of effect. In addition, the bored piles required in the far southeast of the site for the Pike Fold Viaduct could create new vertical contaminant pathways between aquifers. Even where groundwater is not contaminated, there is potential for mixing of different groundwater chemistries. Direct (localised) and therefore major magnitude impacts are predicted in the southeast of the site, resulting in a **moderate adverse** significance of effect. Potential localised moderate magnitude impacts on groundwater flows and levels could propagate downgradient into the centre of the site, resulting in a **moderate adverse** significance of effect (high groundwater dependency area).

Operation

2.5.28 The presence of below ground structures in the southern half of the site (such as the Pond, drainage connections, and bored piles associated with the Pike Fold Viaduct), could permanently alter local groundwater levels and flows in the superficial and potentially bedrock aquifer(s). Direct, localised moderate changes to groundwater levels and flows could occur within the south of the site, which would result in a **moderate adverse** or **slight adverse** significance of effect (depending on the groundwater dependency of different parts of the site).

2.5.29 The backfilling of trench excavations required for the permanent drainage network has the potential to result in localised changes in groundwater levels. This could either be due to backfilled material acting as a permanent barrier to groundwater flow or forming a preferential pathway for groundwater flow. Although this represents a direct impact in the south of the site, major changes in groundwater levels and flows are unlikely. Moderate impacts in groundwater levels and flows in this part of the site are therefore predicted, resulting in a **moderate adverse** or **slight adverse** significance of effect (depending on the groundwater dependency).

2.5.30 There is potential for local groundwater recharge rates to be permanently disrupted from the increased interception of overland flows. This could be due to an increase in impermeable surface areas, permanent highway drainage, reprofiled ground etc. However, the relative contribution of direct rainfall in recharging the superficial aquifers is likely to be partially limited compared to the recharge rates and volumes provided by surface water and groundwater inputs from the wider hydrological catchment. As a result, minor magnitude impacts are expected to recharge rates sustaining the GWDTE, and effects with a potential **slight adverse** or **neutral** significance of effect (depending on the groundwater dependency).

2.5.31 Considering the Scheme lies within the south of the GWDTE, and the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), impacts on groundwater quality in this part of the site from accidental leaks / spills of fuels and chemicals (i.e. due to road collisions) and/or routine runoff associated with the new highway could lead to minor magnitude impacts. This would result in a potential **slight adverse** or **neutral** significance of effect in the south of the site (depending on the groundwater dependency).

Summary

2.5.32 A summary of the effects to the site is provided in Table 2.16.

Table 2.16 Summary of effects to Cowl Gate Farm

Groundwater Dependency	Ecological Designation	Value	Potential Impacts	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
High	None	Medium	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Moderate	**Moderate adverse**
Low		Low				Slight adverse
High		Medium	Mobilisation of suspended solids (groundwater quality)	Construction	Moderate	**Moderate adverse**
Low		Low				Slight adverse
High		Medium	Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	Moderate	**Moderate adverse**
Low		Low			Major	**Moderate adverse**
High		Medium	Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	Major	**Large adverse**

Groundwater Dependency	Ecological Designation	Value	Potential Impacts	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Low		Low				**Moderate adverse**
High to low		Medium to low	Cutting dewatering (groundwater levels / flows / quality)	Construction	No impact	N/A
High		Medium	Pond dewatering (groundwater levels / flows / quality)	Construction	Major	**Large adverse**
Low		Low				**Moderate adverse**
High		Medium	Drainage connection dewatering (groundwater levels / flows / quality)	Construction	Major	**Large adverse**
Low		Low				**Moderate adverse**
High		Medium	Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	Minor	Slight adverse
Low		Low				Neutral
High		Medium	Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	Minor	Slight adverse
Low		Low				Neutral
High to low		Medium to low	Ground settlement in superficial deposits (groundwater levels / flows)	Operation	Negligible	Neutral

Groundwater Dependency	Ecological Designation	Value	Potential Impacts	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
High		Medium	Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	Moderate	**Moderate adverse**
Low		Low				Slight adverse

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

2.6 The Hills South

Site setting, topography and hydrological catchment

2.6.1 The site comprises a pond and margins, located within Pike Fold Golf Course, and 50m to the east of the M66 southbound embankment.

2.6.2 No inflows or outflows are shown on OS maps connected to the pond. However, a hydrogeological walkover survey was undertaken at the site in December 2021, which identified two outfalls discharging into the western edge of the pond, and an outflow flowing underground to the east. The pond is assumed to have been constructed to provide drainage for the surrounding golf course.

2.6.3 The land surrounding the pond is relatively flat, with elevations ranging from 91mAOD to 92mAOD. The pond itself lies at 91mAOD, with the pond margins observed during the hydrogeological walkover survey to slope steeply downwards from all sides.

2.6.4 The main contributing hydrological catchments for the site extend 160m north and west, with the highest peaking at an elevation of 104mAOD in the north (The Hills). The M66 embankment to the west of the pond may limit a proportion of the natural hydrological inputs to the site from the west.

Soils and geology

2.6.5 The GI data provides geological information for two boreholes drilled 45m west of the site. Relevant information from the two GI borehole records is summarised in Table 2.17. Their locations are shown in Figure 13.5.1: Groundwater Dependant Terrestrial Habitats in Annex A of this report.

2.6.6 Soils at the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023).

2.6.7 Geological maps show that the site is located within a large area of made ground, associated with Pike Fold Golf Club. Made ground was encountered in borehole WS-N08, to a depth of 0.8mbgl, and comprised layers of silty sand with occasional gravel-size coal fragments (refer to Table 2.17).

2.6.8 The superficial geology at the site comprises peat deposits overlying glacial till (BGS, 2023). The mapped extent of the peat is shown to finish within the southern part of the site, just north of the southern site boundary. The two GI boreholes (located 45m west of the site), lie outside of the area of peat shown on BGS mapping and recorded layers of gravelly silty sand to depths of more than 5.45mbgl (WS-N07) and 6.45mbgl (WS-N08).

2.6.9 Bedrock at the site comprises the Pennine Middle Coal Measures Formation which consists of mudstone, siltstone, and sandstone (BGS, 2023). Bedrock was not proven in either of the two GI boreholes.

Table 2.17 Borehole records for The Hills South

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
WS-N07	0	0.35	Slightly gravelly, slightly clayey, fine to coarse SAND with low cobble content and abundant roots (up to 22mm diameter) (TOPSOIL)	Strike at 4.1, rose to 3.5 after 20 minutes
	0.35	5.45	Slightly gravelly, slightly clayey, fine to coarse SAND, overlying gravelly, silty, fine to coarse SAND, slightly clayey, silty, fine to coarse SAND with occasional fine to medium gravel size coal fragments	
WS-N08	0	0.8	Slightly silty to silty, partially organic, fine and medium SAND with frequent rootlets, overlying fine and medium grained SAND with traces of rootlets (MADE GROUND)	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	0.8	6.45	Slightly clayey, silty, fine to coarse SAND, overlying slightly gravelly, slightly clayey, fine SAND with occasional fine to coarse sand size coal pieces, slightly gravelly, slightly sandy SILT, slightly clayey, silty, fine and medium SAND with rare subangular to subrounded, fine and medium gravel, slightly gravelly, and slightly clayey, silty, fine to coarse SAND	Seepage at 3 and a strike at 5, which fell to 6 after 20 minutes

Groundwater

2.6.10 Groundwater level monitoring information for the site is provide in Table 2.18. Twelve groundwater level readings were taken at WS-N07, between January 2022 and May 2023. Groundwater levels in this location ranged from 1.91mbgl to 2.79mbgl. Although no groundwater monitoring was undertaken in WS-N08, a seepage, followed by a strike, was recorded at the time of drilling, at depths of 3mbgl and 5mbgl, respectively (refer to Table 2.17).

2.6.11 The BGS susceptibility to groundwater flooding dataset classifies most of the site as having potential for groundwater flooding to occur at surface level, with potential for flooding of properties situated below ground level in a small area in the north (BGS, 2021).

2.6.12 During the hydrogeological walkover survey undertaken at the site in December 2021, groundwater features were not identified. However, the margins of the pond were found to be wet and boggy, particularly in the area surrounding the outfalls along the pond's western edge. Slightly higher up the pond sides, drier conditions prevailed.

2.6.13 There are no springs, sinks, sources, issues, collects, or spreads within the site boundary, as shown on OS maps and historical maps. However, given the wet, boggy ground conditions encountered on site, the high potential for groundwater flooding as indicated by BGS data, and the absence of site-specific groundwater level data from GI boreholes, the potential for localised shallow groundwater levels surrounding the pond cannot be ruled out.

2.6.14 No licenced groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). In addition, PWS questionnaire results were available for the site, which in February 2022 confirmed that there were no PWSs within the GWDTE.

Table 2.18 Groundwater level monitoring information for The Hills South

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min Depth (mbgl)	Max Depth (mbgl)
WS-N07	2 to 4	Sand (superficial deposits)	17/01/2022 – 02/05/2023	12	1.91	2.79

2.6.15 The GI data includes groundwater quality information for one sample collected from WS-N07 on 04/02/2022 at a depth of 3.5mbgl. EQS exceedances were detected for heavy metals (aluminium, chromium as Cr^{3+}, copper and zinc). Detectable concentrations of total PAHs were also found. The source of the heavy metals and PAHs in the sandy superficial deposits at this location could be associated with the M66 construction, or its drainage, which lies adjacent to WS-N07 .

Habitats and vegetation

2.6.16 A UKHab survey was undertaken for The Hills South. The site was identified as eutrophic standing waters (the pond), surrounded by modified grassland to the south, east, and west, and other broadleaved woodland to the north. None of these habitat types alone would typically comprise a GWDTE. However, the UKHab survey notes recorded that the margins of the pond were dominated by soft rush and bull rush (see Table 2.19), indicative of wet ground conditions. As such, the presence of GWTDE cannot be ruled out in this location, and if present, would be confined to the pond margins.

Table 2.19 UKHab survey data for The Hills South

UKHab Classification	Description	Relation to Site (Location)	Survey Notes	Potential for GWDTE
r1a	Eutrophic standing waters	Within the site	Golf course pond. Margins dominated by soft rush and bull rush	Yes – terrestrial margins of pond only
g4	Modified grassland	Surrounds site to the south, east, and west	Golf course grassland	No
w1g	Other woodland; broadleaved	Adjacent to the site in the north	Golf course screening woodland plantation. No understory or ground layer. Canopy birch and cherry	No

2.6.17 There are no ecological designations present within the site.

Conceptual site model

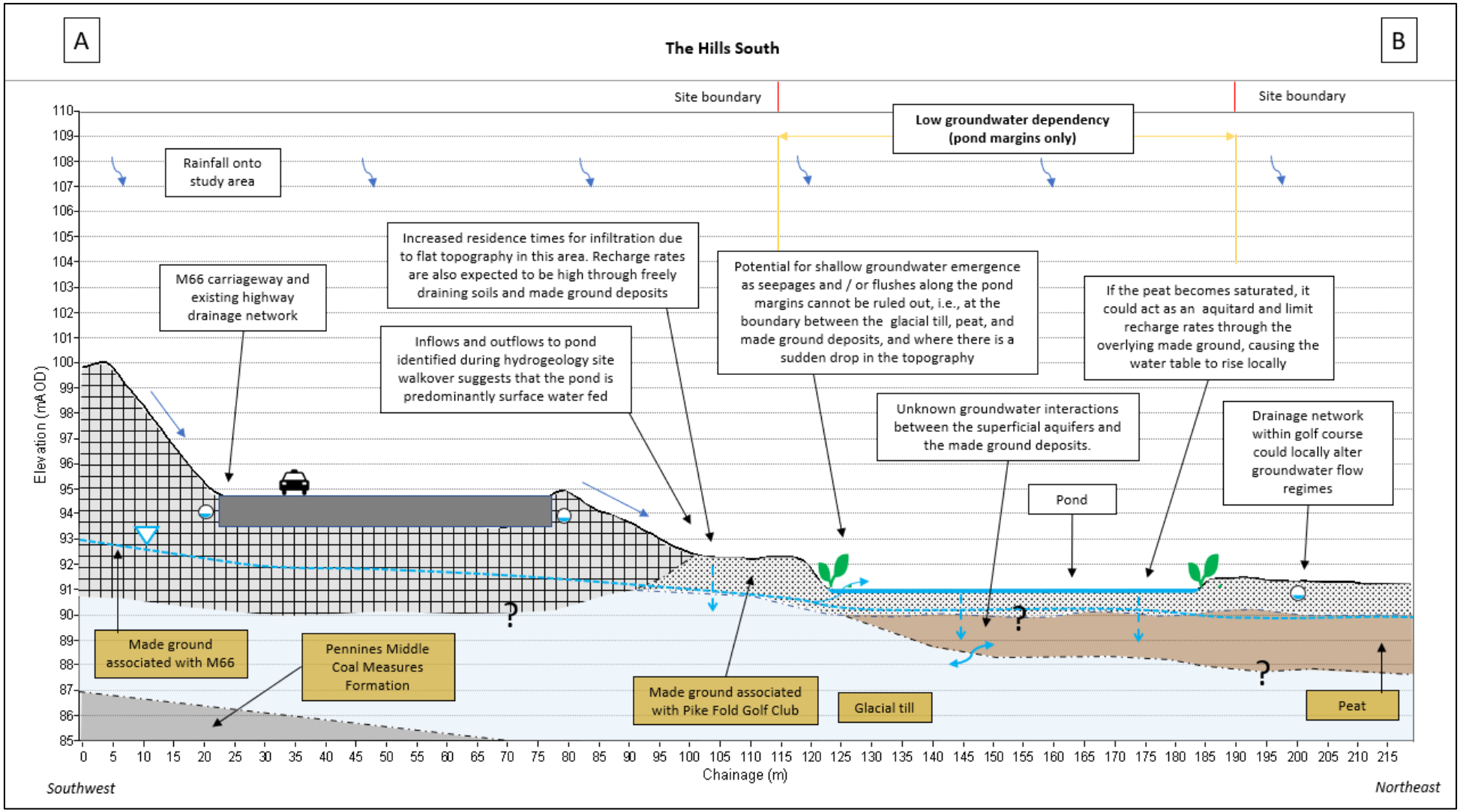
2.6.18 Plate 2.5 shows a conceptualised cross-section running southwest to north-east through the centre of the site.

2.6.19 The hydrogeological walkover survey in December 2021 confirmed the presence of a surface water drainage network (associated with the surrounding golf course) discharging into the west of the pond, and an outflow conveying flows from the pond to the east. The pond (and therefore) most of the site is assumed to be surface water fed and is **not considered to be a GWDTE**.

2.6.20 However, the pond margins are dominated by soft rush and bull rush, both indicative of wet ground conditions. Given that wet and boggy ground conditions were then identified surrounding the pond during the hydrogeological walkover survey, the marginal vegetation could constitute a GWDTE. Based on the high potential for groundwater flooding as indicated by BGS data, there is potential for shallow groundwater flows to be routed through the made ground and glacial till from the north and west, which could promote localised seepages at the break in slope immediately up-gradient of the pond's water's edge. However, it is also possible that the rush vegetation is supplied predominantly by surface water, from the adjacent drainage infrastructure, direct rainfall, and or surface water runoff. In the absence of site-specific groundwater level data from GI boreholes, the pond margins are conservatively attributed as having a **low groundwater dependency**.

2.6.21 Given that the site has no ecological designation, according to Table 13.15 in Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1), the value of the GWDTE is medium (pond margins only) to none.

Plate 2.5 Conceptual site model for The Hills South



Assessment of effects

2.6.22 The site lies 20m east, and down-gradient of the Order Limits for the Scheme.

Construction

2.6.23 The site lies outside of the estimated dewatering zones of influence for the nearest cutting, pond and drainage connections. Therefore, no dewatering impacts on groundwater flows, levels or quality at the site are predicted.

2.6.24 Ground disturbance (associated with ground compaction, soil stripping, vegetation clearance, and construction of haul roads) would occur 20m up-gradient of the site. Given the likely groundwater flow directions in the area, precautionary minor magnitude changes in groundwater levels could occur in the west of the GWDTE, which would result in a **slight adverse** significance of effect. In addition, precautionary minor magnitude impacts are predicted in the west of the site from the construction of the nearest embankment (30m to the west) due to its associated piling requirements. This would result in a **slight adverse** significance of effect in this location.

2.6.25 Ground disturbance due to the above-mentioned activities could also impact on existing groundwater quality, due to the mobilisation of suspended solids and/or accidental spills and leaks of fuels and chemicals. Considering the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), the proximity of the earthworks and groundwater flow directions in the area, precautionary minor magnitude impacts on groundwater quality are predicted in the west of the site. This would result in a **slight adverse** significance of effect. In addition, the sheet piles required to the west of the site for the embankment could create new vertical contaminant pathways, or cause mixing of different groundwater chemistries, between the made ground and superficial aquifers. However, impacts would be very localised and likely attenuated up-gradient of the site boundary, such that only negligible impacts on groundwater quality are predicted in the west of the site. This would result in a **neutral** significance of effect.

Operation

2.6.26 Considering the distance of the Scheme from the GWDTE, the existing M66 infrastructure, and likely groundwater flow directions in the area, negligible magnitude impacts in groundwater levels and flows are predicted at the site, resulting in a **neutral** significance of effect.

2.6.27 In addition, considering the distance of the Scheme from the GWDTE, best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), and the likely groundwater flow directions in the area, any accidental leaks/spills of fuels and chemicals and/or routine runoff associated with the road could lead to negligible impacts on groundwater quality across the site, resulting in a **neutral** significance of effect.

Summary

2.6.28 A summary of the effects to the site is provided in Table 2.20.

Table 2.20 Summary of effects to The Hills South

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Low	None	Low	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Minor	Slight adverse
			Mobilisation of suspended solids (groundwater quality)	Construction	Minor	Slight adverse
			Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	Negligible	Neutral
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	Minor	Slight adverse
			Cutting / widening dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Pond dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
			Drainage connection dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	No Impact	N/A
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	Negligible	Neutral
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	No Impact	N/A
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	Negligible	Neutral

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

2.7 Castle Brook South

Site setting, topography and hydrological catchment

2.7.1 The site is located approximately 100m east of the M66 embankment, immediately south of Pike Fold Golf Course, and is bordered to the south by Egypt Lane.

2.7.2 OS maps show an unnamed Ordinary Watercourse (and tributary of Castle Brook) issuing along the western site boundary. The Ordinary Watercourse flows north and then east around the edges of the site and along the site's entire northern boundary, before discharging into Castle Brook. Upgradient of the confluence, a second unnamed Ordinary Watercourse flows along the site's eastern boundary, and joins with the Castle Brook tributary, adjacent to the north-east corner of the site.

2.7.3 During a hydrogeological walkover survey undertaken at the site in December 2021, the small section of unnamed Ordinary Watercourse along the western site boundary had no flows and comprised pools of standing water. The section of the Ordinary Watercourse along the northern site boundary, did however exhibit low to moderate flows.

2.7.4 The site itself is relatively flat, with elevations ranging from 91mAOD generally across the site, to 92mAOD in the southwest corner. The total hydrological catchment for the site includes several sub-catchments, with the largest extending approximately 600m southeast to the residential area of Simister. The presence of the M62 embankment and topographic mound within the Egypt Lane South site to the southwest, likely limit a proportion of the natural hydrological inputs to the site.

Soils and geology

2.7.5 The GI data provides geological information for nine boreholes drilled within the site. Relevant information from these borehole records is summarised in Table 2.21. Their locations are shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report.

2.7.6 Soils across the site are described at freely draining slightly acid sandy soils (Cranfield University, 2023).

2.7.7 Made ground is shown to be present, surrounding the site to the north, south, and west, and potentially encroaches into the southern margins of the site (BGS, 2023). However, no GI boreholes within the site recorded made ground deposits (refer to Table 2.21).

2.7.8 The superficial geology is mapped as peat overlying glacial till (BGS, 2023). The southern boundary of the site marks the southernmost extent of the peat deposits, as shown by geological maps. However, only one GI borehole record located along the southern site boundary noted occasional pockets of fibrous peat within a sandy clay layer from 0.25mbgl to 1.20mbgl (WS-N04A, see Table 2.21). This correlates with the review of soil survey results (Jacobs, 2023), which suggests that thin, isolated ‘peaty soils’ were identified in two localised areas along the western and southern site boundaries only.

2.7.9 From the GI, a silty sand topsoil was generally encountered across the site, overlying superficial deposits to depths of between 4mbgl and 20mbgl. The full thickness of the superficial deposits was not proven, but the lithology was shown to generally comprise layers of sandy gravelly clays with sand bands in the centre of the site, and sand-dominated layers (particularly in the upper horizons) in the west.

2.7.10 Bedrock at the site is the Pennine Middle Coal Measures Formation comprised of mudstone, siltstone and sandstone (BGS, 2023).

Table 2.21 Borehole records for Castle Brook South

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
WS-N09	0	0.3	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Not recorded*
	0.3	7.45	Silty, fine and medium SAND, overlying slightly sandy CLAY, silty, fine and medium SAND, slightly clayey, silty, fine to coarse SAND, interbedded, thinly laminated CLAY with fine and medium SAND and slightly clayey, silty, fine to coarse SAND	
WS-N04	0	0.3	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Not recorded
	0.3	10.45	Slightly gravelly, sandy, slightly clayey SILT, overlying slightly sandy CLAY, slightly gravelly, silty, fine to coarse SAND, and slightly sandy, slightly gravelly CLAY	
WS-N06	0	0.3	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Seepage at 0.8
	0.3	8.45	Silty, fine and medium SAND, overlying very sandy, slightly clayey SILT, clayey, very silty, fine and medium SAND, thinly laminated SILT with fine and medium sand and silty, fine and medium SAND	
BH-N09	0	0.4	Silty, fine to coarse SAND with abundant roots (TOPSOIL)	Strike at 14.7, rose to 6.4 after 20 minutes
	0.4	20.2	Sandy CLAY, overlying sandy, slightly clayey SILT, clayey, very silty, fine to coarse SAND, slightly gravelly, sandy, silty CLAY, slightly gravelly, slightly sandy, silty CLAY with low cobble content, gravelly, clayey, silty, fine to coarse SAND, and slightly gravelly, sandy CLAY with low cobble content	
WS-N04A	0	0.25	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Not recorded
	0.25	10.45	Slightly sandy CLAY with occasional pockets of fibrous peat, overlying slightly sandy, slightly gravelly CLAY, silty, fine and medium SAND, slightly sandy, slightly gravelly CLAY, fine and medium SAND, slightly gravelly, slightly sandy, silty CLAY, gravelly, fine to coarse SAND, slightly sandy, slightly gravelly CLAY, and slightly sandy, slightly gravelly CLAY	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
WS-N06A	0	0.3	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Seepage at 1
	0.3	6.45	Silty, fine and medium SAND with clay pockets, overlying silty SAND with clay pockets, very sandy CLAY, clayey, very silty, fine and medium SAND, sandy, slightly clayey SILT with sand laminations, silty, fine to coarse SAND, interbedded, soft, thinly laminated CLAY with thin laminae of fine and medium sand and silty, fine to coarse SAND	
WS-N05	0	0.3	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Not recorded
	0.3	7.45	Fine to coarse SAND with occasional silt and clay pockets, overlying slightly sandy CLAY, interbedded, thinly laminated, slightly clayey SILT with thinly laminated fine and medium SAND, clayey, very silty, fine and medium SAND, interbedded, thinly laminated SILT with thinly laminated fine and medium SAND, fine and medium SAND, interbedded, thinly laminated, SILT with thinly laminated fine and medium SAND, fine and medium SAND, gravelly, fine to coarse SAND and slightly sandy, slightly gravelly CLAY	
WS-P01	0	0.3	Grass over silty, fine and medium SAND with abundant rootlets (TOPSOIL)	Not recorded
	0.3	4	Stiff CLAY, overlying interbedded, thinly laminated, slightly clayey SILT with thin laminae of fine and medium SAND, and slightly gravelly, silty, fine to coarse SAND	
WS-N05A	0	0.3	Grass over silty, fine and medium SAND with occasional rootlets (TOPSOIL)	Not recorded
	0.3	10.45	Slightly sandy, very silty CLAY, overlying silty, fine and medium SAND, slightly sandy CLAY, silty, fine and medium SAND, and slightly gravelly, sandy CLAY	
*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered.				

Groundwater

2.7.11 Groundwater level monitoring data for the site are summarised in Table 2.22 and were collected from August 2021 to May 2023. The highest recorded groundwater levels were generally at a depth of 1 mbgl, or shallower, except for one borehole in the west of the site (BH-N09 (2)) which recorded a groundwater level of 1.9 mbgl. A groundwater level of 0.18 mbgl was recorded in the northwest of the site (WS-N09). Groundwater is likely to be stored within the more permeable sand and silt horizons of the superficial aquifer and may be confined by the presence of clay layers.

2.7.12 No susceptibility to groundwater flooding data is available for most of the site, as the BGS dataset does not provide coverage for areas underlain by peat (BGS, 2021b). Inferred groundwater levels from the site's groundwater flooding susceptibility are therefore not available for the most part. The southwest of the site, is however, shown to have potential for groundwater flooding to occur at surface level.

2.7.13 During the hydrogeological walkover survey undertaken at the site in December 2021, hydrological features were not identified, but the east of the site was found to be wet underfoot. The west of the site was relatively dry.

2.7.14 The only hydrological feature shown on OS maps and historical maps within the site and its vicinity, is the issues located along the western site boundary. This "issues" was not observed during the hydrogeological walkover and may have been hidden by vegetation. However, standing water was observed in the mapped channel. Based on the groundwater level monitoring data, combined with the findings from the hydrogeology walkover survey, groundwater levels might be shallow (at times) generally across the site, following periods of prolonged or intense rainfall, and subsequent recharge to the superficial aquifer.

2.7.15 No licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). In addition, PWS questionnaire results were available for the site, which in February 2022 confirmed that there were no PWSs within the GWDTE.

Table 2.22 Groundwater level monitoring information for Castle Brook South

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min Depth (mbgl)	Max Depth (mbgl)
WS-N09	1 to 3	Sand and clay (superficial deposits)	11/08/2021 – 02/05/2023	20	0.18	0.97
WS-N04	2 to 5	Silt, clay and sand (superficial deposits)	12/08/2021 – 02/05/2023	18	0.56	1.84

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min Depth (mbgl)	Max Depth (mbgl)
WS-N06	0.9 to 5	Sand and silt (superficial deposits)	11/08/2021 – 02/05/2023	20	1	1.97
BH-N09 (1)*	13.9 to 14.9	Clay, silt and sand (superficial deposits)	11/08/2021 – 07/04/2022	11	0.83	Dry
BH-N09 (2)*	17.1 to 18.1		08/09/2021 – 02/05/2023	5	1.9	Dry
WS-N04A	4 to 6	Clay and sand (superficial deposits)	11/08/2021 – 02/05/2023	10	0.96	Dry
WS-N06A	2.15 to 2.64	Sand, silt and clay (superficial deposits)	11/08/2021 – 02/05/2023	10	0.74	1.69
WS-P01	1.2 to 2	Clay, silt and sand (superficial deposits)	07/09/2021 – 02/05/2023	18	0.30	1

*(Number) denotes where there are multiple standpipes installed within one borehole.

2.7.16 The GI data includes groundwater quality information for four out of nine GI locations. EQS exceedances of various heavy metals and / or ammoniacal nitrogen as N were identified in samples collected at all four locations (see Table 2.23). Detectable concentrations of total PAHs were also recorded at WS-N09 and WS-N04, along with detectable concentrations of total TPHs at WS-N04. The source of the heavy metals, PAHs and TPHs in the superficial deposits at these locations might be associated with the M66 or Egypt Lane, both of which lie upgradient and close to the GI locations. The presence of ammoniacal nitrogen as N could be the result of agricultural activity at the site. The highest nitrate value recorded was 1.2mg/l at WS-N04, which is below the threshold value for a wet grassland habitat type (UKTAG, 2012).

Table 2.23 Groundwater quality information for Castle Brook South

GI Location	Sample depth	Sample date	EQS exceedances
WS-N09*	0.9	03/02/2022	Ammoniacal Nitrogen as N, aluminium, copper, iron, manganese, nickel
WS-N04**	2.5	04/02/2022	Aluminium, copper, nickel, zinc
WS-N06	1.5	03/02/2022	Ammoniacal Nitrogen as N, aluminium, iron, manganese, nickel, zinc
WS-P01	1.5	04/02/2022	Ammoniacal Nitrogen as N, aluminium, copper, iron, manganese, nickel

GI Location	Sample depth	Sample date	EQS exceedances
*Denotes where there are detectable concentrations of total PAHs; **Denotes where there are detectable concentrations of total TPHs; ***Denotes where there are detectable concentrations of both total PAHs and TPHs.			

Habitats and vegetation

2.7.17 A UKHab survey was undertaken for Castle Brook South. The site was classified as a g3c15 habitat type, i.e., other neutral grassland with a significant component of *Juncus* (rush) species. The dominance of rush vegetation could indicate waterlogging within the site, and GWDTE could therefore be present.

2.7.18 There are no ecological designations present within the site.

Conceptual site model

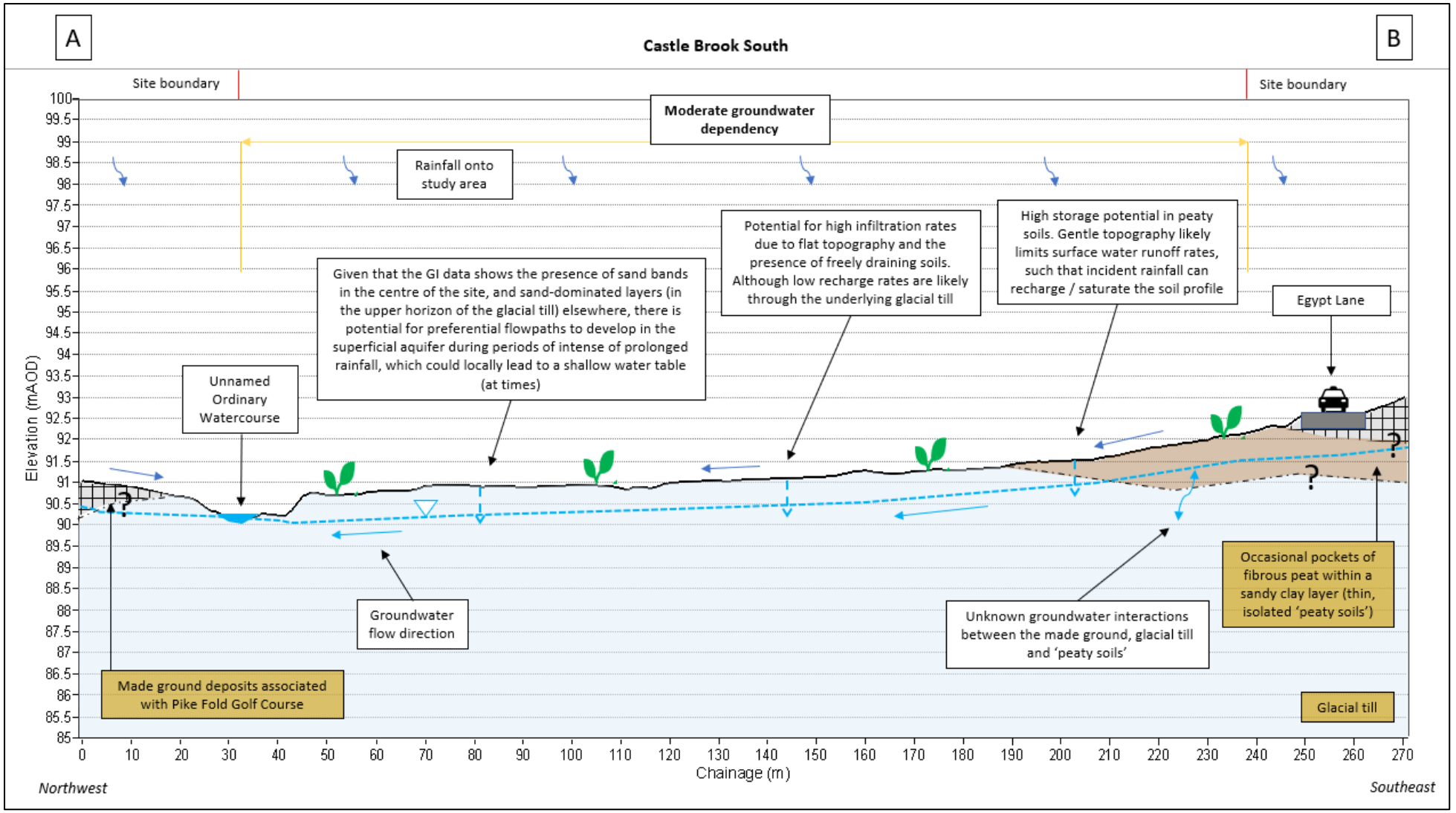
2.7.19 Plate 2.6 shows a conceptualised cross-section running northwest to southeast through the east of the site.

2.7.20 Considering the flat topography of the site and the general presence of freely draining, sandy / silty soils, recharge rates are expected to be high to the superficial aquifer following periods of prolonged or intense rainfall. This is reflected by the monitored groundwater levels which were typically at a depth of 1mbgl, or shallower. Wet ground conditions were also generally encountered across the site during the hydrogeological walkover survey.

2.7.21 The GI data indicate that groundwater is likely to be stored and transmitted within the more permeable sand and silt horizons identified in the upper horizons of the glacial till. In the far south and west of the site, thin, isolated ‘peaty soils’ were also identified, which could receive direct recharge from incident rainfall, and be quick to saturate due to the relatively high storage potential of peaty soils. Based on the monitored groundwater levels, the findings of the hydrogeology walkover survey, and the dominant presence of rush vegetation, groundwater levels are expected to be shallow across the site, following recharge events to the superficial aquifer. The site is therefore classified as having a **moderate groundwater dependency.**

2.7.22 Given that the site has no ecological designation, the value of the GWDTE is medium.

Plate 2.6 Conceptual site model for Castle Brook South



Assessment of effects

2.7.23 The Order Limits for the Scheme cover the entire site, with both temporary working areas and assets, and permanent infrastructure located within the site boundary.

Construction

2.7.24 The site lies outside of the estimated dewatering zone of influence for the nearest cutting. No cutting-related dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted. However, Pond 1 is located in the centre of the site. The 25m estimated dewatering zone of influence for this asset lies in an area classified as having a moderate groundwater dependency. Given the direct nature of the impacts expected, a major magnitude change in groundwater levels is anticipated in the centre of the site, which would result in a **large adverse** significance of effect.

2.7.25 Ground disturbance (associated with ground compaction, soil stripping, vegetation clearance, and construction of new drainage connections, haul roads, compounds, and temporary works areas) would occur across the entire site. Given the direct nature of the impacts expected, a major magnitude change in groundwater levels is anticipated throughout the GWDTE, which would result in overall effects with a **large adverse** significance. In addition, direct impacts are predicted in the south and west of the site from the construction of the Northern Loop due to its vertical drainage requirements. However, given that the vertical drains are typically 100mm wide, up to 6mm thick, and spaced at approximately 1m intervals, impacts to groundwater flows are expected to be very localised and minor. This would result in a **slight adverse** significance of effect in these locations.

2.7.26 Ground disturbance due to the above-mentioned activities could also impact on existing groundwater quality, due to the mobilisation of suspended solids and/or accidental spills and leaks of fuels and chemicals. Considering the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), and the fact that contaminants could directly enter shallow groundwater from the works area across the site, overall moderate magnitude impacts on groundwater quality are predicted. This would result in a **moderate adverse** significance of effect. In addition, the vertical drains required in the south and west of the site for the Northern Loop embankment could create new vertical contaminant pathways between strata in the superficial aquifer. Although the impacts would be direct in these locations, assuming that bedrock would not be encountered during piling or installation of the vertical drains, localised minor magnitude impacts on groundwater quality are predicted in the south and west of the site, due to the limited size of the vertical drains, and on the basis that a degree of vertical mixing (albeit minor) may already occur within the glacial till. This would result in a **slight adverse** significance of effect.

Operation

2.7.27 The presence of below ground structures in the centre, south, and west of the site (such as the pond, swale, and drainage connections), could permanently alter local groundwater flows and levels in the superficial aquifer. Moderate impacts in groundwater levels and flows in these parts of the site are predicted, resulting in a **moderate adverse** significance of effect. For the vertical drains associated with the northern loop embankment, localised negligible changes to groundwater levels and flows are expected in the south and west of the site due to the assets being positioned directly beneath the embankment footprint (i.e., where no GWDTE are assumed to remain during the operation phase). No measurable impacts to groundwater flows are predicted to extend laterally away from the embankment edge (due to the nature of how the GWDTE is sustained). This would result in a **neutral effect**.

2.7.28 The backfilling of trench excavations required for the permanent drainage connections has the potential to result in localised changes in groundwater levels. This could either be due to backfilled material acting as a permanent barrier to groundwater flow or forming a preferential pathway for groundwater flow. Although this represents a direct impact in the centre, south, and west of the site, major changes in groundwater levels and flows are unlikely. Moderate impacts in groundwater levels and flows in these parts of the site are therefore predicted, resulting in a **moderate adverse** effect.

2.7.29 There is potential for local groundwater recharge rates to be permanently disrupted from the increased interception of overland flows. This could be due to an increase in impermeable surface areas, permanent highway drainage, reprofiled ground etc. However, the relative contribution of direct rainfall in recharging the superficial aquifers is likely to be limited compared to the recharge rates and volumes provided by surface water and groundwater inputs from the wider hydrological catchment. As a result, minor magnitude impacts are expected to recharge rates sustaining the GWDTE, and a **slight adverse effect**.

2.7.30 Considering the Scheme lies within the south and west of the GWDTE, and the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), impacts on groundwater quality in these parts of the site from accidental leaks / spills of fuels and chemicals (i.e., due to road collisions), and / or routine runoff associated with the new highway could lead to minor magnitude impacts. This would result in a **slight adverse effect** in the south and west of the site.

Summary

2.7.31 A summary of the effects to the site is provided in Table 2.24.

Table 2.24 Summary of effects to Castle Brook South

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Moderate	None	Medium	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Moderate	**Moderate adverse**
			Mobilisation of suspended solids (groundwater quality)	Construction	Moderate	**Moderate adverse**
			Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	Minor	Slight adverse
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows) – including construction of drainage connection	Construction	Major	**Large adverse**
			Cutting dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Pond dewatering (groundwater levels / flows / quality)	Construction	Major	**Large adverse**
			Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	Minor	Slight adverse
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	Minor	Slight adverse
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	Negligible	Neutral

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	Moderate	**Moderate adverse**

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

2.8 Egypt Lane South

Site setting, topography and hydrological catchment

2.8.1 Egypt Lane South lies immediately north-east of the M60 J18. The M66 borders the site to the west and the M62 to the south. Egypt Lane bounds the site to the north, with an adjoining access track that runs along the site's eastern boundary.

2.8.2 There are no hydrological features shown within the site, as indicated by OS maps and historical maps, although the entire site is shown to be a marsh. A hydrogeological walkover survey was undertaken at the site in December 2021, which confirmed the absence of hydrological features within the site and noted marshy conditions throughout.

2.8.3 A large topographic mound occupies most of the central and northern parts of the site. The elevation of the site ranges from 103mAOD at the peak of mound to 93mAOD in the far north.

2.8.4 The total hydrological catchment for the site includes several sub-catchments to the south, west, and east, with the largest extending 350m southeast to the residential area of Simister. The topographic mound creates a localised catchment divide, which itself receives direct hydrological inputs from incident rainfall. The M66 embankment to the west, and the M62 to the south likely limit a proportion of the natural hydrological inputs to the site.

Soils and geology

2.8.5 The GI data provides geological information for 14 boreholes drilled within the site. Relevant information from these borehole records is summarised in Table 2.25. Their locations are shown on Figure 13.5.1: Groundwater Dependent Terrestrial Habitats in Annex A of this report.

2.8.6 Soils across the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023).

2.8.7 Geological maps show that most of the site is covered by made ground, except for a small area in the south. The large topographic mound within the site was created entirely with fill material, derived from earthworks associated with the construction of the M60 J18. All 14 borehole records within the site identified made ground deposits to depths of between 3mbgl and 12mbgl (where their full thickness was proven) (see Table 2.25). The made ground was found to comprise layers of gravelly sand, silt, and clay. In most instances (11 out of 14 of the GI boreholes), layers of sand were described in the upper horizons, overlying sandy, gravelly clays. The exception is BH-N17 and BH-N18, which described sandy gravelly clays overlying sand close to ground surface.

2.8.8 The superficial geology at the site comprises glacial till (BGS, 2023). The mapped extent of peat deposits located to the north of the site is shown to stop along the northern site boundary. The western boundary of the site marks the mapped edge of the glaciofluvial sands and gravels, which extend west/southwest away from the site.

2.8.9 Superficial deposits were encountered in six out of 14 of the GI boreholes (see Table 2.25). The base of the superficial deposits was not proven in any of these six locations but was recorded to depths of 12.5mbgl to 30mbgl. Typically, the superficial deposits comprised predominantly sand layers in the upper horizons, except for BH-N18 and BH-N08B, which showed a clay lithology with interbedded sand bands. The review and interpretation of soil survey results (Appendix 9.2: Agricultural Land Classification Survey Report of the Environmental Statement Appendix (TR010064/APP/6.3)) also indicates that a very localised area of thin remnant ‘peaty soil’ is present along the southern site boundary.

2.8.10 Bedrock comprises Pennine Middle Coal Measures Formation, consisting of mudstone, siltstone and sandstone (BGS, 2023).

Table 2.25 Borehole records for Egypt Lane South

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
BH-N18	0	4.1	Sandy, organic CLAY/SILT with frequent rootlets, overlying slightly gravelly, sandy, friable CLAY with gravel of sandstone, mudstone, concrete and brick, slightly gravelly, sandy CLAY and sandy CLAY (MADE GROUND)	Seepage at 7
	4.1	15	Slightly sandy, very silty, thinly laminated CLAY with occasional bands/lenses of clayey, fine and medium sand overlying clayey, silty, fine to coarse SAND with occasional thin bands of laminated sandy clay, slightly gravelly, sandy, slightly silty CLAY with localised pockets of coarse clayey sand, and slightly gravelly, sandy, silty CLAY	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
BH-N18OB	0	0.3	Reeds over clayey, fine, and medium SAND, overlying sandy, gravelly CLAY. Gravel is subrounded to rounded, fine to coarse including siltstone, sandstone, and brick (MADE GROUND)	Not recorded*
BH-N08	0	0.55	Silty, fine and medium SAND, overlying slightly gravelly, sandy, slightly silty CLAY with low cobble content (MADE GROUND)	Not recorded
BH-N08A	0	12	Silty, fine and medium SAND, overlying slightly gravelly, sandy, slightly silty CLAY with angular to subrounded, fine to coarse gravel of brick, sandstone and concrete, slightly gravelly, slightly sandy to sandy, slightly clayey SILT with occasional firm, clay pockets, very sandy, slightly silty CLAY, slightly clayey, silty, fine to coarse SAND (MADE GROUND)	Not recorded
	12	12.5	Slightly gravelly, fine to coarse SAND	
BH-N08B	0	11	Silty, fine and medium, partially organic SAND with frequent rootlets, overlying slightly sandy, slightly gravelly CLAY with gravel of fine to coarse brick, sandstone, mudstone, timber and metal pieces, gravelly, silty, fine and medium SAND, slightly gravelly, silty, fine and medium SAND with occasional pockets of clay, slightly gravelly, silty, fine and medium SAND with occasional partially organic, silty, fine and medium sand pockets with relict fibrous plant material, Slightly gravelly, sandy CLAY with bands of silty, fine and medium sand, overlying slightly silty, fine and medium SAND, slightly clayey, fine and medium SAND locally thinly interlaminated with clay bands (MADE GROUND)	Not recorded
	11	15.5	Slightly gravelly, silty, fine to coarse SAND, and slightly gravelly, sandy, silty CLAY	
BH-N17	0	8.9	Slightly gravelly, sandy, slightly silty CLAY with low cobble and boulder content of rare metal pipe pieces, sandstone, limestone, brick, concrete etc., overlying gravelly, clayey, silty to very silty, fine to coarse SAND, and gravelly, clayey, silty, fine to coarse SAND (MADE GROUND)	Not recorded

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
	8.9	15.2	Slightly gravelly, slightly clayey, fine to coarse SAND, overlying thinly laminated, slightly gravelly, slightly sandy CLAY, slightly gravelly, clayey, very silty, fine to coarse SAND, and slightly gravelly, sandy, silty CLAY	
BH-N17OB	0	0.2	Grass over slightly clayey, fine and medium SAND (MADE GROUND)	Not recorded
BH-N07	0	3	Slightly gravelly, silty, fine and medium SAND with gravel of brick, concrete and quartzite, overlying clayey, fine and medium SAND with occasional clay pockets, and slightly gravelly, slightly clayey, silty, fine to coarse SAND (MADE GROUND)	Not recorded
	3	30.26	Slightly clayey, silty, fine to coarse SAND, overlying slightly gravelly, silty, fine to coarse SAND with occasional pockets of fibrous peat, slightly gravelly, sandy, silty CLAY, slightly sandy, slightly gravelly CLAY, slightly gravelly, slightly sandy, silty CLAY with gravel of siltstone, sandstone, quartzite and mudstone.	
BH-N07OB	0	0.2	Silty, slightly gravelly, fine and medium SAND with angular to subrounded, fine to coarse gravel of brick, concrete and quartzite (MADE GROUND)	Not recorded
BH-N14	0	5.5	Slightly gravelly, clayey, fine to coarse SAND with subangular to rounded, fine to coarse gravel of brick, concrete, mudstone, limestone, quartz etc. overlying slightly gravelly, sandy, slightly clayey SILT, and gravelly, clayey, very silty, fine to coarse SAND with low cobble content and clay pockets/bands (MADE GROUND)	Not recorded
	5.5	15	Gravelly, clayey, very silty, fine to coarse SAND with occasional clay lenses/pockets, overlying clayey, fine to coarse SAND locally thinly laminated with clay bands, gravelly, silty, fine to coarse SAND, gravelly, slightly clayey, fine to coarse SAND, and slightly gravelly, sandy, silty CLAY	
WS-N12	0	3.32	Grass over slightly gravelly, silty, fine to coarse SAND with abundant rootlets, overlying gravelly, slightly clayey, very silty, fine to coarse SAND (MADE GROUND)	Not recorded
WS-N12A	0	3.35	Grass over silty, slightly gravelly,silty, fine to coarse SAND with abundant rootlets, overlying slightly gravelly, silty, fine to coarse SAND (MADE GROUND)	Not recorded

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
WS-N12B	0	3.45	Grass over slightly gravelly, silty, fine to coarse SAND with abundant rootlets and gravel of quartzite and concrete, overlying gravelly, slightly clayey, very silty, fine to coarse SAND, firm CLAY and slightly gravelly, silty, fine to coarse SAND (MADE GROUND)	Not recorded
WS-N12C	0	3.45	Grass over slightly gravelly, silty, fine to coarse SAND with abundant rootlets, overlying gravelly, slightly clayey, silty, fine to coarse SAND, slightly sandy, slightly gravelly CLAY (MADE GROUND)	Not recorded
*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered.				

Groundwater

2.8.11 Available groundwater level monitoring information for the site is summarised in Table 2.26. Groundwater level monitoring data were collected from August 2021 to May 2022. The data show that the highest groundwater levels recorded at the site ranged from 1.72mbgl in the west, to 12.9mbgl, 50m north of the site (WS-N12C and BH-N14 respectively). Most of the groundwater levels recorded lie at an elevation that broadly correlates with the response zone of that borehole. Sub-artesian pressures are recorded in BH-N07 where water level is 13m above the top of the borehole's response zone suggesting that the groundwater in this location may be confined by lower permeability clay layers in the overlying strata and made ground.

2.8.12 The BGS susceptibility to groundwater flooding dataset classifies the site as having potential for groundwater flooding to occur at surface level, or to properties situated below ground level (BGS, 2021).

2.8.13 During the hydrogeological walkover survey undertaken at the site in December 2021, no groundwater features were identified, but the entire site was found to be very wet underfoot. At the base of the mound, there were some patches of drier land, but this became immediately boggy again towards the edges of the site.

2.8.14 There are no springs, sinks, sources, issues, collects, spreads, or wells within the site boundary, as shown on OS maps and historical maps. However, given the wet, boggy ground conditions encountered on site, the high potential for groundwater flooding as indicated by BGS data, and the shallow groundwater level reading in the west of the site, it's possible that the water table can approach the ground surface (at times) within certain parts of the site.

2.8.15 No licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). In addition, PWS questionnaire results were available for the site, which in February 2022 confirmed that there were no PWSs within the GWDTE.

Table 2.26 Groundwater level monitoring information for Egypt Lane South

Borehole ID	Response Zone (mbgl)	Lithology	Date Range	No. of Readings	Min Depth (mbgl)	Max Depth (mbgl)
BH-N18	1 to 4	Made ground	07/09/2021 - 07/04/2022	15	3.48	4.07
BH-N08B	11 to 14	Made ground / clay and sand (superficial deposits)	07/09/2021 - 02/05/2022	20	11.44	13.84
BH-N17	1 to 8.50	Clay and sand (made ground)	12/08/2021 – 07/04/2022	11	Dry	Dry
BH-N07 (1)*	16 to 18	Sand and clay (superficial deposits)	11/08/2021 – 07/04/2022	11	3.28	Dry
BH-N07 (2)	3.5 to 6		11/08/2021 – 07/04/2022	12	2.62	Dry
BH-N14	11.5 to 14.5	Sand and clay (superficial deposits)	07/09/2021 - 07/04/2022	9	12.9	13.31
WS-N12C	1.5 to 3	Made ground	11/08/2021 – 02/05/2023	20	1.72	Dry
*(Number) denotes where there are multiple standpipes installed within one borehole.						

2.8.16 The GI data includes groundwater quality information for five out of 14 GI locations. EQS exceedances of various heavy metals and ammoniacal nitrogen as N were identified in samples collected at all five locations (see Table 2.27). All locations except WS-N12C also recorded detectable concentrations of total PAHs, with BH-N14 showing detectable concentrations of total PAHs and total TPHs. The source of the heavy metals, PAHs and / or TPHs could be associated with construction of the M60 J18 Simister Island which lies adjacent to the site or associated drainage. The presence of ammoniacal nitrogen as N (up to 4.2mg/l compared to an EQS of 0.3mg/l) could be the result of agricultural activity at the site. However, the highest nitrate value recorded was 0.1mg/l at WS-N12C, which is below the threshold value for the wet grassland habitat type present.

Table 2.27 Groundwater quality information for Egypt Lane South

GI Location	Sample depth	Sample date	EQS exceedances
BH-N18*	4	03/02/2022	Ammoniacal Nitrogen as N, iron, manganese, nickel, zinc
BH-N08B*	13.5	03/02/2022	Aluminium, cadmium, iron, manganese, nickel, zinc
BH-N07*	4	03/02/2022	Ammoniacal Nitrogen as N, aluminium, iron, manganese, nickel
BH-N14***	13.5	02/02/2022	Ammoniacal Nitrogen as N, iron, manganese, nickel, zinc
WS-N12C	2.5	03/02/2022	Copper, manganese
*Denotes where there are detectable concentrations of total PAHs; **Denotes where there are detectable concentrations of total TPHs; ***Denotes where there are detectable concentrations of both total PAHs and TPHs.			

Habitats and vegetation

2.8.17 A UKHab survey was undertaken for Egypt Lane South. The site was classified as a g3c15 habitat type, i.e., other neutral grassland with a significant component of *Juncus* (rush) species. The UKHab survey notes recorded a dominance of soft rush, with a ground layer dominated by spear moss; both of which are indicative of wet ground conditions. GWDTE could therefore be present throughout the site.

2.8.18 There are no ecological designations present within the site.

Conceptual site model

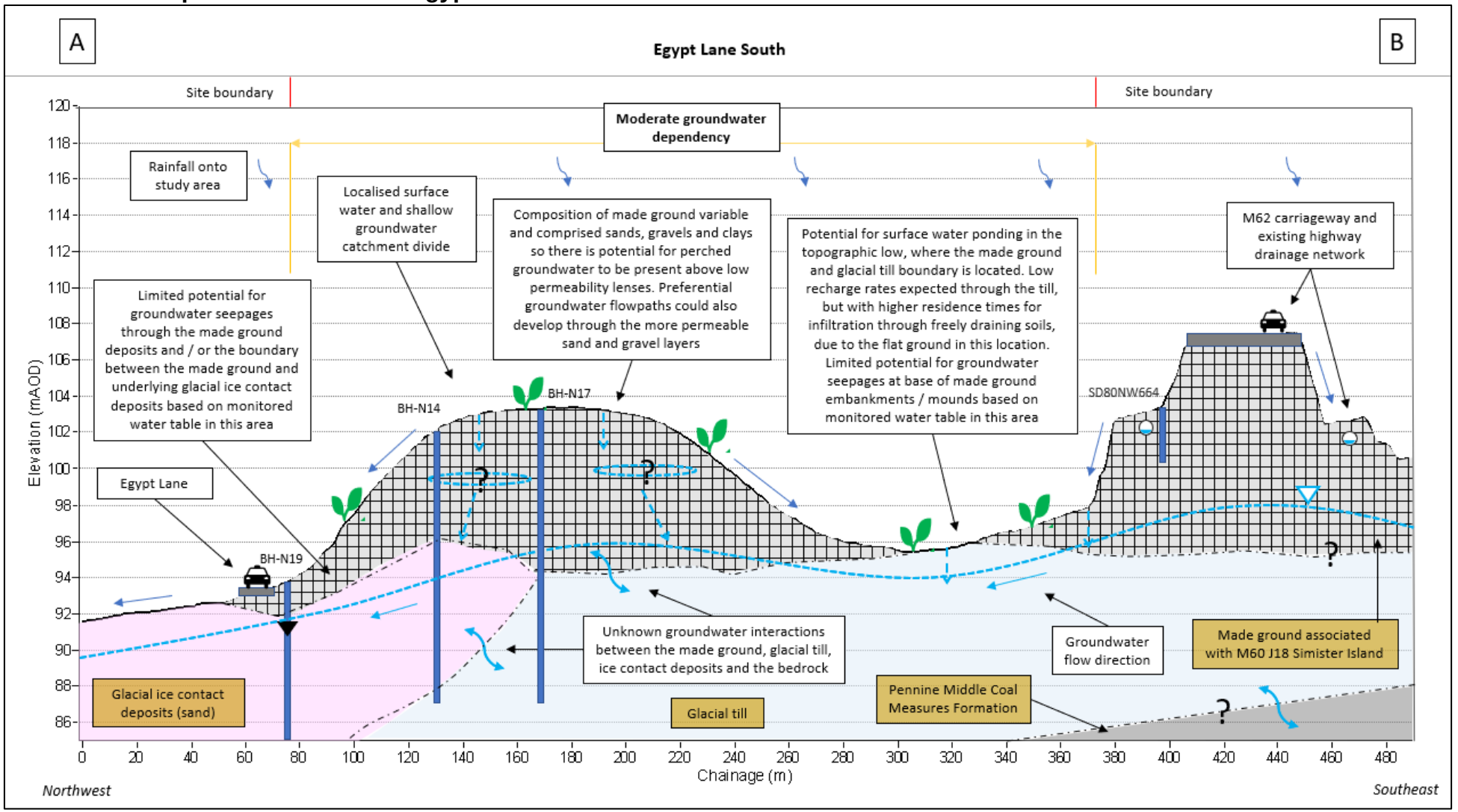
2.8.19 Plate 2.7 shows a conceptualised cross-section running northwest to southeast through the centre of the site.

2.8.20 The site forms a large topographic mound and localised catchment divide, which peaks in its centre and slopes downwards towards the site boundary in all directions. The superficial and bedrock aquifers likely receive wider groundwater inputs from the sub-catchments to the south, west, and east, with the M62 expected to limit a proportion of the natural inflows to the site. The highest monitored groundwater levels at the site ranged from 1.72mbgl in the west and 12.9mbgl in the northwest. In isolation, these water levels would be unlikely to create the wet and boggy ground conditions observed during the hydrogeological walkover survey.

2.8.21 However, the made ground deposits that have formed the mound were identified as being predominantly comprised of sand layers in the upper horizons, overlying clay bands at depth. The combination of the topography and lithology across the site therefore provides high potential for perched shallow groundwater (recharged directly via effective rainfall) to be present, and for prolonged periods. The sand dominated layers could allow preferential groundwater flows to develop in the made ground, which if laterally semi-continuous, could lead to the formation of groundwater seepages along the base of the mound. The wet grassland vegetation, although fed predominantly by rainfall is therefore expected to be sustained by groundwater. For this reason, the site is considered to have a **moderate groundwater dependency**.

2.8.22 Given that the site has no ecological designation, the value of the GWDTE is medium.

Plate 2.7 Conceptual site model for Egypt Lane South



Assessment of effects

2.8.23 The Order Limits for the Scheme cover the entire site, except for the far southern edge. This includes both temporary working areas and assets, and permanent infrastructure located within the site boundary.

Construction

2.8.24 The site lies outside of the estimated dewatering zone of influence for the nearest pond. No dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted from this asset. However, widening and cutting 4 (base of Northern Loop) and several new drainage connections are predicted in the centre, west and south of the site. Widening and cutting 4 has the potential to slightly intercept groundwater by approximatively 0.1m. In this instance, it is not applicable to attribute a dewatering zone of influence but rather expect that groundwater level disruption will be extremely localised (i.e., expected to extend to no more than 5m from the edge of the excavation). As a result, any drawdown impacts on groundwater levels and flows would be minor and temporary, and restricted to the far west of the site. This would result in a **slight adverse effect**. The remainder of the site would experience negligible or no impacts. On the other hand, moderate magnitude impacts on groundwater levels and flows are conservatively attributed to localised areas in the far south and west of the site, associated with dewatering of the new drainage connections for catchment 1A. This is on the basis that the 25m estimated dewatering radius of influence extends into these parts of the site, whereby a **moderate adverse effect** could occur.

2.8.25 Ground disturbance (associated with ground compaction, soil stripping, vegetation clearance, and construction of haul roads, compounds, and temporary works areas) would occur across most of the site. Given the direct nature of the impacts expected, a major magnitude change in groundwater levels is anticipated throughout the GWDTE, which would result in a **large adverse effect**. In addition, direct impacts would occur in the far west of the site as a result of the construction of the Simister Pike Fold Viaduct due to the associated piling requirements. Although this represents a direct impact, major changes in groundwater levels and flows are unlikely due to limited geographical extent and density of the bored piles. Moderate impacts to groundwater levels and flows in far west of the site are therefore predicted, resulting in a localised **moderate adverse effect**. For the vertical drains, required along the northern site boundary for the Northern Loop embankment, impacts to groundwater flows are expected to be very localised and minor, resulting in a **slight adverse effect** in these locations. This is due to their limited spatial extent within the site, as well as limited sizing and density.

2.8.26 Ground disturbance due to the above-mentioned activities could also impact on existing groundwater quality, due to the mobilisation of suspended solids and/or accidental spills and leaks of fuels and chemicals. Considering the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), and the fact that contaminants could directly enter shallow groundwater from the works area across the site, overall moderate magnitude impacts on groundwater quality are predicted. This would result in a **moderate adverse effect**. In addition, both the bored piles and vertical drains required in the far west and north of the site for the Simister Pike Fold Viaduct and Northern Loop embankment could create new vertical contaminant pathways between made ground deposits, superficial, and potentially bedrock aquifers. Even where groundwater is not contaminated, there is potential for mixing of different groundwater chemistries. However, considering the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5) with regards to piling, as well as the limited geographical extent, size and density of the vertical drains, these activities are expected to generate direct, but localised and minor changes to groundwater quality in these locations. This would result in a **slight adverse effect**.

Operation

2.8.27 The presence of below ground structures in the centre, west, south, and north of the site (such as the drainage connections and bored piles associated with the Simister Pike Fold Viaduct), could permanently alter local groundwater flows and levels in the superficial aquifers. Moderate impacts in groundwater levels and flows in these parts of the site are predicted, resulting in a **moderate adverse effect**. For the vertical drains associated with the Northern Loop embankment, localised negligible changes to groundwater levels and flows are expected along the northern site boundary, due to the assets being positioned directly beneath the embankment footprint (i.e., where no GWDTE are assumed to remain during the operation phase). No measurable impacts to groundwater flows are predicted to extend laterally away from the embankment edge (due to the nature of how the GWDTE is sustained). This would result in a **neutral effect**.

2.8.28 The backfilling of trench excavations required for the permanent drainage connections has the potential to result in localised changes in groundwater levels. This could either be due to backfilled material acting as a permanent barrier to groundwater flow or forming a preferential pathway for groundwater flow. Although this represents a direct impact in the centre, south, and west of the site, major changes in groundwater levels and flows are unlikely. Moderate impacts in groundwater levels and flows in these parts of the site are therefore predicted, resulting in a **moderate adverse effect**.

2.8.29 There is potential for local groundwater recharge rates to be permanently disrupted from the increased interception of overland flows. This could be due to an increase in impermeable surface areas, permanent highway drainage, reprofiled ground etc. Given the importance of the relative contribution of direct rainfall in recharging the superficial aquifers at the site, precautionary moderate magnitude impacts are expected to recharge rates sustaining the GWDTE, and a **moderate adverse effect**.

2.8.30 Considering the Scheme lies within the centre, west and north of the GWDTE, and the best-practice mitigation measures referred to in the First Iteration EMP (TR010064/APP/6.5), impacts on groundwater quality in these parts of the site from accidental leaks / spills of fuels and chemicals (i.e., due to road collisions), and / or routine runoff associated with the new highway could lead to minor magnitude impacts. This would result in a **slight adverse effect** in these locations.

Summary

2.8.31 A summary of the effects to the site is provided in Table 2.28.

Table 2.28 Summary of effects to Egypt Lane South

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Moderate	None	Medium	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Moderate	**Moderate adverse**
			Mobilisation of suspended solids (groundwater quality)	Construction	Moderate	**Moderate adverse**
			Creation of vertical pathways for contaminated groundwater in short and/or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	Minor	Slight adverse
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	Major	**Large adverse**
			Cutting dewatering (groundwater levels / flows / quality)	Construction	Minor	Slight adverse
			Pond dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
			Drainage connection dewatering (groundwater levels / flows / quality)	Construction	Moderate	**Moderate adverse**
			Short and/or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	Moderate	**Moderate adverse**
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	Minor	Slight adverse
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	Negligible	Neutral
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	Moderate	**Moderate adverse**

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

2.9 Simister Allotment Gardens

Site setting, topography and hydrological catchment

2.9.1 Simister Allotment Gardens forms a wooded area located immediately east of the M60 J18, north of residential properties along Simister Lane and Simister Green, and south of the existing M62 carriageway. Small allotment gardens border the site's south-eastern boundary.

2.9.2 OS maps show an unnamed Ordinary Watercourse that flows southwest towards the site from Lower Draughts Farm, and along the northern site boundary for approximately 40m. The Ordinary Watercourse then turns north, before entering culvert under the M62. There are no hydrological features shown on OS maps within the site. This was confirmed during a hydrogeological walkover survey, which was undertaken at the site in December 2021.

2.9.3 The elevation of the site ranges from 96mAOD in the north to 103mAOD in the south, adjacent to the rear end of properties along Simister Lane. The total hydrological catchment for the site includes several sub-catchments to the north, east, south and west, with the largest extending approximately 400m east and peaking at an elevation of around 105mAOD. The M62 embankment to the north, and the residential areas to the south and west of the site likely alter the natural hydrological inputs to the site.

Soils and geology

2.9.4 No GI data were available close to the site at the time of writing. There are no historical borehole records located within the site itself. However, a series of boreholes were drilled further north of the site for the existing M62 carriageway, the closest of which lies 5m north of the site boundary (SD80NW670). Relevant information extracted from this borehole record is provided in Table 2.29, along with information obtained from a second borehole, which was drilled 40m north of the site (SD80NW676) and penetrated the base of the made ground deposits in this area (BGS, 2023).

2.9.5 Soils at the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023). Made ground to the north of the site is recorded as a slightly clayey slightly gravelly fine and medium sand, proven to a depth 2mbgl in the northernmost borehole (refer to Table 2.29).

2.9.6 The superficial geology comprises peat in the centre and east of the site, glaciofluvial sands and gravels in the southeast, and hummocky glacial deposits of sand and gravel in the south (BGS, 2023). Glacial till is mapped in the north and west and is expected to be present at depth beneath most of the site. Borehole SD80NW676 recorded a firm slightly sandy, slightly gravelly clay to its termination depth of 3mbgl, which is consistent with the superficial geology in this location. However, given the shallow nature of the historical borehole records and absence of site-specific GI data, the thickness, lithology, and hydrogeological properties of the superficial deposits within the site remain unknown.

2.9.7 Bedrock comprises the Pennine Middle Coal Measures Formation, and consists of mudstone, siltstone, and sandstone units (BGS, 2023).

Table 2.29 Borehole records for Simister Allotment Gardens

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
SD80NW670	0	0.3	Slightly clayey slightly gravelly fine and medium sand with occasional rootlets (MADE GROUND)	Not recorded*
	0.3	1.7	Slightly clayey slightly gravelly fine and medium sand (MADE GROUND)	
	1.7	2.2	Silty sandy slightly gravelly clay (MADE GROUND)	
SD80NW676	0	0.3	Slightly clayey slightly gravelly fine and medium sand with some rootlets and occasional plastic/glass (MADE GROUND)	Not recorded
	0.3	2	Slightly clayey very gravelly fine and medium sand with sandstone cobbles (MADE GROUND)	
	2	3.1	Firm slightly sandy slightly gravelly CLAY	
*Not recorded refers to there being no reference to groundwater on the borehole log, not that groundwater was not encountered.				

Groundwater

2.9.8 There are no GI boreholes available close to the site to provide an indication of groundwater seeps, strikes, or rest water levels. In addition, the nearest historical borehole records do not provide any groundwater level information (see Table 2.29).

2.9.9 No groundwater features were identified during the hydrogeological walkover survey undertaken at the site in December 2021. However, a shallow topographic low was identified in the centre of the site and was found to be very wet underfoot. The rest of the site remained relatively dry.

2.9.10 The BGS susceptibility to groundwater flooding dataset classifies most of the site as having potential for groundwater flooding to occur at surface level, or to properties situated below ground level (BGS, 2021b). The exception is the southwest corner of the site; considered to have limited potential for groundwater flooding to occur. It should be noted that while no data are available in the north-east of the site, the BGS susceptibility to groundwater flooding dataset does not provide coverage for areas underlain by peat. Inferred groundwater levels from the site's groundwater flooding susceptibility are therefore not available in this part of the site.

2.9.11 Historical maps show two wells located 5m west and 25m east of the site. However, no licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). At the time of writing, no PWS questionnaire results were available for the site and no hydrogeological walkover surveys of the two wells were undertaken due to access constraints. The presence of PWSs within the site cannot therefore be ruled out.

2.9.12 No springs, sinks, sources, issues, collects, or spreads are shown on OS maps within the site or its immediate vicinity, although a spring is shown some 200 m east of the site. However, based on the wet ground conditions encountered in the centre of the site during the hydrogeology walkover survey, alongside the BGS susceptibility to groundwater flooding data, groundwater is expected to be shallow in the central part of the site.

2.9.13 No groundwater quality information from the GI data is available for this site.

Habitats and vegetation

2.9.14 A UKHab survey was undertaken for Simister Allotment Gardens. The site was classified as a w1g habitat type, i.e., other woodland; broadleaved. Alone this would not typically comprise a GWDTE. However, the UKHab survey notes recorded the presence of a 'wetland area' within the site. As such, a hydrogeological walkover survey was subsequently undertaken at the site in December 2021, which confirmed the presence of the wetland in the centre of the site (in a small clearing within the woodland area). GWDTE could therefore be present in this location, albeit confined to the wetland area in the centre of the site.

2.9.15 There are no ecological designations present within the site.

Conceptual site model

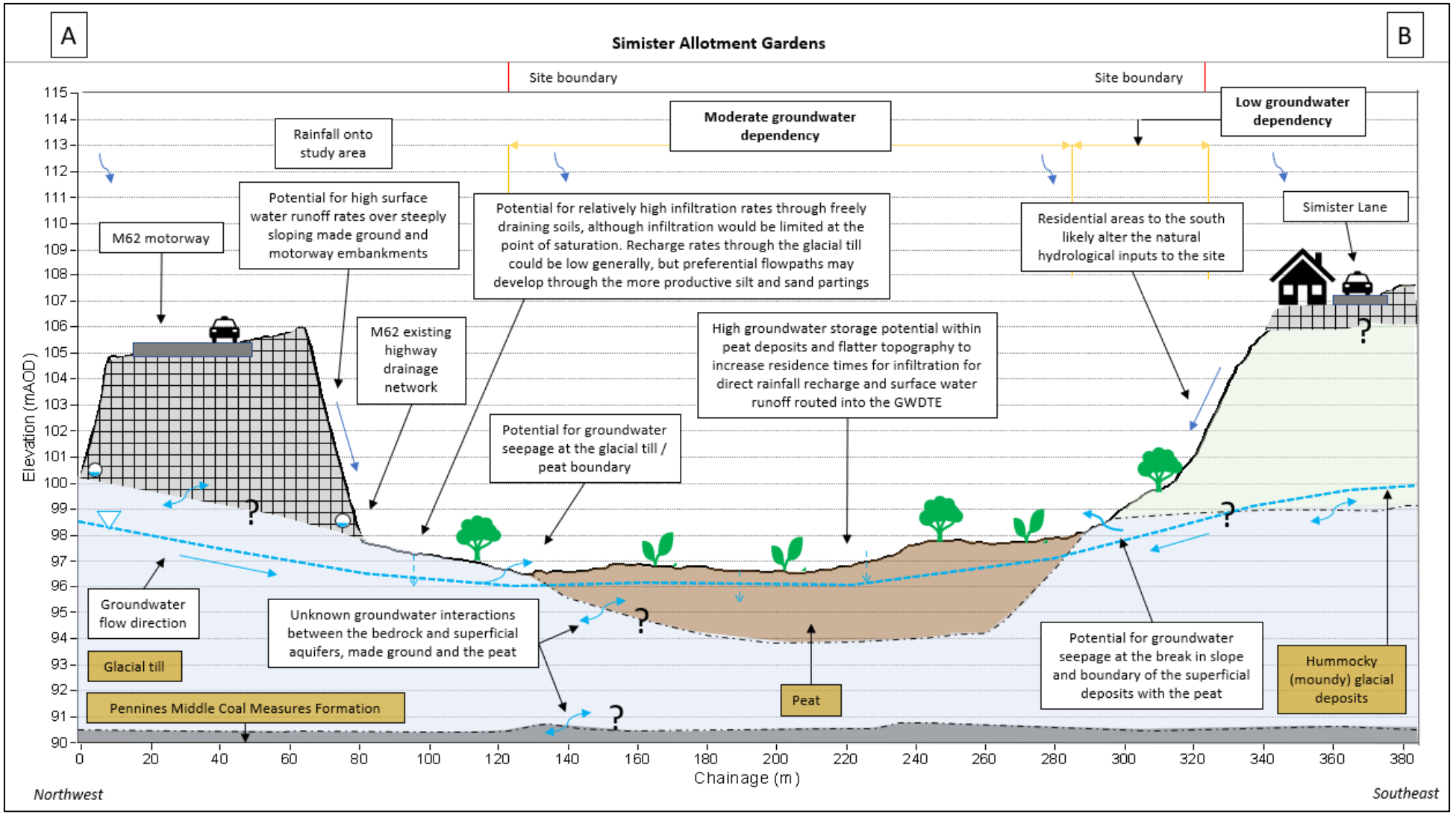
2.9.16 Plate 2.8 shows a conceptualised cross-section running northwest to southeast through the centre of the site.

2.9.17 The centre and north of the site sit in a topographic low, with surface water runoff (and groundwater stored in the superficial aquifers / made ground) likely to be routed to these locations from the Egypt Lane South site (to the south), and the M62 embankment (to the north). The peat / peaty soils (if / where present across the centre and north of the site) could therefore be recharged from direct rainfall, attenuation of overland flows routed to these areas, and / or shallow groundwater inflows from the wider groundwater catchment. Due to the high groundwater storage potential within peat deposits, the increased residence times for infiltration due to the flat topography, the potential for groundwater seepages to develop at the breaks in slope around the edges of the topographic low, and observations from the hydrogeology walkover survey, the central and northern parts of the site are considered to have a **moderate groundwater dependency**.

2.9.18 The steeper sloping ground in the south and far northwest of the site is expected to be characterised by high surface water runoff rates with limited time for infiltration. Groundwater levels are therefore not anticipated to be particularly shallow in these locations, which is consistent with the dry ground conditions identified during the hydrogeological walkover survey in these areas. Consequently, the southern and far north-western parts of the site are classified as having a **low groundwater dependency**.

2.9.19 Given that the site has no ecological designation, the value of the GWDTE is medium to low.

Plate 2.8 Conceptual site model for Simister Allotment Gardens



Assessment of effects

2.9.20 The far north-western edge of the site lies 20m south and partially down-gradient of the Order Limits at its closest point.

Construction

2.9.21 The site lies outside of the estimated dewatering zones of influence for the nearest cutting, pond and drainage connections. No dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted.

2.9.22 The nearest ground disturbance (associated with ground compaction, soil stripping and vegetation clearance etc. within the Order Limits) is located more than 50m west of the site. Given the presence of the existing M62 infrastructure, all potential localised impacts on groundwater levels and flows within the works footprint are expected to be attenuated prior to reaching the site boundary. Due to groundwater flow directions in the area, precautionary negligible magnitude impacts to groundwater flow are predicted to the far northwest of the site, which would result in a **neutral effect**. No impacts are predicted to the GWDTE from the construction of the cuttings, embankments, gantries, bridges, or drainage assets, given their distance from the site.

2.9.23 Negligible impacts to existing groundwater quality are conservatively predicted to the site during the construction of the Scheme due to groundwater flow directions in the area, resulting in a **neutral effect**.

Operation

2.9.24 There are no permanent below ground structures or embankments within the vicinity of the site to locally alter groundwater levels and flows supporting GWDTE. No operational impacts to groundwater flows and levels at the site are therefore predicted.

2.9.25 Considering the distance of the Scheme from the GWDTE, the existing M62 infrastructure, likely groundwater flow directions in the area, and the filtering effect of aquifer material, no impacts on groundwater quality are expected to the site during the operation phase.

Summary

2.9.26 A summary of the effects to the site is provided in Table 2.30.

Table 2.30 Summary of effects to Simister Allotment Gardens

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Low to moderate	None	Low to Medium	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	Negligible	Neutral
			Mobilisation of suspended solids (groundwater quality)	Construction	Negligible	Neutral
			Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	No Impact	N/A
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	Negligible	Neutral
			Cutting dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Pond dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Drainage connection dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	No Impact	N/A
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	No Impact	N/A
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	No Impact	N/A

Groundwater Dependency	Ecological Designation	Value	Potential Impact	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	No Impact	N/A
			Intercept contaminated groundwater in long-term, or mixing of different groundwater chemistries (groundwater quality)	Operation	No Impact	N/A

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

2.10 Parkwood Cottages South

Site setting, topography and hydrological catchment

2.10.1 The site lies approximately 80m south of Parkwood Cottages, adjacent to the M60 southbound carriageway, which forms the site's southern boundary. Heaton Park Golf Course and Hazlitt Wood SBI are located further to the south, and south of the M60. An access track to Parkwood Cottages runs along the site's eastern boundary.

2.10.2 No hydrological features are shown on OS maps within the site. An unnamed Ordinary Watercourse is shown to issue 100 m north, immediately to the east of Parkwood Cottages, and flows north-east.

2.10.3 The site slopes gently southeast, with elevations ranging from 101mAOD in the west / northwest to 93mAOD in the east / southeast. The total hydrological catchment for the site comprises several sub-catchments to the north, east, and northwest. However, due to the presence of the M60 embankment along the southern site boundary, and the unnamed Ordinary Watercourse to the north, the majority of hydrological inputs to the site are expected to arise from the catchment head located 250m to the east and peaking at an elevation of 108mAOD.

2.10.4 No hydrogeological walkover survey has been undertaken at the site due to landowner access restrictions.

Soils and geology

2.10.5 No GI data were available close to the site at the time of writing. Additionally, there are no historical borehole records within the site itself, however there are three boreholes located 10m, 35m and 50m southwest of the site (SD80NW359, SD80NW68 and SD80NW176, respectively), associated with the existing M60 carriageway (see Table 2.31).

2.10.6 Soils at the site are described as freely draining slightly acid sandy soils (Cranfield University, 2023).

2.10.7 Made ground deposits are shown by geological maps to extend northwards from the M60 embankment into the southern edge of the site. A sandy or silty clay fill (with brick, rock, coal fragments and cinder traces) is described in the three historical borehole records to the southwest, with depths ranging from 0.9mbgl to 3.7mbgl (see Table 2.31).

2.10.8 The underlying superficial geology comprises hummocky glacial deposits of sand and gravel (BGS, 2023). The mapped geology is consistent with the lithology identified in the historical borehole records underlying the made ground deposits, which is described as layers of silty/sandy clay, with sand inclusions and rock and coal fragments (see Table 2.31). In the area to the southwest of the site, the full thickness of the superficial deposits was not proven, with the boreholes terminating at depths of between 3mbgl and 10mbgl.

2.10.9 Bedrock at the site is the Chester Formation, comprised of sandstone (BGS, 2023). A northwest-southeast trending fault is located 50m north of the site, separating the Chester Formation from the Pennine Middle Coal Measures Formation (mudstone, siltstone and sandstone).

Table 2.31 Borehole records for Parkwood Cottages South

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
SD80NW176	0	0.2	TOPSOIL	Not encountered
	0.2	0.9	Sandy CLAY fill with brick, rock and some coal fragments (MADE GROUND)	
	0.9	2.8	Silty CLAY with pebble gravel and silty sand pockets and coal fragments	
	2.8	3	CLAY with coal fragments	

Borehole ID	Top (mbgl)	Base (mbgl)	Lithology Description	Groundwater Strike (mbgl)
SD80NW68	0	0.1	Turf and TOPSOIL	Very slight seepage between 2.5m and 3m
	0.1	1.2	Sandy CLAY fill (MADE GROUND)	
	1.2	2.2	Sandy CLAY becoming silty sand at base	
	2.2	3.2	Laminated silty CLAY with fine sand in part	
	3.2	4.2	Sandy CLAY	
	4.2	8	Silty sandy CLAY with occasional rock fragments	
SD80NW359	0	0.2	TOPSOIL	Not encountered
	0.2	2.4	Silty CLAY with occasional pebbles, sandstone fragments, cinders, and traces of brick (MADE GROUND)	
	2.4	3.7	Silty SAND with clay inclusions, traces of cinder and vegetation (MADE GROUND)	
	3.7	10	Silty CLAY with occasional sand and silt inclusions, pebbles, sandstone, siltstone and mudstone fragments	

Groundwater

2.10.10 There are no GI boreholes available close to the site to provide an indication of groundwater seeps, strikes, or rest water levels. Only one of the nearby historical borehole records (SD80NW68) encountered groundwater as a slight seepage between 2.5mbgl and 3mbgl (see Table 2.31), in a laminated silty clay layer (with sand) in the superficial deposits. The other two historical boreholes remained dry at the time of drilling. This suggests that groundwater is likely to be contained within the sandier clay layers of the superficial aquifer.

2.10.11 No hydrogeological walkover survey has been undertaken at the site due to landowner access restrictions. However, a walkover survey of an issues located 100m north of the site was carried out in April 2023. No culvert inlet / outlet, seepage, or spring discharge was identified.

2.10.12 The BGS susceptibility to groundwater flooding dataset classifies the site as having limited potential for groundwater flooding to occur (BGS, 2021b). However, the northern boundary of the site is classified as having potential for groundwater flooding to occur to property situated below ground level.

2.10.13 No licensed groundwater abstractions were identified within the site or its vicinity (Environment Agency, 2021). At the time of writing, no PWS questionnaire results were available for the site and so the presence of PWSs cannot be ruled out.

2.10.14 Given the above, and the absence of springs, sinks, sources, issues, collects, or spreads within the site boundary, as shown on OS maps and historical maps, groundwater levels are not anticipated to be particularly shallow in this area.

2.10.15 No groundwater quality information from the GI data is available for this site.

Habitats and vegetation

2.10.16 A UKHab survey was undertaken for Parkwood Cottages South. The site was classified as a g3c15 habitat type, i.e., other neutral grassland with a significant component of *Juncus* (rush) species. The dominance of rush vegetation could indicate waterlogging within the site, and GWTDE could therefore be present.

2.10.17 There are no ecological designations present within the site.

Conceptual site model

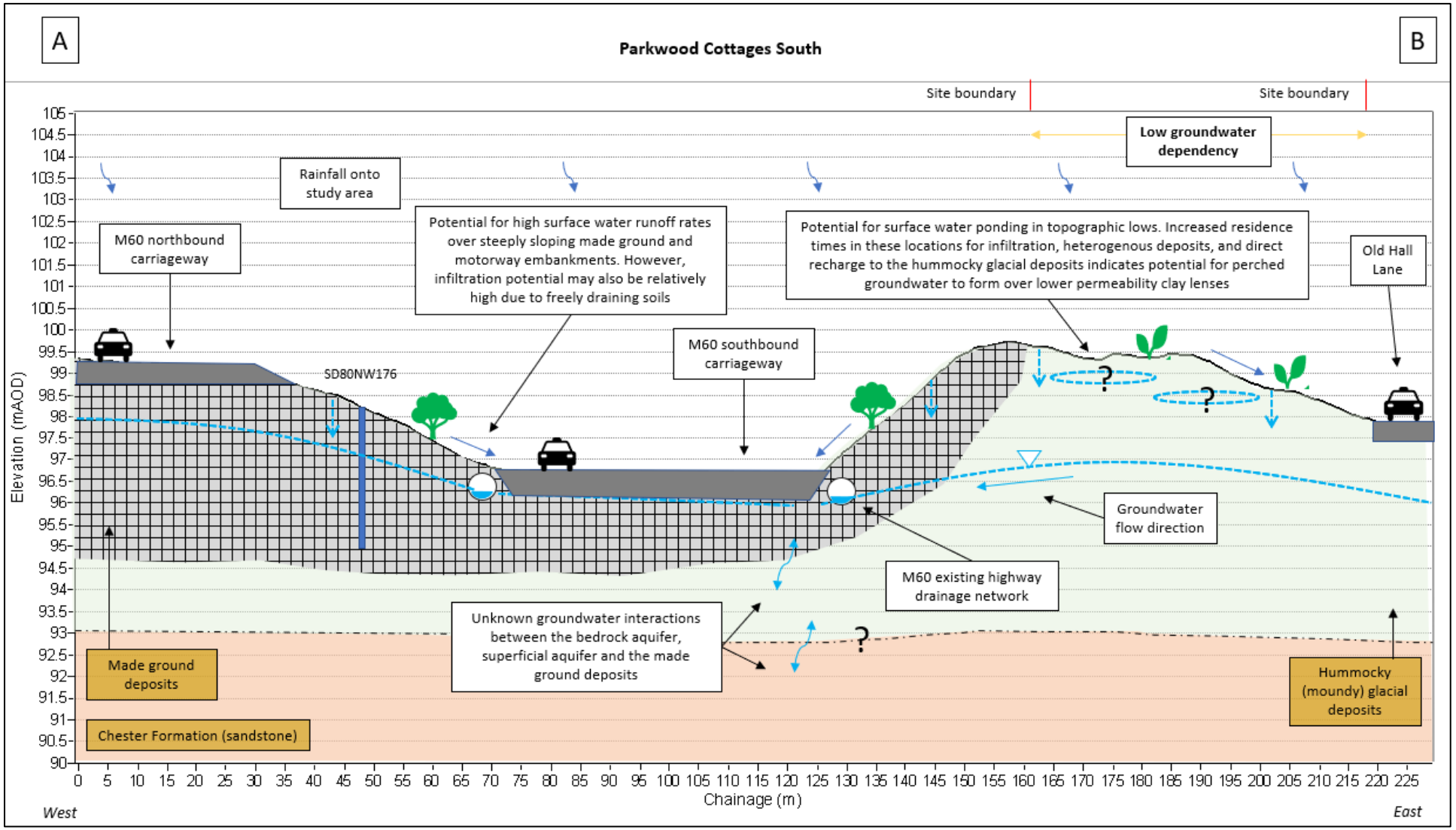
2.10.18 Plate 2.9 shows a conceptualised cross-section running west to east through the centre of the site.

2.10.19 The site is situated between the M60 southbound carriageway embankment to the west, and Old Hall Lane and the catchment head beyond to the east. Localised topographic lows within the site likely receive surface runoff from the north and east, as well as incident rainfall across the site. Infiltration potential may be relatively high due to the presence of freely draining soils. And with the anticipated absence of made ground, recharge would be direct to the hummocky glacial deposits.

2.10.20 Given the limited potential for groundwater flooding to occur and the absence of springs, sinks, sources, etc. within the site boundary, as shown on OS maps and historical maps, groundwater levels are not anticipated to be particularly shallow at the site. However, due to the variable lithology of the hummocky glacial deposits, potential for groundwater to be locally perched above lower permeability lenses in the superficial aquifer cannot be ruled out. The site is therefore classified as having a **low groundwater dependency**.

2.10.21 Given that the site has no ecological designation, the value of the GWDTE is low.

Plate 2.9 Conceptual site model for Parkwood Cottages South



Assessment of effects

2.10.22 The site lies 40m east and across-gradient of the Order Limits at its closest point.

Construction

2.10.23 The site lies outside of the estimated dewatering zones of influence for the nearest cutting, pond and drainage connections. No dewatering impacts on groundwater flows, levels or quality at the site are therefore predicted.

2.10.24 Given that the Order Limits are located 40m across-gradient from the site, no impacts to groundwater flows and levels because of ground disturbance (associated with ground compaction, soil stripping and vegetation clearance etc. within the Order Limits) are predicted at the site. In addition to this, no impacts are predicted to the GWDTE from the construction of the cuttings, embankments, bridges, gantries, or drainage assets, given their distance from the site.

2.10.25 No impacts to existing groundwater quality are also predicted to the site during the construction of the Scheme.

Operation

2.10.26 There are no permanent below ground structures or embankments within the vicinity of the site to locally alter groundwater levels and flows supporting GWDTE. No operational impacts to groundwater flows and levels at the site are therefore predicted.

2.10.27 Considering the distance of the Scheme from the GWDTE, and its position across-gradient from the site, no impacts on groundwater quality are expected to the site during the operation phase.

Summary

2.10.28 A summary of the effects to the site is provided in Table 2.32.

Table 2.32 Summary of effects to Parkwood Cottages South

Groundwater Dependency	Ecological Designation	Value	Effect	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
Low	None	Low	Accidental leaks / spills of fuels and chemicals (groundwater quality)	Construction	No Impact	N/A
			Mobilisation of suspended solids (groundwater quality)	Construction	No Impact	N/A
			Creation of vertical pathways for contaminated groundwater in short and / or long-term, or mixing of different groundwater chemistries (groundwater quality)	Construction	No Impact	N/A
			Short and / or long-term disturbance of groundwater flows (groundwater levels / flows)	Construction	No Impact	N/A
			Cutting dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Pond dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Drainage connection dewatering (groundwater levels / flows / quality)	Construction	No Impact	N/A
			Short and / or long-term changes in recharge rates (groundwater levels / flows)	Construction / Operation	No Impact	N/A
			Groundwater contamination from routine runoff, or accidental leaks / spills (groundwater quality)	Operation	No Impact	N/A
			Ground settlement in superficial deposits (groundwater levels / flows)	Operation	No Impact	N/A
			Long-term disturbance of groundwater flows (groundwater levels / flows)	Operation	No Impact	N/A

Groundwater Dependency	Ecological Designation	Value	Effect	Phase	Highest Magnitude of Impact*	Highest Significance of Effect*
			Intercept contaminated groundwater in long-term, or mixing of different groundwater chemistries (groundwater quality)	Operation	No Impact	N/A

*There is a range in potential impact magnitudes for certain reasons, primarily due to the size of the GWDTE and the proximity of areas to the works footprint. This table summarises the worst case, i.e., the highest magnitude of impact, and therefore the highest significance of effect.

3 Summary of the effects

3.1.1 A summary of the assessment of groundwater dependency of each GWDTE, and the associated magnitudes of impacts to existing groundwater levels, flows, and quality, is provided in Table 3.1.

3.1.2 Three sites (Cowl Gate Farm, Egypt Lane South, and Castle Brook South) are expected to experience significant adverse effects to the groundwater flows, levels, and / or quality sustaining the GWDTE present, without mitigation being implemented. These three sites are also likely to be subject to partial or total habitat loss because of soil stripping and vegetation clearance within the GWDTE footprint. Mitigation measures specific to the loss of habitat are discussed in Section 13.9 of Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1).

Table 3.1 Summary of potential GWDTEs and associated impacts

Site	Ecological Designation	Groundwater Dependency	Value	Construction / Operation	Highest Magnitude of Impact	Highest Significance of Effect
Hazlitt Wood SBI	SBI	Moderate to low	High to medium	Construction	Minor	Slight adverse
				Operation	Minor	Slight adverse
Hollins Vale LNR, SBI and Hollins Plantation SBI	LNR and SBI	Moderate to low	High to medium	Construction	Negligible	Neutral
				Operation	No impact	N/A
Philips Park LNR and SBI	LNR and SBI	Moderate to low	High to medium	Construction	No impact	N/A
				Operation	No impact	N/A
Cowl Gate Farm	None	High to low	Medium to low	Construction	Major	**Large adverse**
				Operation	Moderate	**Moderate adverse**
The Hills South	None	Moderate to not groundwater dependent	Medium to none	Construction	Minor	Slight adverse
				Operation	Negligible	Neutral

Site	Ecological Designation	Groundwater Dependency	Value	Construction / Operation	Highest Magnitude of Impact	Highest Significance of Effect
Castle Brook South	None	Moderate	Medium	Construction	Major	**Large adverse**
				Operation	Moderate	**Moderate adverse**
Egypt Lane South	None	Moderate	Medium	Construction	Major	**Large adverse**
				Operation	Moderate	**Moderate adverse**
Simister Allotment Gardens	None	Moderate to low	Medium to low	Construction	Negligible	Neutral
				Operation	No impact	N/A
Parkwood Cottages South	None	Low	Low	Construction	No impact	N/A
				Operation	No impact	N/A

Acronyms and initialisms

Acronym or initialism	Term
AOD	Above Ordnance Datum
BAP	Biodiversity Action Plan
BGS	British Geological Survey
CSM	Conceptual Site Model
Defra	Department for Environment, Food and Rural Affairs
EMP	Environmental Management Plan
EQS	Environmental Quality Standards
GI	Ground Investigation
GMEU	Greater Manchester Ecology Unit
GWDTE	Groundwater dependent terrestrial ecosystem
HPI	Habitat of Priority Importance
JNCC	Joint Nature Conservation Committee
LiDAR	Light detection and ranging
LNR	Local Nature Reserve
MAGIC	Multi-Agency Geographic Information for the Countryside
N	Nitrogen

Acronym or initialism	Term
NVC	National Vegetation Classification
OS	Ordnance Survey
PAH	Polycyclic Aromatic Hydrocarbons
PWS	Private Water Supply
SAC	Special Area of Conservation
SBI	Site of Biological Importance
SEPA	Scottish Environmental Protection Agency
SSSI	Site of Special Scientific Interest
TPH	Total Petroleum Hydrocarbons
UKHab	UK Habitat Classification
UKTAG	UK Technical Advisory Group

Glossary

Term	Definition
Collects	Where a bog or a marsh becomes a stream.
Dewatering (groundwater)	Groundwater control which typically involves pumping groundwater from an array of wells or sumps, located in or around an excavation, to temporarily lower groundwater levels to allow excavation to be carried out in dry and stable conditions.
Issues	The source of a stream which is a natural emission from an agricultural drain, or where the stream re-emerges from underground.

Term	Definition
Lodge	A reservoir of any size used for holding water, typically associated with mining or quarrying.
Recharge	Recharge of an aquifer occurs water added to the aquifer through the unsaturated zone after infiltration and percolation following any storm rainfall event.
Seep/seepages	A seep or flush is a moist or wet place where groundwater reaches the surface from an underground aquifer.
Sinks	Where a watercourse disappears into the ground.
Sources	The recognised source of a major waterway.
Spreads	A place where a stream spreads into a marsh or onto a sand or shingle beach or an area of rough grass.
Springs	A point at which groundwater discharges onto the surface.
Strike	The level at which water is first encountered when drilling.

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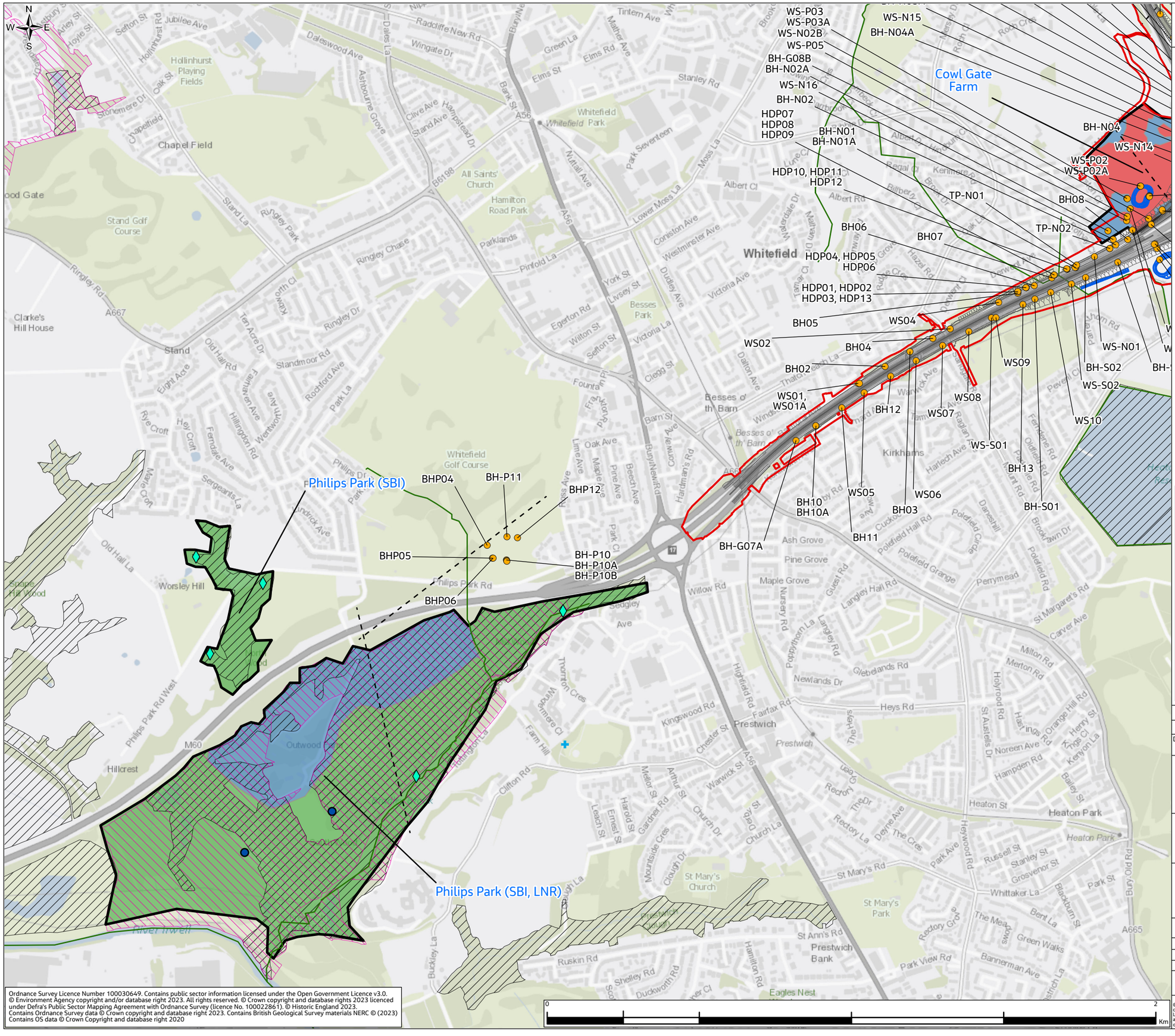
Annex A Figures

Figure 13.5.1: Groundwater Dependent Terrestrial Habitats

Figure 13.5.2: Hydrogeological Walkover Survey Locations

ENVIRONMENTAL STATEMENT APPENDIX 13.5 FIGURE 13.5.1



Legend

- Order Limits
- Ground Investigation (GI) Boreholes
- Scheme Highway Design
- Well
- Spring
- Issues
- Ponds and Swales
- Watercourses
- Groundwater Dependent Terrestrial Ecosystem (GWDTE) Transects
- GWDTE Boundary
- Local Nature Reserves (LNR)
- Sites of Biological Importance (SBI)

GWDTE Groundwater Dependencies

- High
- Low
- Moderate
- Not groundwater dependent

0 2 Km

Rev.	Rev. Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
P01	JAN 24	For DCO application	LT	MS	JR	BB

Development Consent Order Number: TR010064

Development Consent Order Drawing Number: 6.3

Client: national highways

Project: REGIONAL DELIVERY PARTNERSHIP
M60/M62/M66 SIMISTER ISLAND INTERCHANGE

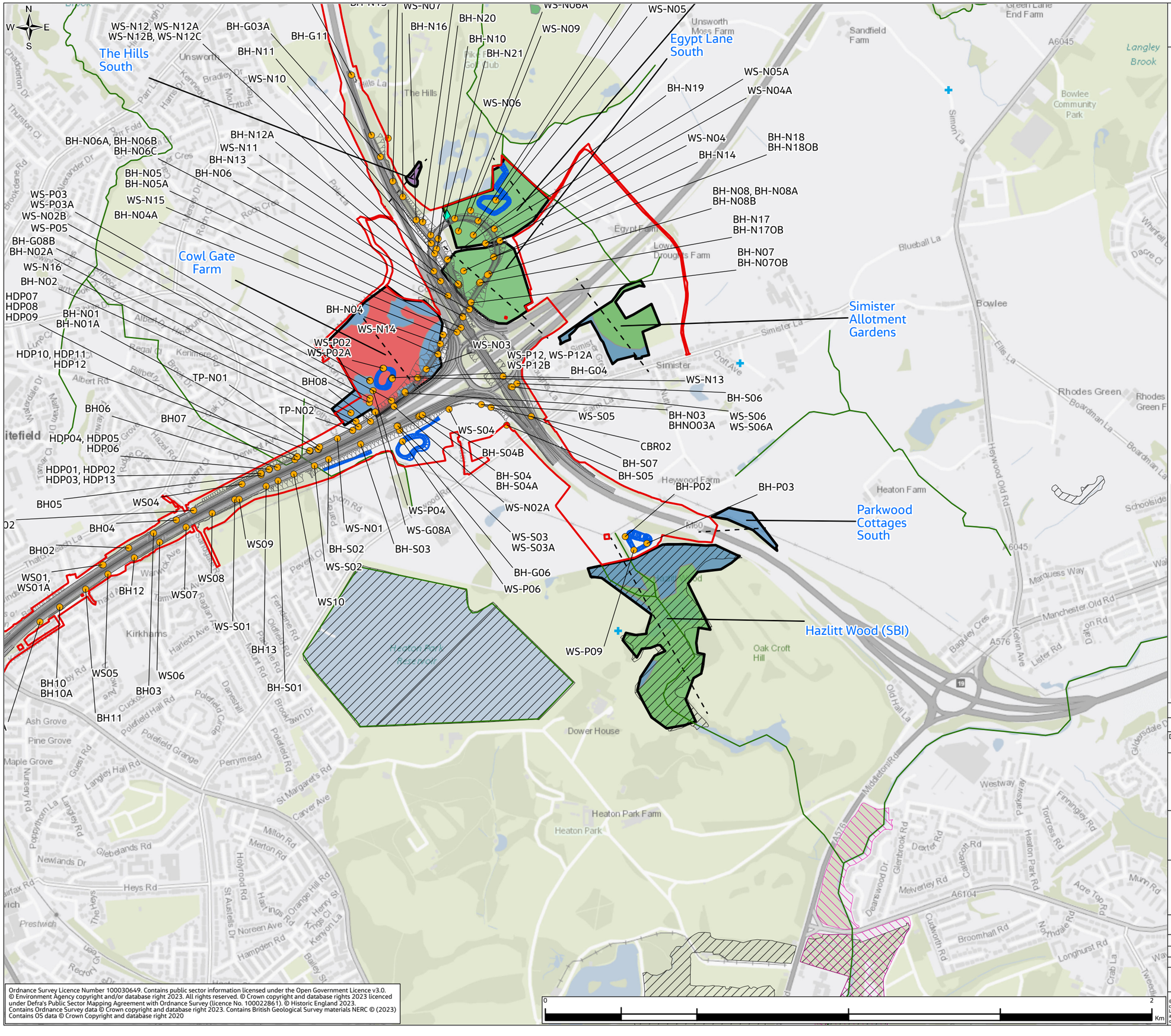
Drawing Title: GROUNDWATER DEPENDENT TERRESTRIAL HABITATS SHEET 1 OF 3

Drawing Status: S4 – SUITABLE FOR STAGED APPROVAL

Scale @ A3	1:12,000	DO NOT SCALE	
Jacobs No.	B36601F0	Rev	P01
Client No.	HE548642		

Drawing Number: HE548642-JAC-LDC-SII_MLT-SK-LE-0037

ENVIRONMENTAL STATEMENT APPENDIX 13.5 FIGURE 13.5.1



Legend

- Order Limits
- Ground Investigation (GI) Boreholes
- Scheme Highway Design
- Well
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P01	JAN 24	For DCO application	LT	MS	JR	BB

Development Consent Order Number: TR010064

Development Consent Order Drawing Number: 6.3

Client: national highways

Project: REGIONAL DELIVERY PARTNERSHIP M60/M62/M66 SIMISTER ISLAND INTERCHANGE

Drawing Title: GROUNDWATER DEPENDENT TERRESTRIAL HABITATS SHEET 2 OF 3

Drawing Status: S4 – SUITABLE FOR STAGED APPROVAL

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Jacobs No.	B36601F0	
Client No.	HE548642	Rev P01

Drawing Number: HE548642-JAC-LDC-SII_MLT-SK-LE-0037

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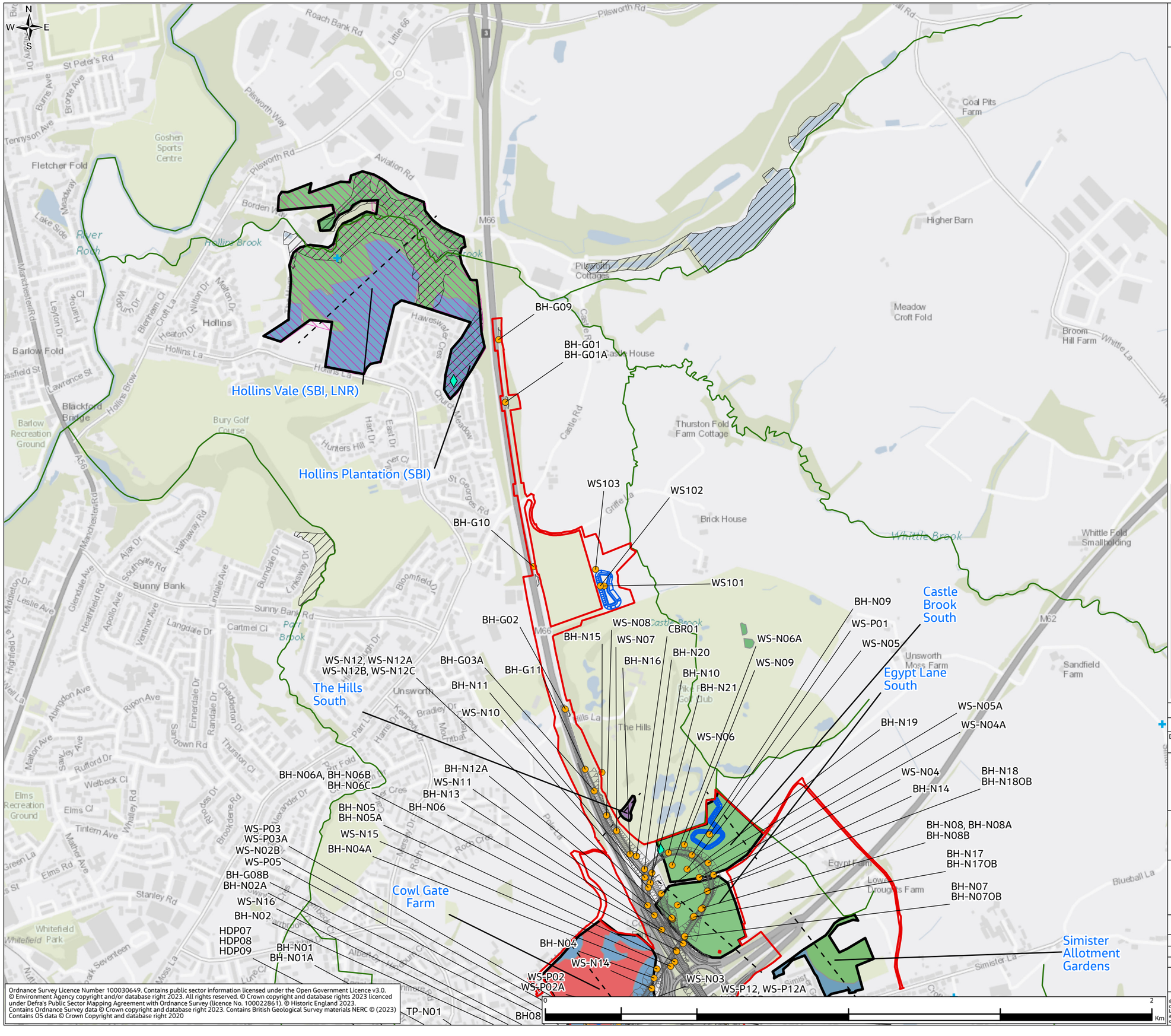
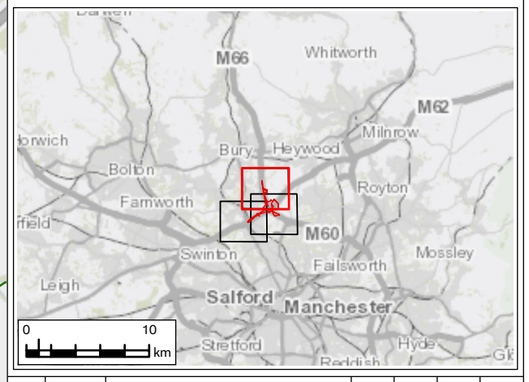
ENVIRONMENTAL STATEMENT APPENDIX 13.5 FIGURE 13.5.1





Legend

- Order Limits
- Ground Investigation (GI) Boreholes
- Scheme Highway Design
- Well
- Spring
- Issues
- Ponds and Swales
- Watercourses
- Groundwater Dependent Terrestrial Ecosystem (GWDTE) Transects
- GWDTE Boundary
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- Not groundwater dependent

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P01	JAN 24	For DCO application	LT	MS	JR	BB

Development Consent Order Number: TR010064

Development Consent Order Drawing Number: 6.3

Client: national highways

Project: REGIONAL DELIVERY PARTNERSHIP
M60/M62/M66 SIMISTER ISLAND INTERCHANGE

Drawing Title: GROUNDWATER DEPENDENT TERRESTRIAL HABITATS SHEET 3 OF 3

Drawing Status: S4 – SUITABLE FOR STAGED APPROVAL

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Jacobs No.	B36601F0	
Client No.	HE548642	Rev P01

Drawing Number: HE548642-JAC-LDC-SII_MLT-SK-LE-0037

ENVIRONMENTAL STATEMENT APPENDIX 13.5 FIGURE 13.5.2

Legend

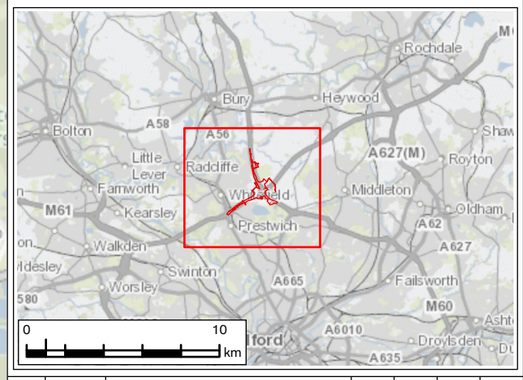
- Order Limits
- Spring
- Well
- Groundwater dependent terrestrial ecosystem (GWDTE) Boundary

Hydrogeological walkover survey locations

Status

- Agreed
- Outstanding
- Refused

Hollins Vale
Castle Brook South
The Hills South
Egypt Lane South
Simister Allotment Gardens
Cowlgate Farm
Parkwood Cottages South
Philips Park
Hazlitt Wood



Rev.	Rev. Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
P01	JAN 24	For DCO application	LT	MS	JR	BB

Development Consent Order Number: TR010064

Development Consent Order Drawing Number: 6.3

Client: national highways

Project: REGIONAL DELIVERY PARTNERSHIP M60/M62/M66 SIMISTER ISLAND INTERCHANGE

Drawing Title: HYDROGEOLOGICAL WALKOVER SURVEY LOCATIONS

Drawing Status: S4 – SUITABLE FOR STAGED APPROVAL

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Client No.	HE548642	Rev	P01

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