Technical Note

Project:	Bradwell B Nuclear Power Plant - Load Test Pit		
Subject:	Abstraction Licence Application – Supporting Information v1 (updated)		
Author:	Charles Stafford	Checked:	Dan Welch
Reviewed:	Sam Williams	Authorised:	Duncan Cartwright
Date:	02/03/2020	Project No.:	5193653
Distribution:	National Permitting Service Ross Stewart/ Neil Burke	Representing:	Environment Agency BRB GenCo Ltd

Introduction

This document supports the application for a water resources licence for abstraction at the proposed site of Bradwell B Nuclear Power Plant, Bradwell on Sea made by Bradwell Power Generation Company Limited (BRB GenCo Ltd).

The document includes supplementary information required by parts B and C of form WR328 as well as references to additional documentation of relevance to the application, as detailed in Table 1.

Table 1 - Summary of supporting information for abstraction licence application

Part	Question	Supporting information included in this document	Referenced documents
B	5	Groundwater Investigation	Environment Agency meeting minutes (Appendix A)
	6	Discharge details	Mott MacDonald Interim Drainage Strategy (Appendix B)
	10	Abstraction locations	Drawing 412657-MMD-00-XX-DR-C-0003 (Appendix C)
	11	Rights of access	Drawing SZC-NNBPEA-XX-000-DRW-000016 - REV 06 (Appendix D)
	12	Environmental assessment	Hydrogeological Impact Appraisal (Appendix E)
	13	Abstraction details	Mott MacDonald Interim Drainage Strategy (Appendix B)
	14	Safe passage for eels	Environment Agency Correspondence (Appendix A)

Part	Question	Supporting information included in this document	Referenced documents
C	4	Method and measurement of abstraction	Mott MacDonald Interim Drainage Strategy (Appendix B)
	5	Water-usage calculations	Mott MacDonald Interim Drainage Strategy (Appendix B)

Part B

Question B5 – Groundwater investigation at the site

It was agreed with the Environment Agency that there is no requirement for a groundwater investigation prior to submission of the licence application. This was agreed at a meeting on 3 December 2019 at Iceni House (with attendance by Neil Dinwiddie, Hannah Hawkins, Jackie Kames, Sean Hickling and Alex Evans). The agreed minutes of the meeting are attached to this application (Appendix A).

Question B6 – Discharge details

BRB GenCo Ltd have submitted an application for an Environmental Permit to cover the discharge of water associated with the dewatering abstraction.

A single discharge location is sought. Abstracted water will be discharged to an ordinary watercourse (tributary of Weymarks River) at National Grid Reference (NGR) TM 01249 08474. Detail of the discharge arrangements are included within the Mott MacDonald Interim Drainage Strategy (Appendix B)

The maximum discharge rate of 15 l/s (1,296 m^3/d) is based on maximum greenfield run-off rates for the area of the site managed by the drainage strategy. The actual dewatering discharge is anticipated to be lower than this as shown in Question B13.

Question B10 – Abstraction locations

A map showing the proposed location of the abstraction, within the Load Test Pit excavation (referred to as “Bradwell_1”), is included as Drawing 412657-MMD-00-XX-DR-C-0003 (Appendix C).

Bradwell_1 is defined as the area between NGR’s TM 01071 08331, TM 01180 08369, TM 01243 08180 and TM 01136 08146. The grid references quoted in Question B10 are approximate design locations; as-built locations may differ from these, to within 10 m.

The drainage strategy, designed by Mott MacDonald, is included as Appendix B. Nuisance water in Bradwell_1 (comprised of a mix of direct rainfall and groundwater seepage from the superficial perched aquifer and weathered London Clay bedrock) will drain via gravity to a temporary Pumping Station (Pump Sump) at a level of approximately -7.5 m above ordnance datum (AOD). From here, the nuisance water will be pumped out of the excavation to the lined perimeter drainage system within the site area. All abstracted nuisance water will be directed to the proposed discharge location, via a Settlement/ Attenuation Pond.

Question B11 – Rights of access and planning permission

As shown in Drawing SZC-NNBPEA-XX-000-DRW-000016 - REV 06 (Appendix D), the Load Test Area straddles three land boundaries:

- Bradwell B Power Generating company Limited (BRB GenCo Ltd) lease (blue);
- Wallum (pink); and
- Strutt & Parker (green).

Within the BRB lease, BRB GenCo Ltd have full right of access until under a 30-year agreement, which covers the duration of the Bradwell B project. Within Wallum and Strutt & Paker land, BRB GenCo Ltd have in place access agreements that provide BRB GenCo Ltd with the necessary rights of access to undertake the site investigation works until 16 December 2022 and 4 December 2022, respectively. BRB GenCo Ltd is currently negotiating extensions to both of these access agreements to cover the maximum duration of the site investigation works and has a high-level of confidence that the necessary extensions will be agreed. Ultimately, as part of overall project delivery, this land will be acquired by BRB GenCo Ltd.

Further details of rights of access, including the relevant lease and access agreements, are available on request.

Planning permission is currently being sought for the proposed development of Bradwell B nuclear power plant.

Question B12 – Environmental assessment

A Hydrogeological Impact Appraisal (HIA) has been carried out for the dewatering abstraction. This HIA is presented in the form of a Technical Note as a supporting document with this application form (Appendix E).

The HIA was prepared based on the interim drainage strategy designed by Mott MacDonald (Appendix B). It provides an assessment of the potential impacts from the dewatering system, based on the current design.

Question B13 – Abstraction details

The dates provided in Question B13 are indicative only. Dewatering is anticipated to commence in May 2020 and continue for approximately 2 years. However, to ensure a significant level of contingency, Question B13 allows for dewatering to continue for a period of 3 years (May 2023).

For the purpose of licensing, the initial 30 days of the Permit (May 2020) will comprise the construction phase of the dry Load Test Pit excavation. The period from 31 days (June 2020) onwards, until the cessation of abstraction (May 2023), is considered to comprise the operational (long-term) phase, throughout which the abstraction will be used to maintain dry conditions within the excavation.

Nuisance water comprising groundwater seepage and direct rainfall will drain via gravity to a temporary Pumping Station (Pump Sump) in the base of Bradwell_1 throughout the 3-year period. The maximum abstraction rates have been derived as follows.

Maximum flow rate

For licensing purposes, in order to provide sufficient contingency in the event of a 1-in-100 year rainfall event, the maximum daily and hourly abstraction volumes are based on a peak flow rate of 100 l/s in-line with the pump capacity.

However, based on calculations presented in Section 10.3 “Groundwater Ingress Calculation Summary” of the Interim Drainage Strategy, developed by Mott MacDonald (Appendix B), it is assumed that the maximum flow rate required to construct a dry excavation will be approximately 5.62 l/s for a period of 30 days. To allow for an additional 20% contingency, the maximum flow rate during construction is approximated to be 6.74 l/s.

Thereafter, it is calculated that the long-term maximum flow rate will be 2.72 l/s (or 3.26 l/s, when allowing for an additional 20% contingency).

Maximum hourly amount

The maximum hourly amount is based on the maximum pumping rate of the pumps.

Maximum daily amount

The maximum daily amount is based on the estimate of maximum greenfield run-off rates that are unlikely to be exceeded in any given day.

It is expected that 100% of the abstracted water will be discharged with no consumptive use or any intervention resulting in unfavourable changes to water quality. The abstraction will be active 24 hours per day to ensure that the excavation remains dry at all times.

Calculated flow rates, estimated for the lifetime of the permit, are summarised in Table 2.

Maximum annual abstraction volume

The total annual abstraction volume quoted in Question B13 is based on the calculations presented in Section 10.3 “Groundwater Ingress Calculation Summary” of the Interim Drainage Strategy developed by Mott MacDonald (Appendix B). During Year One, the total annual abstraction volume includes nuisance water associated with the initial ingress of groundwater from the superficial perched aquifer within the cut off wall during construction, the continued removal of groundwater ingress from the weathered London Clay bedrock and direct rainfall.

For Year One, the total annual abstraction volume is estimated based on the following:

- the maximum abstraction rate during construction (including 20% contingency) of 6.74 l/s for 30 days; plus

- the long-term maximum flow rate (including 20% contingency) of 3.26 l/s for the remaining 11 months of the year; plus
- For contingency, it is assumed that there is the potential for one 1-in-100 year storm event to take place within the year. Therefore, an additional 1,300 m^3 is added to the total volume.

The total of the above elements, when rounded to 3.s.f. results in an estimated total annual abstraction volume for Year One of 116,000 m^3.

From Year Two onwards, it is assumed that groundwater ingress from the superficial aquifer within the cut-off wall is no longer a component of the abstraction and that the long-term rate occurs for 365 days a year. For contingency, it is assumed that there is the potential for one 1-in-100 year storm event to take place each year and, as such, an additional 1,300 m^3 is added to the total volume. This results in an estimated total annual abstraction volume for Year Two onwards of 107,000 m^3 per year, when rounded up to 3.s.f.

For licensing purposes, the greater annual volume of 116,000 m^3 for the Year One period is applied for.

Table 2 - Summary of abstractive volumes

Period of Operation	Timescale	Total annual abstraction volume (m^3/annum)	Total daily abstraction volume (m^3/d)	Total hourly abstraction volume (m^3/hr)	Maximum flow rate (l/s)
Year 1					
Construction *(with 20% contingency)*	30 days	14,580 *(17,496)*	486 *(583)*	20 *(24)*	5.62 *(6.74)*
Long-term *(with 20% contingency)*	11 months	80,400 *(96,480)*	240 *(288)*	10 *(12)*	2.72 *(3.26)*
Storm Event	3.5 hour event in period	1,300	1,300	360	100
Total	Year 1	116,000	1,300	360	100
Year 2 Onwards					
Long-term *(with 20% contingency)*	1 year	87,600 *(105,120)*	240 *(288)*	10 *(12)*	2.72 *(3.26)*
Storm Event	3.5 hour event in period	1,300	1,300	360	100
Total	Year 2 onwards	107,000	1,300	360	100
Licence Submission		**116,000**	**1,300**	**360**	**100**

Question B14 – Safe passage for eels

Neil Dinwiddie (EA Project Manager – Bradwell B Nuclear New Build), confirmed via email dated 22 January 2020 that there is no requirement to screen the proposed abstraction. The Load Test Pit excavation is not connected to any watercourse or waterbody (Appendix A).

Question B18 – Declaration and signature

This form has been signed by Alan Raymant (Director) on behalf of BRB GenCo Ltd.

Part C

Question C4 – Method and measurement of abstraction

Nuisance water in Bradwell_1 will drain via gravity to a temporary Pumping Station (Pump Sump) where it will be elevated to the lined perimeter drainage system within the site area. The water from the Pump Sump will be connected to the same discharge line, prior to connection with the lined perimeter drainage system, and monitored using an in-line flow meter so that the abstraction rate can be recorded.

Question C5 – Water-usage calculations

All nuisance water abstracted from Bradwell_1 will be directed to the proposed discharge location, via a Settlement/ Attenuation Pond. The pond will have a capacity of 4,000 m^3 (Appendix B).

It is expected that 100% of the abstracted water will be discharged with no consumptive use or any intervention resulting in unfavourable changes to water quality. There will be no intervening use of water prior to discharge.

Question C6 – Management agreements

Based on the outcome of the HIA (Appendix E), there are no substantive impacts identified to either groundwater or surface water flow or quality. On this basis there will be no potential impacts to designated sites under the jurisdiction of Natural England.

Therefore, there is no identified requirement to enter into a management agreement with any relevant statutory bodies to enable the dewatering works to be undertaken.

Question C8 – Supporting documents

The map included in Appendix B shows the abstraction locations, discharge points, drainage system, attenuation pond and red line boundary.

Table 1 summarises the referenced and supporting documents that should be considered alongside this application.

Appendix A. – Environment Agency Correspondence

Minutes of Environment Agency Meeting

E-mail from Neil Dinwiddie

Agenda

Meeting: BRB GI Permitting Kick-Off **At:** Iceni House, Ipswich

Date: 03/12/2019 **Time:** 11.00-12.40

Between: Environment Agency, BRB

Attendees

Neil Dinwiddie (EA)
Hannah Hawkins (EA)
Jackie James (EA)
Sean Hickling (EA)
Alex Evans (EA)
Neil Burke (BRB)
Ross Stewart (BRB)
Kwun Shing Chan (Mott McDonald)
John Webber (Mott McDonald)
Mike Sheard (Wood)
Duncan Cartwright (Atkins)
John Dickson (Atkins)
Dan Welch (Atkins)
Sam Williams (Atkins)
Paul Birkenshaw (Atkins)

1. Introductions

Introductions were made.

2. Project Overview

RS Provided an overview of the Ground Investigation Project and key milestones. The GI project is on the critical path for the BRB Project and start is programmed for start of May 2020. The load test is programme for up to 3 years.

KSC provided an outline for the GI Project. There are two main elements:

- Boreholes and trail pits to provide foundation and geo-environmental information. There will be one pump test borehole.
- The Load Test comprises an excavation with three pile-load tests and some other instrumentation at its base, and outside the excavation two areas where excavated Material is mounded to provide a "mounding test", as well as two areas to house the remaining arisings from the excavation, and two attenuation ponds.

Other points are:

- The attenuation ponds take surface water drainage from the load test area, from the mounds and spoil heaps and from the base of the excavation. The attenuation ponds are sized to accommodate the 1 in 100 year event and control discharge to achieve a 2 litre/s/ha release rate (equivalent to the typical greenfield runoff rate). The ponds discharge north east to an unnamed watercourse (not thought to be a Main River) and to the south east to the Weymarks Ditch (this river is classed as a Main River however, the extent is to be confirmed). The attenuation ponds also afford suspended solids settlement and provide pollution control measures (oil booms).
- The load test area drainage is set out to broadly replicate the existing catchments with the northern part (including the excavation) draining to the north and the southern part draining to the south-east.
- There are drainage ditches at the bottom of mound areas and interceptor drains around the edge of the excavation - these are lined where necessary to prevent groundwater in surface deposits from entering the ditches.
- The banks of the excavation will be covered in an impermeable barrier, such as concrete canvass or shotcrete.

Cont'd

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Agenda

3. Permitting Requirements

The potential requirement for waste permitting or materials re-use under CLAIRE was raised by the EA (these may apply if wastes are likely to be generated and removed from the site). BRB to check proposals.

FRA Permit

The EA noted that no flood risk activity permits were needed for the 2017 GI study (although noted that a FRA was submitted as part of the planning application to Maldon District Council as works were within Flood Zone 3 [high probability, albeit defended]). This was primarily because the boreholes and trail pits were kept out of the byelaw distances from main rivers/sea defences. EA will review advice sent previously to BRB and revise as necessary with updated distance criteria and/or exemptions.

EA noted that installing discharge structures in a Main River is likely to require a Flood Risk Activity Permit (and noted that doing so in an ordinary watercourse may require consent from the LLFA (Essex County Council). EA would check the extent of the Weymarks Ditch Main River.

Based on the advice back in 2017, boreholes and trail pits are not likely to require an Flood Risk Activity permit as long as they are outside the relevant byelaw distances from Main Rivers and Sea Defences and do not impede or obstruct flows. BRB would ensure this is the case.

The Load Test area is outside the 1 in 100 year indicative floodplain (without sea defences) apart from the attenuation pond which is inside the indicative floodplain area. The EA's view was that this was not a significant concern provided that all excavated spoil was stored in Flood Zone 1 and would not trigger the need for an FRA Permit.

Abstraction Licences

JW reported that very little water would need to be pumped from the GI boreholes and trial pits, and this not amount to more than 20m3/day in total. The EA noted that as this is below the abstraction licensing threshold, an Abstraction Licence would not be required for this activity. Similarly, a Consent to Investigate a Ground water Source would not be required.

The surface water drainage may be regarded as a surface water abstraction and require an Abstraction Licence. EA requested further details on the amount of surface water to be collected – BRB will supply this in Technical Note to the EA.

The nature of the surface water drains was discussed. The design includes a groundwater cut-off membrane to stop groundwater in the surficial deposits entering the excavation, and a shallow interceptor drain to collect surface water flows; the drains will be lined, where required, to prevent the in-flow of groundwater from surface deposits. Water collecting at the bottom of the excavation (primarily rainwater) would be pumped to the attenuation ponds. The EA asked for further information on the programme of works, depth of groundwater and surficial deposits, design of the drains, and interceptor membrane, along with quantification of groundwater that would be pumped from the excavation and/or collected in any drains. They also asked for information demonstrating how the interceptor drains would be designed to maintain groundwater levels. BRB will provide this information in the Technical Note. This will allow the EA to provide advice on whether a surface water and/or groundwater Abstraction Licence will be required.

Incident rainfall will also need to be pumped from the excavation. The EA requested that BRB supply quantities of rainfall arising (this will be provided in the Technical Note). This will allow the EA to provide advice on how rainwater dewatering will be treated - whether it will require an Abstraction Licence and whether there are any issues around rainwater harvesting (it was noted that there is no storage of rainwater proposed - discharges will be designed to match greenfield runoff rates from the attenuation ponds).

Agenda

Water Discharge Activity Environmental Permit

Groundwater pumping from the borehole will amount to c.2m3 for each pumped borehole (only one is proposed). The EA were of the opinion that, provided groundwater extracted from the borehole is tested and is not contaminated, the water can be discharged to ground subject to local agreement with the EA. An Environmental Permit would not be needed for such a low-risk activity.

The attenuation pond outfalls may well need a Water Discharge Activity Environmental Permit. BRB would provide available information on proposed discharge locations, receiving watercourses, and any available background information in the Technical Note to allow EA to provide an opinion on whether an Environmental Permit is required.

The application would need to contain information on proposed discharge locations, receiving water flows and water quality, discharge flow and contaminants, including suspended sediment. Information on treatment techniques, flocculants to aid settling, or any other proposed additions should be included in the application. There may also be a requirement for an HRA and WFD screening/assessments - the EA will advise on requirement for WFD and/or HRA screening/assessments once the Technical Note is provided.

The availability of background data was discussed – little data is likely to be available on the receiving watercourses. The EA would check their records to see if they had any flow or water quality data. BRB were advised to start collecting information, and plan to continue collecting data into determination.

4. Determination Periods

EA confirmed that determination periods for Abstraction Licences and Water Discharge Environmental Permit applications were 3 months, or 4 months if advertising was required. EA would determine whether advertising from Bradwell site is required and confirm to BRB.

5. Actions

Ref	Action	Who	By when
1	BRB to send Technical Note to EA by end of this week.	BRB	06/12/19
2	EA to identify which watercourses are Main Rivers.	EA	Closed 09/12/19
3	EA to consider permitting requirements following receipt of Technical Note and issue advice on permitting requirements and allied HRA/WFD requirements to BRB within 2 weeks of receipt of Technical Note.	EA	20/12/19
4	EA to review & update previous FRA Permitting advice to BRB and re-issue to BRB.	EA	Closed 09/12/19
5	EA to review available data on water quality and flows in the unnamed watercourse (watercourse the north attenuation pond would discharge to) and Weymarks River and let BRB know the data available.	EA	11/12/19
6	EA to advise on advertisement requirements for permit/licence applications.	EA	11/12/19

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Welch, Dan

From: Dinwiddie, Neil <neil.dinwiddie@environment-agency.gov.uk>
Sent: 22 January 2020 08:09
To: Welch, Dan
Cc: Stewart, Ross; Dickson, John; Cartwright, Duncan
Subject: RE: Data Request - Bradwell B Abstractions and Discharges Search

Hi Dan,

Thanks for your question. This has been referred to one of our fisheries specialists.

From an Eel Regulations compliance perspective, you will not be required to screen an abstraction to dewater a new excavation if it's not connected to any watercourse or waterbody, and eels can be prevented from entering the new excavation. If you are unsure of whether eels may be able to enter the site then it would be best to screen.

In addition, you will also need to ensure that any discharge does not cause a barrier to fish or eel movement from excessive sediment discharge or disturbance, and that the discharge does not cause water quality issues that could impact on eels or fish.

Ross – following our last telecom, we were expecting to see your updated background figures and calculations behind % split. This information will allow us to provide more tailored advice on your permitting requirements. Are you please able to advise when this information may be sent?

Regards,
Neil.

Neil Dinwiddie
Project Manager – Bradwell B Nuclear New Build
East Anglia Area (Essex, Norfolk & Suffolk)
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☎ 07786 524 855
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From: Welch, Dan [mailto:Dan.Welch@atkinsglobal.com]
Sent: 17 January 2020 14:39
To: Dinwiddie, Neil <neil.dinwiddie@environment-agency.gov.uk>
Cc: Stewart, Ross <ross.a.stewart@aecom.com>; Dickson, John <John.Dickson@atkinsglobal.com>; Cartwright, Duncan <Duncan.Cartwright2@atkinsglobal.com>
Subject: RE: Data Request - Bradwell B Abstractions and Discharges Search

Thanks Neil,

I also left a voicemail regarding the requirement to provide eel screening/ safe passage for eels (Question B14.1 of Form WR330: Application for a water resources abstraction licence – part B).

We assume this would not be a requirement for the abstraction, which is effectively a new excavation in a field. Are you able to confirm this or alternatively, can direct me to someone in the Area Fisheries Team who can provide confirmation.

Regards
Dan

Dan Welch *BSc (Hons) MSc FGS CGeol EurGeol RoGEP*
Senior Hydrogeologist, Contaminated Land and Hydrogeology
EDPM - Infrastructure

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Company

From: Dinwiddie, Neil <neil.dinwiddie@environment-agency.gov.uk>
Sent: 17 January 2020 14:35
To: Welch, Dan <Dan.Welch@atkinsglobal.com>
Cc: Stewart, Ross <ross.a.stewart@aecom.com>; Dickson, John <John.Dickson@atkinsglobal.com>; Cartwright, Duncan <Duncan.Cartwright2@atkinsglobal.com>
Subject: RE: Data Request - Bradwell B Abstractions and Discharges Search

Hi Dan,

Thank you for your e-mail and data request.

I have now passed this on to our local customers and engagement team (in Ipswich) to progress this data request. They will be in touch with you to confirm timeframes for responding.

Apologies for only just passing this on – I have been heavily involved in local flood duty incident response work over the last few days, linked to recent rainfall.

Regards,
Neil.

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From: Welch, Dan [mailto:Dan.Welch@atkinsglobal.com]
Sent: 16 January 2020 10:26
To: Dinwiddie, Neil <neil.dinwiddie@environment-agency.gov.uk>
Cc: Stewart, Ross <ross.a.stewart@aecom.com>; Dickson, John <John.Dickson@atkinsglobal.com>; Cartwright, Duncan <Duncan.Cartwright2@atkinsglobal.com>
Subject: Data Request - Bradwell B Abstractions and Discharges Search
Importance: High

Good morning Neil,

Further to my voicemail yesterday afternoon, Atkins wish to progress a data request to support the preparation of the abstraction licence for the load test at Bradwell B.

Please can you provide:

- Details of licensed and unlicensed groundwater and surface water abstractions/ private water supplies in the area; and
- Details of groundwater and surface water discharge consents in the area.

Please let me know if there is a fee for the provision of this information. If you have any queries, please let me know.

Regards
Dan

Dan Welch *BSc (Hons) MSc FGS CGeol EurGeol RoGEP*
Senior Hydrogeologist, Contaminated Land and Hydrogeology
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Appendix B. – Interim Drainage Strategy

MOTT MACDONALD As

Technical Note

Project:	Bradwell B Nuclear Power Plant - Load Test		
Our reference:	412799/MDD/RP/DG/0001_F	**Your reference:**	
Prepared by:	David Vanneck	**Date:**	27/01/2020
Approved by:	Antonia Farrow	**Checked by:**	John Webber
Subject:	Interim Drainage Strategy		

1 Introduction

This interim Drainage Strategy Technical Note has been prepared by Mott MacDonald for the information of BRB Gen Co, the Environment Agency (EA) and others of the purpose and design of the following at Bradwell B Power Station:

i. The Ground Investigation (boreholes and trial pits)

ii. The Load Test Investigation (settlement and heave tests)

iii. The proposed drainage strategy for the Load Test including general design principles, initial calculations and layout. The key drainage features are illustrated on the appended sketch Figure Number 1, Surface Water Drainage Strategy (412799-MMD-SK-DG-0001).

Preliminary intrusive ground investigations are proposed on land adjacent and to the east of Bradwell Power Station, near Bradwell-on-Sea, Essex, to inform the design of a potential new Nuclear Power Station on the site. The application site covers approximately 4.6km^2 and is approximately centred at National Grid Reference TM 01343 08483. The proposed works would be split out into two components. The first component of the works (in this statement entitled the "Ground Investigation Campaign") would consist of exploratory holes sunk into the ground using a variety of techniques, including rotary, sonic and cable percussive drilling, cone penetration testing and the formation of machine excavated trial pits.

The second component of the works (in this statement entitled "Load Test Investigation") would consist of four principal aspects. The first, would be forming an excavation within the ground, and installing various loading tests at the base of the excavation. The second would be to form (at varying heights) earth filled berms, from the material obtained from the excavation. The third aspect would be to undertake long-term monitoring of both proposed Ground Investigations and Load Tests. The final aspect would be to reinstate the excavation with the excavated material.

Associated works would include establishment and use of a temporary Site Compound located on existing hardstanding at approximate National Grid Reference TM 01053 08018, for the undertaking of the Load Test Investigation. Further associated works, in relation to the Ground Investigation Campaign include the establishment of a temporary site compound near East Hall Farm and temporary use (for a period of up to 5 years) of an existing building for the logging, sampling and storage of soil samples (cores) collected in the works.

The remainder of this Technical Note focuses on the Drainage Strategy to be employed for the duration of the proposed Ground Investigations.

2 Load Test Area Description

The second component of the works, the Load Test Investigation, will be focused on a 10-hectare site east of the location of the new Nuclear Power Station and comprises a number of test, storage and temporary site accommodation areas. The area of the Load Test Investigation is illustrated in Figure 1 (Appendix A).

For reference and to provide context to the description of the proposed Load Test Investigation, examples of similar load tests are illustrated on Figure 2 (Appendix A).

The load test facility is being undertaken to reflect the construction sequence and loading from the new Power Station, principally the excavation and foundation settlement. An approximately 220m long by 114m wide, up to 14m deep open cut excavation will be formed to expose the top of the unweathered London Clay. The test is expected to be undertaken over a 2-3 year period.

The aim will be to carry out three Plate Load Tests on the same geological formation. The excavation will be instrumented and monitored before, during and after the excavation to record the associated short-term and long-term movement as well as pore water pressure response and ground swelling behaviour.

Two 4m diameter and one 7m diameter Plate Load Tests will be carried out at the bottom of the excavation. Reaction frames will be structurally connected to the tension piles to provide necessary reaction force to the hydraulic jacks which will be used to apply load to the test plates. At the bottom of the excavation there will be an instrumented Heave Test, to be located away from the three load test plates. This is simply an extension of the excavation which is required for the Plate Load Test facility. It is proposed that one section will be left open to swell with the clay exposed at surface, an adjacent section will be blinded with a thin layer of concrete.

The Load Test Area comprises several distinct zones, each requiring specific drainage systems. The total site area extends to approximately 10 hectares; only areas which have changed in character (reprofiled, elevated, excavated, remaining as an exposed cut-face) and are likely to generate silt laden surface water run-off will be positively drained, other undisturbed areas will remain as-existing without any formal drainage. Based on a Load Test Investigation excavation formation level of -7.00mAOD, the test area comprises:

- Load Test Excavation, approximate depth 13.5-14.0 metres (25,080m^2)
- Spoil storage area (16,400m^2)
- Plant Storage and Materials Lay-down Area (3,000m^2)
- Topsoil storage area (12,400m^2)
- Topsoil storage area (2,000m^2)
- Surcharge Test Area (+6m above GL) (5,500m^2)
- Surcharge Test Area (+8m above GL) (23,500m^2)
- Contractors Site Compound: Comprising Portakabin accommodation and light vehicle parking and located on existing redundant runway/hardstanding

3 Drainage Design Constraints

The site layout and drainage design provision are constrained by:

- Client defined site boundary/land ownership boundaries/potential site access points
- Geological constraints (soil types)
- Topographical features including levels and gradients, existing roads, buildings and watercourses
- Potential surface water drainage outfall locations
- Limitations of existing watercourse capacity

- Avoidance of impacts on groundwater resources (particularly perched water tables located in the superficial deposits
- Hydraulic limitations imposed by third parties (Environment Agency) especially limitations placed on works within a Flood Plain (below the 4.5mAOD contour) or works affecting an existing watercourse (either an Ordinary Watercourse or a Main River)
- Existing public and/or private utilities

4 Information available

The following information has been used to develop the initial drainage strategy:

- LIDAR topographical mapping (Source: Environment Agency database)
- Environment Agency flood risk mapping (Source: Environment Agency, on-line resource)
- Flood Risk Assessment by AMEC Foster Wheeler (October 2017)
- Soil Investigations and Soil Contamination Report by AMEC Foster Wheeler (October 2017)

Further information to be acquired to inform the design and support Environment Agency application:

- Topographical survey of the Load Test Investigation site area (requested – RFI-LT013)
- Ground-penetrating radar (GPR) utilities survey (requested – RFI-LT011)
- Topographical survey of Watercourse at location of proposed connection (requested – RFI-LT013)
- Watercourse flow and quality assessments to inform the EA of baseline conditions

5 Geology and Groundwater

5.1 Local Geology

The soil sequence at the location of the proposed Load Test investigation comprises the following soil types (based on the 1987 Soil Investigation records):

- Topsoil – Depth 300, but varies locally, typically 250-480mm
- Superficial deposits, comprising predominantly Head Deposits, River Terrace Sands and Gravels – Depth varies locally, typically 900-1800, max 2500mm
- Weathered London Clay, typical depth 4800mm
- Competent London Clay, typical depth 37,700mm

5.2 Local Groundwater

Within the superficial deposits minor localised perched aquifers are to be expected in the River Terrace Deposits and coarser Glacial Deposits in the region where they overlie the weathered London Clay (source reference Bradwell B CFS & PSHA Ground Investigation Report, January 2019 (Jacobs)).

The recorded perched water levels in Superficial Deposits in and around the Load Test area from existing historical ground investigations (1987) are:

- BH207 – Superficial Deposit depth extends to 2.28m below EGL, described as ‘CLAY’, ground water not present
- Borehole 212 – Superficial Deposit depth extends 1.55m below EGL, no groundwater encountered
- Borehole BRB BH234 – Groundwater level not determined due to coring technique
- Trial pit 750 – Seepage at 2.6mBGL (2.29mAOD) (predominately clay material)
- Trial pit 713 – Superficial Deposit depth extends to 1.3m below EGL, no groundwater encountered

- Borehole 409 – Response Zone for piezo installed between 1.10 – 2.10mbgl. between Oct ’86 and March ’87; 31 readings were taken and ranged from dry to highest level of 0.82mBGL (5.33mOD).

6 Sources of Water Ingress

Six sources of surface and groundwater ingress are considered in the drainage design (Refer to Appendix A for Figures illustrating the following where required):

- **Load Test Pit Excavation**
  - Direct surface water run-off from the exposed excavation side-slopes and invert will be drained by perimeter ditches at the base of excavation and routed to a Pump Sump situated in a convenient, maintainable and accessible location. A range of pumps will be installed to provide Duty/Standby and Assist Functions. Smaller pumps will be provided for removal of base flows and larger pumps for the removal of high inflow rates. Spare pumps and control equipment will be provided, together with an independent back-up generator for system redundancy. Pumped discharges will be elevated via rising mains and discharge to the Crest Drainage system comprising open channels and piped culverts discharging to the Silt Retention/Attenuation/Pollution Retention Pond to effect water quality treatment. See Figure 1.

- **Surcharge Test, Soil Storage Bund and Peripheral Areas**
  - Direct surface water run-off from Test and Storage Bunds will be generated from the exposed compacted Clays and may contain mobilised silt; it is assumed that recompacted bunds will generate 100% run-off. It is assumed that other soil and topsoil areas will generate 80% run-off. Run-off will be collected in lined perimeter trapezoidal drainage channels and routed to the outfall via the Silt Retention/Attenuation/Pollution Retention Pond. See Figure 3.

- **Tidal Flooding**
  - The site is located above +4.5mAOD and higher than the area which is protected by the Tidal Flooding Defence Embankment, apart from the northern attenuation and settlement pond. The excavation will be protected by a “1:1000-year Flood Defence Breach Bund” with crest level 5.500mAOD (5.170 + 0.300m freeboard). Therefore, the site is not at risk of tidal flooding. The Attenuation Pond and related control structures lie below existing ground level and is not regarded as impacting on the Flood Plain either as an obstruction or a volume displacement. See Figure 1.

- **Fluvial Flooding**
  - The site is entirely within Flood Zone 1, apart from the northern attenuation and settlement pond, which is within Flood Zone 3. Areas of the site which are designated Flood Zone 2 and Flood Zone 3 are also protected by the Tidal Flooding Defence Embankment. Therefore, the site is at very low risk of fluvial flooding. See Figure 1.

- **Pluvial/Natural Catchment Flooding**
  - The site lies within a very low pluvial/surface water flood risk area.
  - The site is situated at the crest of a topographical rise, and there is negligible risk to the site from Pluvial Flooding since there is an absence of an uphill contributing catchment (Figure 4)
  - In the event of any overland surface water flows from localised catchment areas, surface water run-off will be intercepted by a lined trapezoidal perimeter channel (ditch) and rerouted to the Outfall via the Attenuation Pond. Further flood protection will be given to the Test Area by a bund between the ditch and the site with an appropriate crest level to mitigate flood potential from pluvial sources. See Figures 3 & 4.

- **Groundwater Ingress (see Appendix B : Calculations)**
  - Groundwater ingress comprises two principal components :
    - 'Nuisance' groundwater – This may arise from perched water in the permeable overlying River Terrace Sands and Gravels (Secondary Aquifer (surface)). Nuisance water may initially be encountered during the excavation construction phase and would be expected to rapidly dissipate and will not be recharged by the remaining surrounding Secondary Aquifer because a vertical impermeable geomembrane installed to the perimeter of the Excavation and to the full depth of the Superficial Deposits.
      Nuisance water may subsequently arise in the long term from precipitation incident upon the narrow (2.0m wide) crest catchment, percolating into the River Terrace Deposits and emerging from the Load Test Excavation cut-face.
    - Seepage – This will arise from the cut faces and base areas of the Load Test Excavation within Weathered and Competent London Clay. Estimates of flow rates have been made assuming a Load Test Excavation formation level of -7.0m AOD and upper bound permeability limits of the London Clay; these assumptions will be confirmed by the Phase 1 Geotechnical Investigation.
  - The cut faces of the Load Test Pit excavation will remain exposed (unlined). The Superficial Deposits across the site are recorded as both River Terrace Deposits (sand and gravel), Intertidal Deposits (clays and silts) and Head - Diamicton. The superficial deposits that extend across the load test area are classified by the EA as Secondary (undifferentiated) Aquifer at surface. Therefore, any dewatering of these strata will likely fall under the EA Permitting regime.
  - Seepage inflow rates have been assessed using calculations based on the CIRIA C750 guidance (refer to Appendix B). The following seepage inflow rates have been estimated based on a Load Test Pit base level of -7.0mAOD, lower and upper bound permeability of the :
    - Superficial Deposits - *55.4 lit/sec (see Figure 6 and note below)
    - London Clay – 1.7-2.3 lit/sec
  - Figure 6 shows the horizon of the weathered London Clay (base of Superficial Deposits) which would direct perched groundwater into the Load Test Excavation unless mitigation measures were employed.
  - The following has been concluded (see Section 10.1 for further conclusions and assessment of rainfall versus groundwater proportions and Abstraction Licence considerations) :
    - Short term, immediate, and long term groundwater ingress (nuisance water) from Superficial Deposits will require management and discharge during the Construction Phase
    - Long term groundwater ingress (nuisance water) from Superficial Deposits may be excluded and/or minimised from the Load Test excavation by introducing an impermeable vertical barrier around the excavation perimeter to the full depth of the Superficial Deposits. Existing groundwater flows will be redirected around the Load Test Excavation perimeter and will not require Abstraction
    - Seepage inflows from the weathered and competent London Clay will be small, but will be managed and Abstracted during the Construction Phase and in the long term.

- **Existing Field Drainage Systems**
  - Any existing shallow underdrainage/field drainage systems present within the Test Area will be intercepted by the peripheral drainage channel and the flow diverted to the project drainage Outfall via the Settlement/Attenuation Pond

- **Other Ground Investigation Activities**
  - One borehole investigation will be undertaken locally to the Load Test Excavation and a pump testing undertaken to establish soil permeabilities. Volume of water anticipated to be abstracted during the test is less than 20 m^3/day from the Superficial Deposits

Other drainage systems include foul water drainage (any requirements to be confirmed), which is addressed separately in this report.

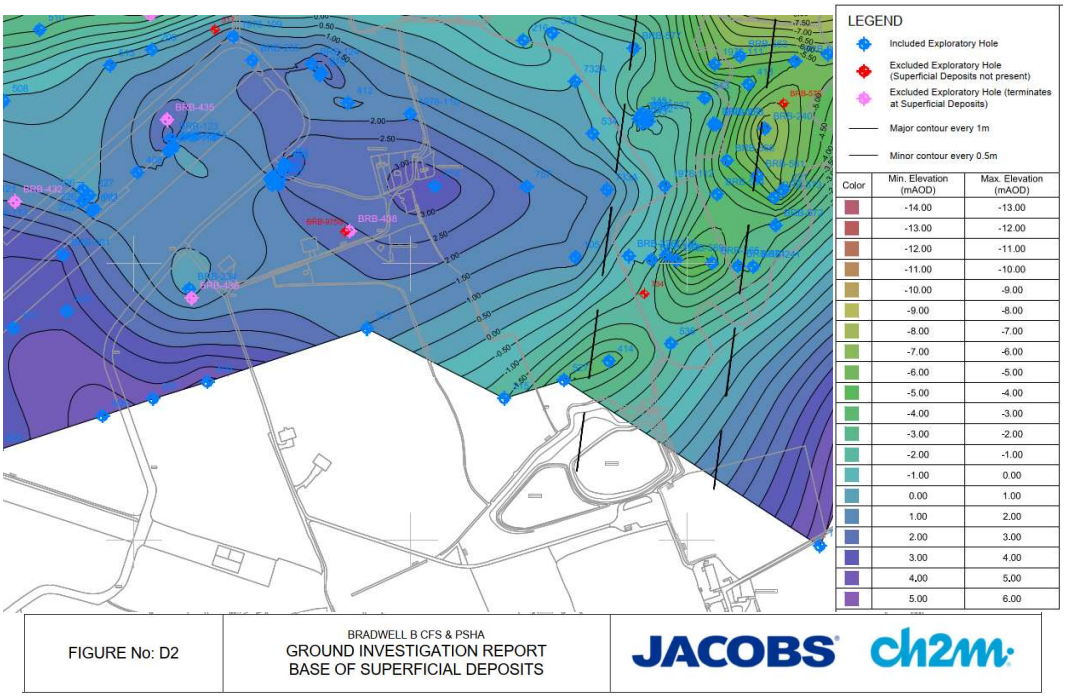


Figure 6 : Contour Plan of Base of Superficial Deposits
Source : Ground Investigation (2017) (Jacobs)

*NOTE : The location of the Load Test Excavation is at a topographical crest where both surface water and ground water shed/divide (see Figure 1 & 4). The Load Test Excavation will intersect any groundwater surface present within the Superficial Deposits with potential to drain it. The location of the Load Test Excavation together with physical mitigation measures (vertical impermeable barrier) to be adopted will minimise or eliminate ground water inflows from Superficial Deposits to the excavation (see Section 9.1).

7 Surface Water Drainage Outfalls

The Preliminary Ground Investigation Flood Risk Assessment (2017) identified the existing land drainage regime, network and features in addition to Flood Risks. Existing watercourses are located approximately 100m to the east (unnamed Ordinary Watercourse) and 200m to the south of the site (Weymarks River, Main River). The direction of land drainage flow is to the East of the Test Site, refer to Figure 4.

It is proposed to discharge surface water run-off collected by the on-site surface water interception system to a single Settlement/Attenuation/Pollution Retention Pond to the north and discharging to the existing Ordinary watercourse located to the east, all subject to verification of watercourse levels, sections and normal water levels. Initial inspection shows the Ordinary Watercourse to have a generous cross section and depth of 1.5m. Construction of an outfall structure in an Ordinary Watercourse requires consent from the Lead Local Flood Authority (Essex County Council). See Plates 1 & 2.

The outfall headwall on the Ordinary Watercourse will be located at approximate National Grid Reference coordinates TM 01249 08474 and as shown on Figure 1 and Plate 2. The headwall will be detailed in accordance with current good practice and will not present an obstruction to flow in the main channel. See Figure 5 for a typical headwall detail.

There are no planned direct connections to Weymarks River (Main River) to the south from the Load Test Site. Consent to undertake works in a Main River would require a Flood Risk Assessment (FRA) Consent from the EA.

A detailed topographical survey of the outfall location and receiving watercourse will be required for detailed design of the drainage system.

Plate 1 : Existing Land Drainage Ditch/Ordinary Watercourse (View east on from Perimeter Road)

Plate 2: Proposed Outfall Headwall Location View south from Access Track

8 Surface Water Quality

The Environment Agency are responsible for the management of developments which have the potential to affect water bodies. Consultations with the EA are to be undertaken by Others. It is normal practice for the EA to impose limitations on surface water quality and quantity (rate of discharge); it is unlikely that BRB Gen Co will acquire Consent to Discharge without significant limitations to peak development flow rates and provision of water quality controls.

BRB Gen Co will be required to comply with Planning Requirements or Conditions which do not automatically confer Consent to Discharge surface water; an application for Consent to Discharge to a watercourse will be required from the Local Lead Flood Authority or the EA (Essex County Council) depending upon the classification of the outfall watercourse. Discharge to groundwater is not proposed due to unsuitable geology comprising mixed superficial deposits overlying low permeability London Clays.

It is anticipated that EA will impose the following surface water discharge limitations; the preliminary drainage design and strategy makes the assumption that the quantitative and quality limitations described are imposed :

- Quantitative discharge rate limitations: Restrict discharge flow from the surface water drainage system outfall into the Ordinary Watercourse to “Greenfield Site Run-Off Rates”, normally taken as 2 litres per second per hectare to maintain the existing drainage flood-flow regime and ensure the avoidance of adverse impacts on the watercourse (erosion, flooding etc).
- Quality limitations: Measures to ensure water quality of discharged surface water from all potential sources of pollution including settlement/removal of silt/cementitious leachate and light liquid/oil separation.
- Pollution management: Causes of accidental pollution would be avoided by adopting current construction site good management practice, this will include :
    - Control of pollution at source (e.g. Use of ‘Spill Kit’s’ at the location of site activities with potential risk)

- Management of refuelling, fuel storage etc (e.g. Well-maintained plant fleet and equipment, double skinned oil storage tanks, designated and bunded hardstanding areas for refuelling, security against vandalism)
- Provision of a floating oil curtain boom within the Silt Settlement/Attenuation Pond (typically a Heavy Duty Floating Fence Boom 560 by Oil Spill Products or equal equivalent).

9 Proposed Drainage System

9.1 Proposed Surface Water Drainage System Description

The proposed Surface Water (SW) drainage system will drain the site into the nearby watercourse by a combination of gravity and pumping and including attenuation and water quality measures. The drainage system comprises the following parts (See Figures 1, 3 & 5):

- Gravity drainage: Surface water run-off generated from site areas will be collected and conveyed by trapezoidal drainage channels/ditches and pipe culverts. Drainage ditches within the Load Test excavation will discharge into a Pump Sump. Drainage ditches located at the crest of the Load Test excavation will be lined and intercept surface water only. Inclusion of an impermeable vertical geomembrane to the perimeter of the excavation will preclude the collection of groundwater by the ditch system. Other strategically located perimeter ditches and pipes will collect and convey surface water to the Settlement/Attenuation/Pollution Retention Pond and ultimately to the existing watercourse to discharge to the existing Land Drainage Network. Discharge rates from the Attenuation Pond will be controlled at the outlet headwall which will incorporate an Orifice Plate or Vortex Flow Control Device or similar. Discharge may be isolated with a Penstock closure device and a Sampling Chamber facility for taking quality samples for testing.
- Trapezoidal Interception ditches: Interception ditches will have a nominal depth of 1.0 to 1.5m, varying locally to suit the terrain, their depth is not expected to intercept any groundwater levels within the Superficial Deposits. Interception ditches will be lined with an impermeable geomembrane (e.g Concrete Canvas or equal equivalent proprietary product) to ensure groundwater is excluded from the new drainage network.
- Pumped drainage: The Load Test Pit will be drained by a temporary Pumping Station. The pumps will extract and elevate the accumulated combined groundwater seepage and surface water run-off from the Pump Sump (below –7.5m AOD) to the perimeter drainage system within the site area. All pumped discharges will pass to the outfall via the Settlement/Attenuation/Pollution Retention Pond.
- Water quality treatment: A combined function Silt Settlement/Attenuation/Pollution Retention Pond located to the north-east of the Test Area will receive all flows from the Site Drainage Network and discharge to the Ordinary Watercourse. The Settlement/Attenuation Pond will be sized for attenuation of peak design flows and to enable settlement of suspended silt and solids (see Section 10). The Pond will include measures to intercept light-liquids (oils and hydrocarbon substances) such as a floating oil boom and will be lined with a semi-impermeable lining to minimise infiltration to the superficial deposits.
- The Silt Retention/Attenuation/Pollution Retention Pond will discharge from the Flow Control Headwall Structure to a Sampling Chamber.
- All surface water run-off will discharge via a new drain (approximately 225mm diameter) to an outfall headwall located in the Ordinary Watercourse located northeast of the Load Test

9.2 Proposed Foul Water Drainage System Description

Welfare facilities will be provided on-site during the Test Pit construction phase and during set-up and monitoring of the Load Test. Details of welfare facilities, capacities and duration on-site are to be developed

from which design flow rates and volumes will be assessed and the most efficient method of foul waste water management assessed.

There are no existing public foul waste water sewers available locally (TBC). Subject to detailed design, waste water would be collected from all welfare facility drainage appliances and stored in a temporary Cesspool constructed for the purpose of the project and complying with the requirements of The Building Regulations, Part H2: Drainage and Waste Disposal, Cesspool Design.

The Cesspool would be maintained in accordance with the Building Regulations guidance, the biological loading and proprietary tank suppliers recommendations. Effluent will be removed from site by Road Tanker and treated at a Water Authority treatment facility.

9.3 Typical Drainage Construction Details

Typical construction details of drainage features described are listed and illustrated in Figures 3 & 5 and comprise:

- Lined trapezoidal surface water drainage interception channel
- Settlement/Attenuation/Pollution Retention Pond Outlet Control Structure
- Sampling chamber
- Precast concrete outfall headwall
- Pumping station

10 Drainage Design Summary

This section summarises surface water and groundwater ingress, comprising short and long term ‘nuisance’ water inflows from the perched Secondary Aquifer and long-term seepage from the London Clays.

10.1 Surface Water Drainage

A series of outline drainage designs and calculations have been prepared to assess drainage requirements, considering several design scenarios and varying design storm return periods, storm durations and expected allowable discharge rates to the receiving watercourse. The following section summarises the initial hydraulic design estimates.

The BRB Gen Co and/or their Contractor may have views on practicality, or the EA or Essex CC may increase or reduce the allowable discharge rate or remove any restriction, in which case alternative scenarios may be considered. All estimates are subject to detailed design when further information is available.

The outline drainage design has been developed using the MicroDrainage Suite of Programmes using both the Modified Rational and Simulation design methods.

The calculations described below consider the Load Test Pit Excavation, Test and Earth Fill Storage Bunds. The drainage installation will comprise the following principal components (refer to Appendix A, Figure 1) :

- Load Test Pit gravity drainage collection network
- Load Test Pit temporary Pumping Station (complete with control kiosk, rising or pumping main, power supply etc)
- Earth Fill Storage Bund perimeter collection conveyance channels/ditches
- *Settlement/Attenuation/Pollution Retention Pond – This would provide a settlement and pollution/oil interception function only, or have an additional attenuation function – depending on the allowable discharge rate to the downstream Ordinary Watercourse

- Attenuation pond outlet headwall structure (incorporating Penstock and Orifice Plate or Vortex Flow Control Device)
- Sampling Chamber
- Outfall headwall to Watercourse to be located at approximate National Grid Reference coordinates TM 01249 08474

*NOTE : The Settlement/Attenuation Pond is located within the Flood Plain (below the 4.5m contour) but since the construction is entirely at or below existing ground level, there are no adverse flood risk impacts and it is understood that this is acceptable to EA.

The preliminary surface water drainage network performance was tested under several design storm return periods; these comprise :

- 1 in 1 year (100% probability of occurring in any one year)
- 1 in 5 year (20%)
- 1 in 30 (3.3%)
- 1 in 100 (1%)

Two design scenarios, referenced Options A and B were modelled. In Option A the drainage system was designed to accommodate all flows without surface-flooding within critical site areas, specifically the Load Test Pit, during the 1 in 100 year event. In Option B the drainage system was modelled wherein the surface water drainage system was designed to preclude flooding of the Load Test Pit Area in the 1 in 100 year event, and all other less critical areas designed to not flood for the 1 in 30 year event.

10.2 Surface Water Drainage Calculation Summary

The two drainage design scenario calculations (A and B) provide estimation of peak discharge rates and attenuation pond storage volumes for the respective design return period, critical design storm durations and Summer/Winter profile storms.

Pumping Station discharge rates have been selected in each case to ensure no flooding in the Load Test Pit excavation for the 1 in 100 year design storm return period. Note that BRB Gen Co expressed a preference to ensure no surface flooding occurs within the Load Test Pit for design storm events up to and including 1 in 100 years.

Table 1 summarises the peak run-off rates from the developed site area both without attenuation and with attenuation to either a 1 in 30 or 1 in 100 year return period. Table 1 also includes the estimated groundwater inflow rates from the Superficial Deposits and underlying London Clay.

The non-attenuated peak design flow rates are extremely high in comparison to that currently experienced by the receiving watercourse. Additionally, a concentrated high peak discharge rate would adversely impact on the receiving watercourse in terms of erosion, flow regime and ecological impacts. Therefore, the drainage model attenuates the peak design flow rates via an Attenuation Pond prior to discharge to the outfall.

For the purpose of space-proofing, Drainage Design Option A requires the maximum Attenuation Pond volume of approximately 4000 cubic metres; assuming a maximum working depth of 1.5 metre, an area of 3300 square metres has been reserved. Peak discharge rate to the Watercourse would be limited to 15 litres/sec in each case.

Drainage Design Option Reference	Drainage Network Design Return Period (1 in Years)	Load Test Pit Maximum Pump Rate (lit/sec)	Total Non-Attenuated Peak Design Flow Rate (All Zones) (lit/sec)	Superficial Deposit Groundwater Inflow Rate (lit/sec)	London Clay Inflow Rate (lit/sec)	***Assumed EA Imposed Maximum Allowable Peak Discharge Rate (lit/sec)	Attenuation Pond Design Return Period (1 in Years)	Attenuation Pond Volume (m3)
A	100	100	1547	****0.0	1.7-2.3	15	100	3809**
B*	100	100	1547	****0.0	1.7-2.3	15	30	3150

Table 1: Summary of Peak Design Flow Rates and Attenuation Storage Volumes

*Option B drainage network designed for 1:100 year event, Attenuation Pond designed for 1 in 30 year event. Note that excess 1:100 Year Flood Flows would require safe routing to the adjacent watercourse.

**For initial design purposes, a 4000 cubic metre Attenuation Pond has been assumed.

***Based on a 7.3 hectare effective catchment area and 2 litres/second/hectare. Remaining areas drain as existing.

****Groundwater inflow from superficial deposits was estimated to be 55.4 lit/sec. Inflow will be excluded from the excavation by installing a vertical impermeable geomembrane to the depth of the London Clay horizon (2.5m max) for the full or part of the perimeter of the Load Test Excavation. Any groundwater flow will pass around and each side of the excavation.

10.3 Groundwater Ingress Calculation Summary

Section 6 described sources of groundwater ingress which comprise two principal components :

- 'Nuisance' groundwater from perched water in the permeable overlying River Terrace Sands and Gravels (Secondary Aquifer (surface)) in the short term (immediate or transient flow) and long-term scenarios
- Seepage arising from the cut faces and base areas of the Load Test Excavation within Weathered and Competent London Clay

See Appendix B for full details of the groundwater ingress discharge estimates; these are summarised here. Note that in all cases seepage estimates assume a Load Test Pit excavation base level of -7.0mAOD, and upper and lower bound permeabilities of the weathered London Clay and deeper competent London Clay, these assumptions will be confirmed by the Phase 1 Geotechnical Investigation.

Immediate/Transient Abstraction Volume

Nuisance superficial groundwater = 7524m^3, 2.9l/sec (finite volume, no recharge due to cut off wall)
Nuisance London Clay groundwater = 1.7-2.3l/sec
Infiltration through crest into excavation (groundwater element) = 690m^3/year, 0.02l/sec
Direct rainfall = 12,940m^3/year, 0.4l/sec (average based on SAAR of 516mm)

Long-term Abstraction Volume

Nuisance superficial groundwater = 0 (no recharge due to vertical impermeable geomembrane barrier)
Nuisance London Clay groundwater = 1.7-2.3l/sec
Infiltration through crest into excavation (groundwater element) = 690m^3/year, 0.02l/sec
Direct rainfall = 12,940m^3/year, 0.4l/sec (average based on SAAR of 516mm)

10.4 Environment Agency Permitting Considerations

Based on EA Guidance document 'New Authorisations, Groundwater Dewatering – Wholly or Mainly' (LIT_16816), a rainfall run-off versus groundwater volume balance has been undertaken to assess whether water abstracted from the Load Test Excavation comprises wholly or mainly groundwater and whether an Abstraction Permit is required or not.

The EA methodology assesses volumes and flow rates on a *yearly* basis and therefore run-off rates from the drained catchment are an average based on the Standard Annual Average Rainfall (SAAR) depth (516mm). In practice, peak surface water discharge rates will be larger than the groundwater ingress base flow rate.

Immediate/Transient Abstraction Scenario
Rainfall : Groundwater = 0.4 : 4.62 l/sec (8% : 92% ratio assuming lower bound ground water seepage rate)
Rainfall : Groundwater = 0.4 : 5.22 l/sec (7% : 93% ratio assuming upper bound ground water seepage rate)

Long-term Abstractive Volume
Rainfall : Groundwater = 0.4 : 1.72 l/sec (19% : 81% ratio assuming lower bound ground water seepage rate)
Rainfall : Groundwater = 0.4 : 2.32 l/sec (15% : 85% ratio assuming upper bound ground water seepage rate)

It is concluded from the EA calculation methodology that the predominant component of water abstracted from the completed Load Test Excavation is predominantly groundwater and an Abstraction Licence will be required.

10.5 Drainage Recommendations

From the initial surface water drainage assessment, the following Client Team actions are recommended to inform subsequent drainage design stages :

- Liaise with EA to agree process to achieve Consent to Discharge surface water flows to the Watercourse and relevant Abstraction Permit requirements (it is expected that attenuation to Greenfield Flow Runoff rates and pollution mitigation treatment will be a minimum requirement for Consent) [Ongoing]
- Liaise with EA and identify whether any FRA Permitting is required
- Undertake water flow and quality assessment of the Ordinary Watercourse adjacent to the proposed outfall headwall to establish the baseline quality and environmental conditions
- Liaise with Essex County Council (as the Lead Local flood Authority) to agree process to achieve Consent to Discharge to an Ordinary Watercourse
- Undertake a detailed topographical survey of the Load Test Site Area
- Undertake a Ground Penetrating Radar Survey of the Load Test Investigation and Berm area
- Undertake a walk-over reconnaissance of the receiving Watercourse to identify significant features, structures, constraints and the like [Completed 04/12/19]
- Undertake a detailed topographical survey of the proposed receiving Watercourse including cross-sections, longitudinal section to assess hydraulic capacity and enable setting of the Settlement/Attenuation Pond invert level
- Acquire details of proposed land use, reprofiling and surface types within the Load Test Site Area to enable assessment of the catchment run-off from the fully developed site area [Ongoing]
- Undertake Stage C2 Preliminary Enquiries of existing utilities (including drainage and other utilities)

11 Programme

The Project Work Programme and works sequence are summarised :

11.1 Ground Investigation Campaign

The indicative programme is as follows:

- Site establishment – 3 weeks from commencement
- Ground Investigation – Up to 1.5 year from site establishment
- Potential Additional Ground Investigation – 3-4 months from start of this phase, if required
- Demobilisation/site reclamation – Up to 3 weeks from completion of ground investigation

Total period is up to 2 years for the ground investigation. The Logging and Core Storage Area would remain in use for up to 5 years following demobilisation and monitoring equipment such as piezometers and seismic instrumentation installed in selected boreholes would be retained for up to ten years.

11.2 Load Test Investigation

The indicative programme is as follows:

- Site establishment – 3 weeks from commencement
- Load test area set up – 3-5 weeks from site establishment
- Excavation and earthwork – 3-5 months from load test area set up
- Load test equipment/pile set up – 4-6 weeks mostly in parallel with last month of excavation and earthwork
- Monitoring period – Up to 1.5 year from load test set up
- Potential extended monitoring period – 6 months from main monitoring period, if required
- Backfill of excavation/demobilisation – Up to 6 months from completion of load test

Total period is up to 3 years for the Load Test with the more intensive construction works in the first 7 months and last 6 months. During the monitoring period, the instrumentation will be data logged remotely with occasional manual survey and site maintenance (i.e. minimal construction activities).

Appendix A : Figures

Figure 1 Surface Water Drainage Strategy	Drg Ref No 412799-MMD-SK-DG-0002
Figure 2 Example of Similar Load Test Installation	N/A
Figure 3 Typical Section of Test Pit and Earth Surcharge Berm	Drg Ref No 412799-MMD-SK-DG-0003
Figure 4 Area Wide Drainage Regime	Drg Ref No 412799-MMD-SK-DG-0004
Figure 5 Typical Construction Details	Drg Ref No 412799-MMD-SK-DG-0005

Indicative Flow Attenuation Control Structure (e.g. orifice plate or Vortex Flow Control)

Existing Unnamed Ordinary Watercourse (Non-Main River)

Floating curtain oil boom

Outfall discharges into the nearest water-course via headwall structure National Grid Reference coordinates TM 01249 08474

Road Crossing Culvert

Sampling Chamber

Combined Settlement, Attenuation and Oil Separation Pond.
Attenuation working volume 4500m³ (1 in 100 year design return period)
Area : 4500m²
Additional sump volume provided for silt retention

PS

Spoil Storage Area
12,800m²

Load Test Pit
20,000m²

Spoil Storage Area
20,430m²

2.0m
2.5m
3.0m
3.5m
4.0m
4.5m
5.0m
5.5m
6.0m
6.5m
7.0m
7.5m
8.0m

6M Berm
6,500m²

9M Berm
9,960m²

Construction Phase Plant Storage and Laydown Area
6,420m²

Access ramps

Existing Building

20 metre wide exclusion zone to existing overhead 11kV HV Power Lines

Existing Ground Investigation Core Store

Temporary Building and other surface water drainage discharges as existing

Contractor Site Compound
5,200m²

N

Notes

1. Do not scale from this drawing.

2. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum.

3. Drawing to be printed in colour.

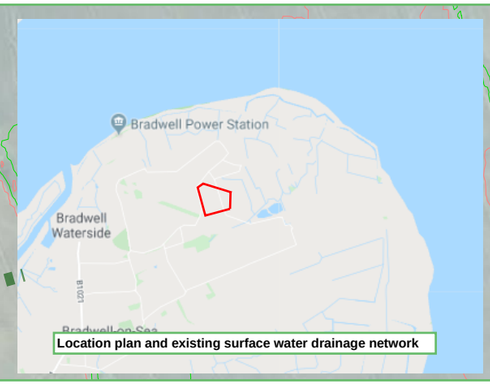
4. Sketch based on Test Pit Option Layout dated 26/11/2019.

5. Flood envelope based on EA published data accessed November 2019.

6. All drainage elements subject to detailed design and are illustrative of the Conceptual Drainage Strategy.

7. Test Pit working space requirement subject to detailed design and swept path analysis.

8. The Load Test Area lies within a very low surface water flood risk zone.



Location plan and existing surface water drainage network

Figure 1: Surface Water Drainage Strategy

412657
Bradwell B - Load Test Area (revised option 26/11/2019)
11/12/2019
Designed: DV
Checked: JW

412657/MMD/SK/DG/0002 Rev B

Key

Proposed SW Drainage

Interception Ditch

Line of Impermeable Vertical Geomembrane

or pipe and flow direction

Rising Main and flow direction

Notional Groundwater Watershed/Divide

EA Flood Zone 3 envelope

PS
Pumping Station

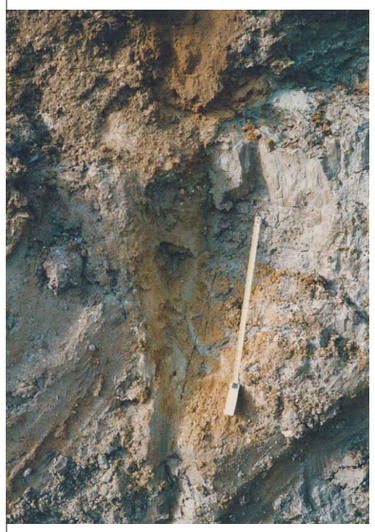
Direction of overland flood flow

Direction of Groundwater flow (Theoretical)

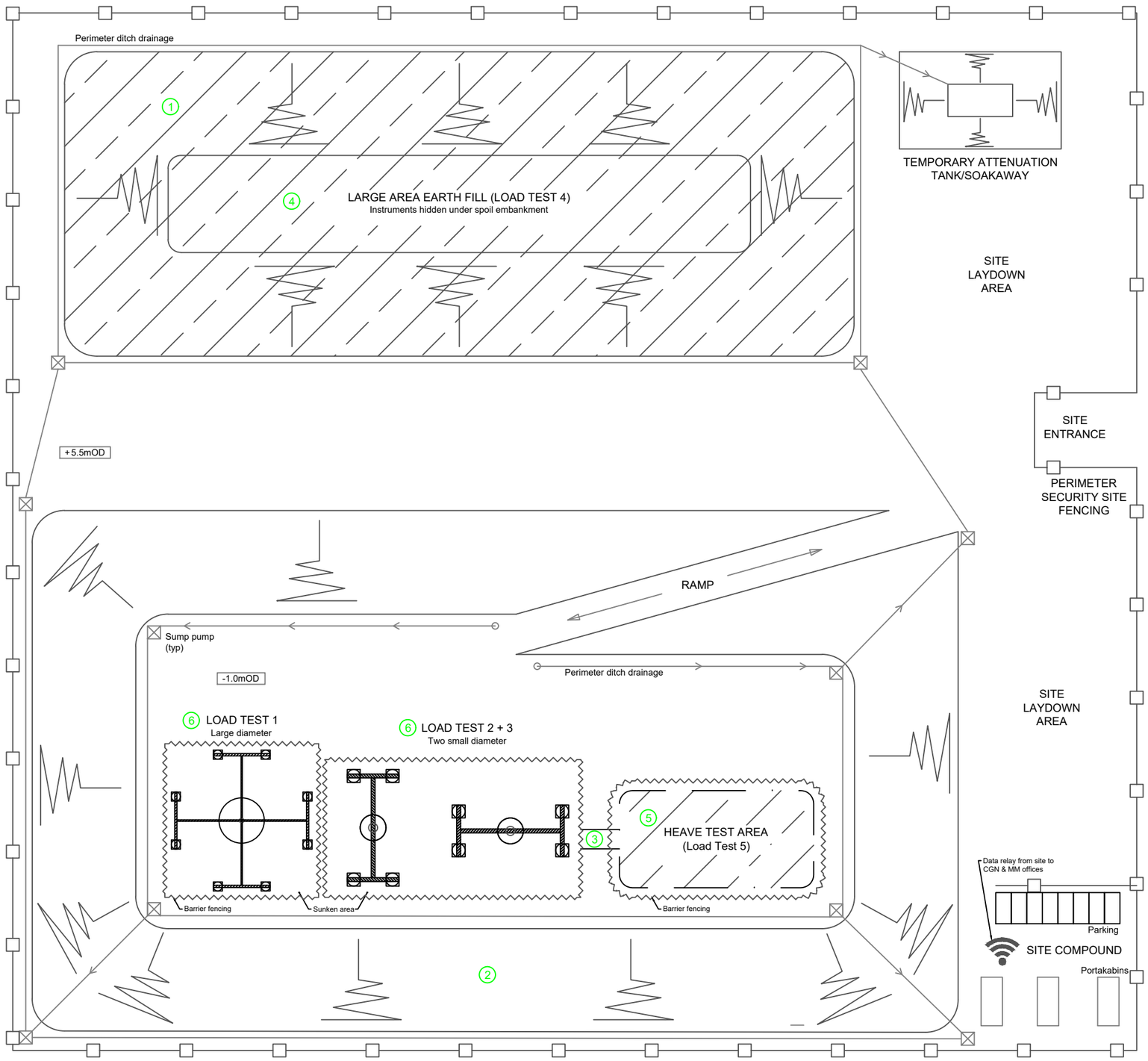
Excavation of load test area (2)

Horizontal inclinometer installed below earth fill (1)

Plate load test (Load Test 2) (6)



Logging exposed excavated surfaces (2)



Site Plan

nts

Location plan

Bradwell-on-Sea
UK

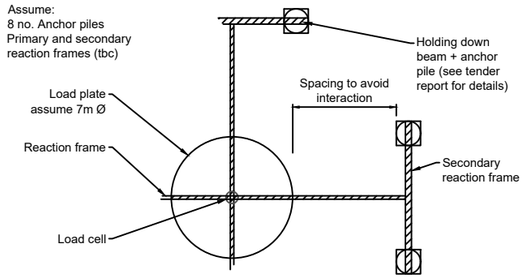
Workflow

1. Instruments installed at start of works (i.e. before any excavation)
2. Logging exposed excavated surfaces of London clay
3. 'Block' samples obtained of London Clay - large undisturbed sample
4. Large area earth fill (Load test 4)
5. Heave test area (Load Test 5)
6. Instruments installed prior to construction of load test plates

Load Test Details

LOAD TEST 1

Assume:
8 no. Anchor piles
Primary and secondary reaction frames (tbc)



LOAD TEST 2 and 3

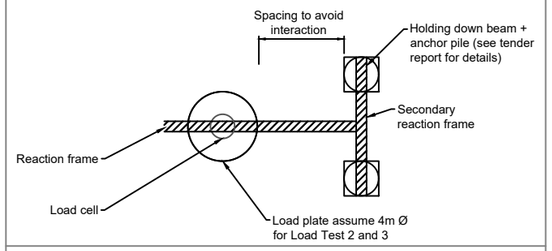


Figure 2: Example of a Similar Load Test Installation

412657
Bradwell B - Load Test
11/12/2019
Designed: DV
Checked: JW

PRELIMINARY ISSUE TO SUPPORT MOTT MACDONALD TENDER RESPONSE ONLY. NOT FOR PRICING OR CONSTRUCTION

FOR INFORMATION ONLY

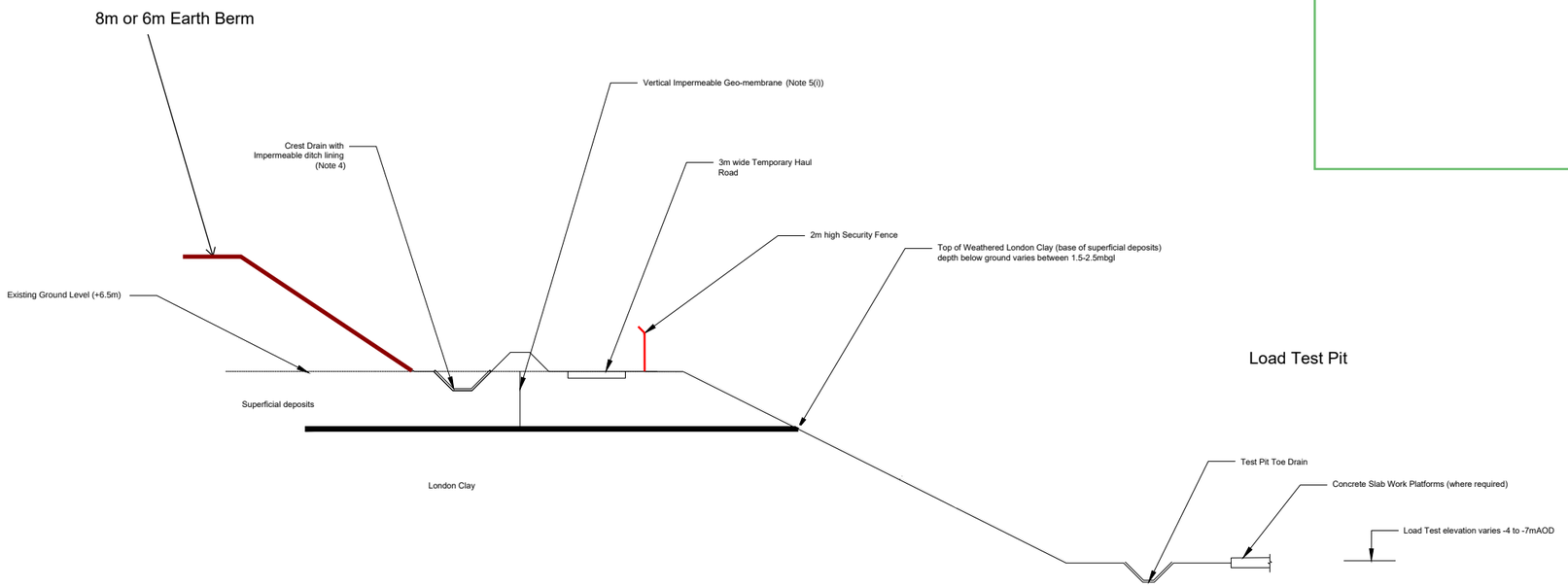


Figure 3: Typical Section of Test Pit and Surcharge Test Earth Berm

412657
Bradwell B - Load Test Area
11/12/2019
Designed: DV
Checked: JW

412657/MMD/SK/DG/0005 Rev C

Notes

1. Do not scale from this drawing.

2. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum.

3. Drawing to be printed in colour.

4. All drainage elements subject to detailed design and are illustrative of the Conceptual Drainage Strategy.

5. Typical material types:
(i) Vertical geomembrane to comprise HDPE or PVC sheet installed using conventional trenching plant.

Notes

1. Do not scale from this drawing.

2. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum.

3. Drawing to be printed in colour.

4. Sketch based on Test Pit Option Layout dated 28/11/2019.

5. The Catchment area of the watercourse which the development discharges into is approximately 5km^2 area (based on Bradwell B Preliminary Ground Investigation Flood Risk Assessment October 2017)

6. The Catchment which lies within Flood Zone 3 benefits from the Tidal Flood Defence Embankment

7. The Tidal Outfalls are closed at high tide and discharge at low tide.

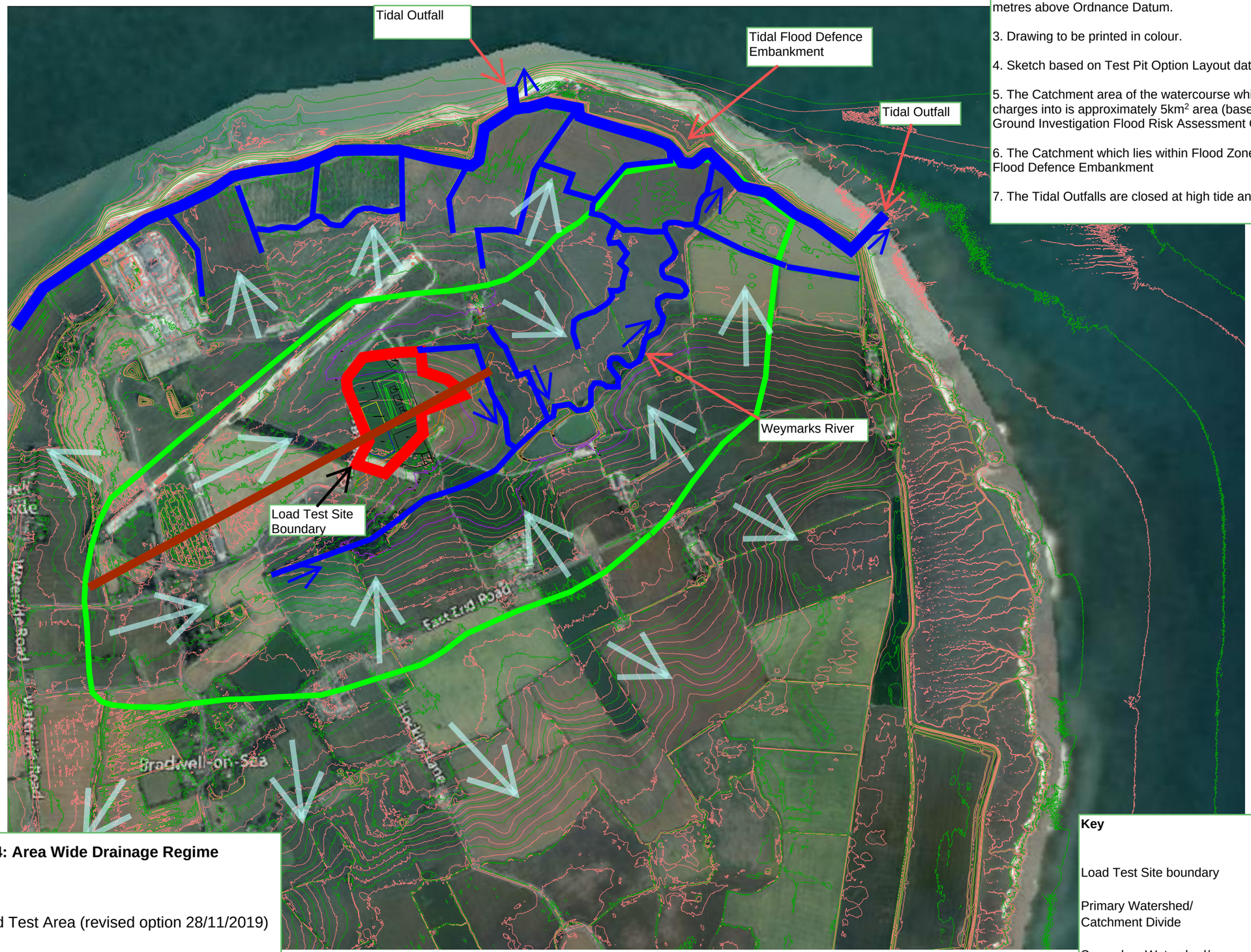


Figure 4: Area Wide Drainage Regime

412657

Bradwell B - Load Test Area (revised option 28/11/2019)
02/12/2019
Designed: DV
Checked: JW

412657/MMD/SK/DG/0003 Rev B

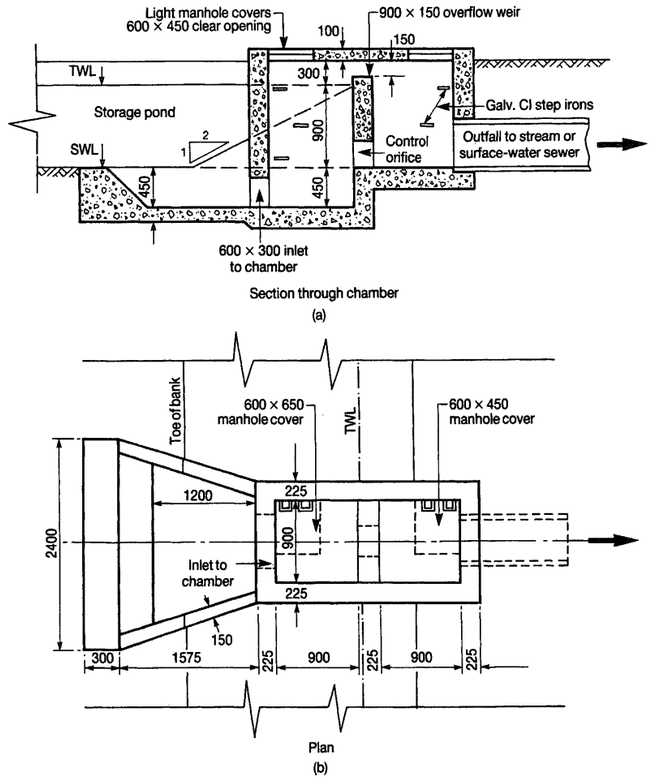
Key

Load Test Site boundary

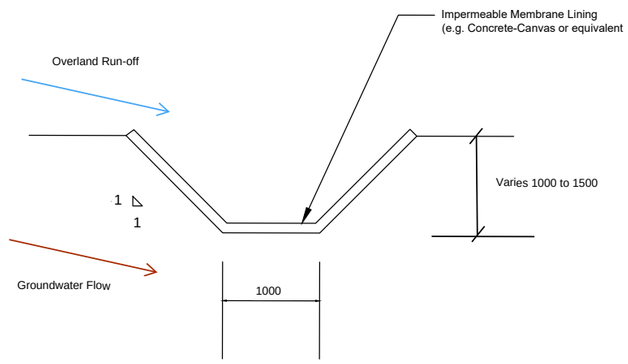
Primary Watershed/ Catchment Divide

Secondary Watershed/ Catchment Divide

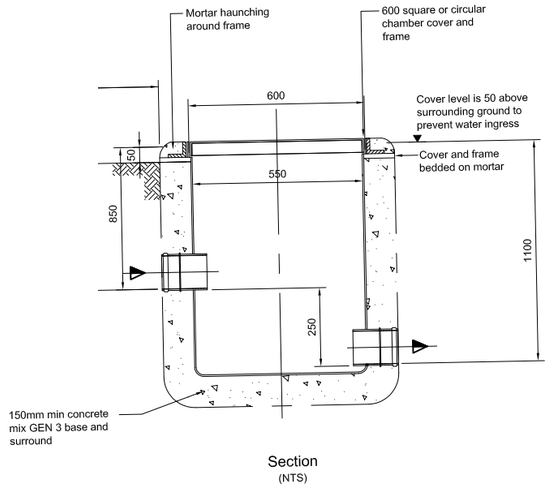
Direction of overland flood flow



Attenuation Pond Typical Outlet Control



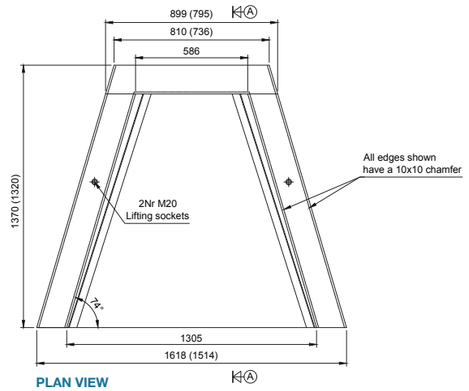
Typical Interception Ditch Section

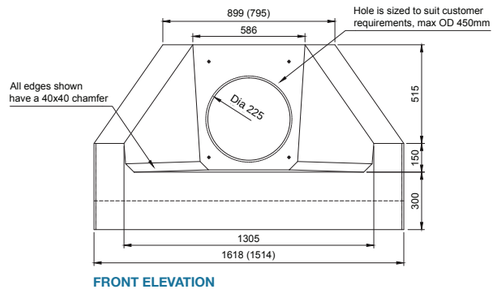


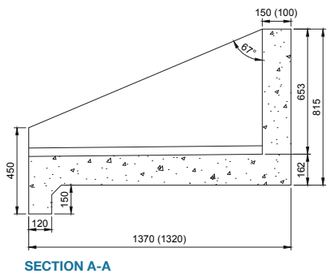
Attenuation Pond Outfall Typical Sampling Chamber

Figure 5: Typical Construction Details

412657
Bradwell B - Load Test
11/12/2019
Designed: DV
Checked: JW







Precast Concrete Outfall Headwall/Connection to Non-Main River

Appendix B : Calculations

Bradwell B – Load Test - Seepage Model Calculations	Version A – 18-12-2019
Nuisance Water Calculation	Version B – 21 01 2020

Bradwell B - Load Test - Seepage Model Calculations

Mott MacDonald

Cover Sheet

File Ref	412799	Version	A
Originator	X Ho	Date	17/12/19
Checker	R Talby	Date	18/12/19

Project Information

Workbook Name:	BRB Load Test Groundwater Seepage Calculations
Project Title:	Bradwell B

Section:		Divn/Dept:	
Subject:	Seepage Assessment Model	Project Nr:	
Project Manager:		File Ref:	412799
Originator	X Ho	Calc Nr:	
Checker		Nr Sheets:	
Template Version	A		

Design Phase

A) ☑ Concept or preliminary ☑ B) Analysis & detailed design ☐ C) Design verification

D) ☐ Other (specify)

Computer Applications Used	Version/Date
Microsoft Excel	2016

Scope of Checking

Manual calculations	Computer generated calculations

Sheets	Calculations by			Checked by		
	Name	Signature	Date	Name	Signature	Date
	X Ho		18/12/19	R Talby		18/12/19

Approved by

Approver	Signature	Date
0		

Version History

Version	Description	Originator	Checker	Date
A	First Issue	X Ho	R Talby	19/12/19

Key

Item	Description
	Optional Input
	Necessary Input
	Macro entered cell
Black Text	*Inputted Value*
Red Text	*A Default or Assumed Value*
Pink Text	*Expert Judgement Value*
Blue Text	*Calculation*
Green Text	*Data from external sources*
Grey Text	*Copied Value*

All other formatting is used to highlight groupings/values etc.

Bradwell B - Load Test - Seepage Model Calculations

Mott MacDonald

Introduction				
	File Ref	412799	Version	A
	Originator	Xinjin Ho	Date	17/12/201
	Checker	Rob Talby	Date	

Introduction

An assessment of the groundwater conditions for the proposed load test at Bradwell

Purpose

To inform the design work of the load test pit at Bradwell and to allow estimation of sufficient capacity to size drainage measures. Nature of analyses are extremely conservative, thus reported expected flows are the upper bound.

Required Output

Groundwater flow rate to perimeter drains; Groundwater flow to base of excavation

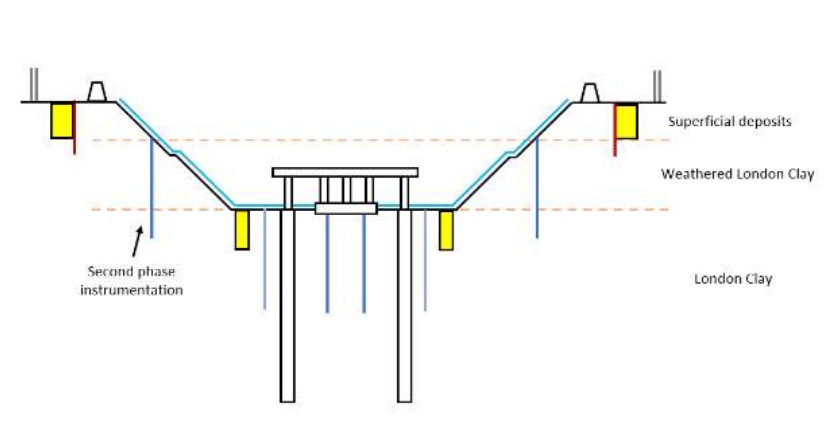
Conclusions

Flow in head deposits - Estimates of flow values are used for the estimation of sufficient capacity. Groundwater level assumption in the head deposits is highly conservative, true value of flow is expected to be lower than calculated value.

Flow in London Clay - Estimates of flow values show that the discharge rate of groundwater into the excavation through the sides and base is minimal, with expected total flow rates (Q in l/s) equal to 1.5-2.2l/s from the sides of the excavation. Minimal contribution from basal flow. Sensitivity checks show that the flow rate is relatively insensitive to the permeability of the London Clay and the height of the excavation (within the range evaluated).

Basic Design Information or Source and Reference

A cross section of the proposed load test excavation is below, where the depth of the excavation is between 7m to 10.5m, side slope is 1V:2H, excavation size is 100mx200m



Identify documents/technical records where output will be used

Environmental Agency planning application

Model selection and design

Analytical modelling has been used only.

Checking

Testing and calibration

Application Category: Informative ~~/ Important / Critical~~

Sensitivity checks

Upper bound - depth of excavation of 10.21m.
Existing ground level assumed at 3.21mEL.
Assume water level is at existing ground level
Permeability - varied between lower and upper bound.
Seepage from sides (superficial and London Clay), considered separately from basal in flow

Change control

Bradwell B - Load Test - Seepage Model Calculations

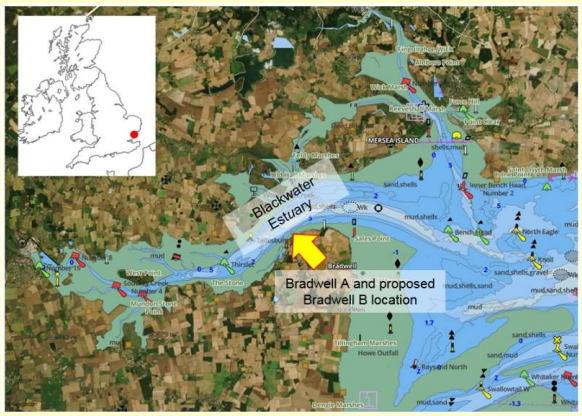
Mott MacDonald

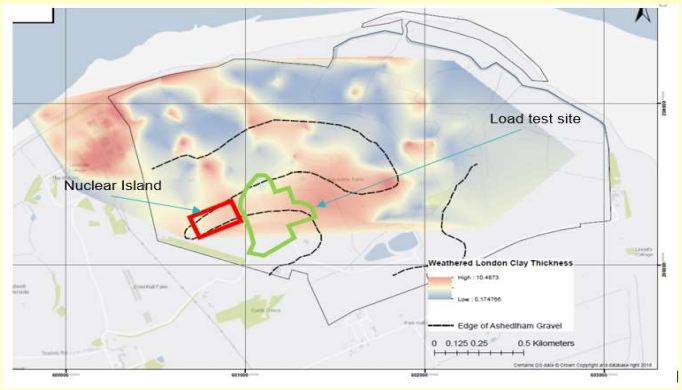
Conceptual Summary

File Ref	412799	Version	A
Originator	Xinjin Ho	Date	17/12/2019
Checker	Rob Talby	Date	18/12/2019

Location / description

The site is located in Bradwell, UK.





Ground model

Strata	Load test - BRB-234 Top (mOD)	Bottom (mOD)	Thickness (m)
Superficial deposits (Head deposits)	3.21	0.71	2.5
Weathered London Clay	0.71	-4.06	4.77
London Clay (unweathered)	-4.06	-41.75	37.69
Harwich formation	-41.75	-54.59	12.84
Lambeth Group	-54.59	-83.55	28.96
Chalk	-83.55	-	-

Ground model

Ground levels based on elevations at western end of cross-section and proposed elevations of design.

Ground level:	Ground level is based on BRB-234 and proposed design elevations of the excavation
Geology:	Analytical solution will consider a homogeneous and isotropic representative stratum based on ground model described above. No groundwater strikes reported within load test site in GIR.
Structures (natural):	None assumed
Structures (artificial):	None present.

Hydrogeology

Groundwater levels / pressures:

Ground levels/pressures:	GWL at existing ground level (+3.21 mAOD) for the Head deposits - note that this assumption is extremely conservative as the groundwater flow in the head deposits are primarily rain driven ; GWL at top of London Clay (+0.71mOD) for London Clay)
Hydraulic connection between aquifers:	n/a

For baseline permeability assumptions see 'Model Assumptions & Boundaries' sheet

Analytical Solution

Permeability profile	Min (m/s)	Mean (m/s)	Max (m/s)	Isotropic (Y/N)?	Comments
Upper bound - London Clay	1.00E-10	2.55E-09	5.00E-09	Y	
Lower Bound - London Clay	1.00E-10	1.55E-09	3.00E-09	Y	
Head deposits	1.00E-08	2.51E-06	5.00E-06	Y	

Section 1 Hydraulic characterisation

Strata	Aquifer/ aquitard?	Unconfined/ confined?	Flow type?	Homogeneous / heterogeneous?
London Clay	Aquifer	Unconfined		
Superficial Deposits	Aquifer	Unconfined		

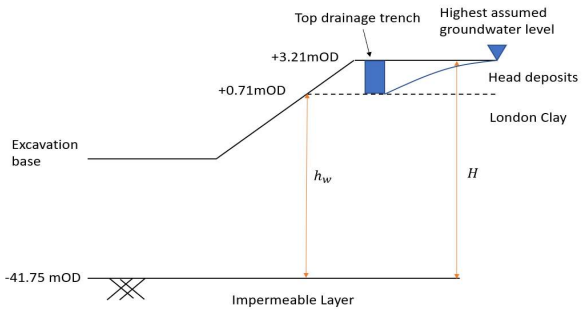
Hydrology

Groundwater recharge processes:	Not sufficient enough data is available to extimate the response of groundwater levels to rainfall. Furthermore, this analytical solution / model is concerned with purely the groundwater component.
River (major):	n/a
River (minor) / Ditches:	n/a

Bradwell B - Seepage Model Calculations

File Ref	412799	Version	A
Originator	X Ho	Date	17/12/19
Checker	R Talby	Date	18/12/19

Conceptualisation of analytical solution



Analytical solution and parameters

Base case Scenario

Analytical solution

	Source:	Assumptions:
$\frac{Q}{x} = q = \frac{kx(H^2 - h_w^2)}{L}$	Chapman (1956); in Mansur and Kaufman (1962), and CIRIA 570 Groundwater Control: design and practice, 2nd ed. (2016).	- fully penetrating slots - Unconfined aquifer - flow from line source on both sides of slot

Distance of Influence, Lo

	Source:	Assumptions:
$L = 1500(H - h_0)\sqrt{k}$	Sichardt's Formula	- Plane flow case (with adjusted calibration factor of 1500 instead of 3000) - Steady-state

Parameters

x	linear length of slot
k	soil/rock permeability
H	initial water table level in aquifer
hw	lowered water level in an equivalent well
Lo	distance of influence (calculated using Sikart equation)
P	depth of penetration of the slot below the original water table

Groundwater Monitoring

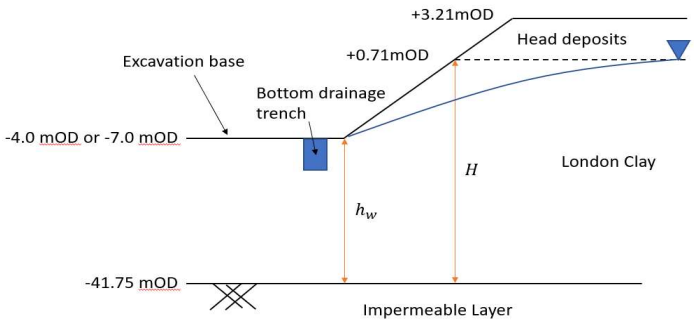
Values

	Head deposits	Notes
Groundwater level (m)	3.2	water table at GL - worst case (*EXTREMELY CONSERVATIVE)
Borehole for which gwl was taken from	-	
Hydraulic permeability - arithmetic mean (m/s)	2.51E-06	
Initial water table. H (m)	45.0	difference between base of LC and EGL
Lowered water level, h (m)	42.5	Base of superficial deposits
$H^2 - h_w^2$	218.8	RT - checked
Distance of influence, Lo	5.9	Calcualted using Sichardt's Formula. RT checked
$\left(\frac{K}{L}\right)$	4.22E-07	RT - checked
x	600.0	perimeter of excavation RT - checked
q (m3/s/m)	9.233E-05	
Q (m3/s)	5.540E-02	
Q (l/s)	55.40	The flow values are extremely conservative as the groundwater flow is primarily rain driven - GIR highlights that no water strikes were found. RT - checked

Bradwell B - Seepage Model Calculations

File Ref	412799	Version	A
Originator	X Ho	Date	17/12/19
Checker	R Talby	Date	18/12/19

Conceptualisation of analytical solution



Analytical solution and parameters

Base case Scenario

Analytical solution

	Source:	Assumptions:
$\frac{Q}{x} = q = \frac{k(H^2 - h_w^2)}{L}$	Chapman (1956); in Mansur and Kaufman (1962), and CIRIA 570 Groundwater Control: design and practice, 2nd ed. (2016).	- fully penetrating slots - Unconfined aquifer - flow from line source on both sides of slot

Distance of Influence, Lo

	Source:	Assumptions:
$L = 1500(H - h_0)\sqrt{k}$	Sichardt's Formula	- Plane flow case (with adjusted calibration factor of 1500 instead of 3000) - Steady-state

Parameters

x	linear length of slot
k	soil/rock permeability
H	initial water table level in aquifer
hw	lowered water level in an equivalent well
Lo	distance of influence (calculated using Sikart equation)
P	depth of penetration of the slot below the original water table

Groundwater Monitoring

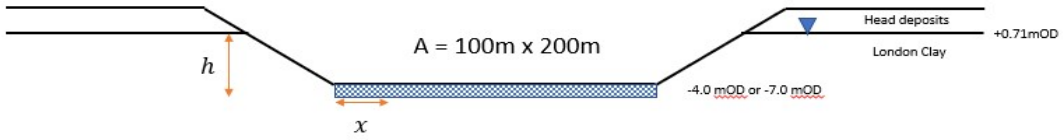
Values	Excavation base at -4mOD		Excavation base at -7mOD		Notes
	Upper Bound - LC	Lower Bound - LC	Upper Bound - LC	Lower Bound - LC	
Groundwater level (mOD)	0.71	0.71	0.71	0.71	Water table at top of London Clay
Borehole for which gwl was taken from	-	-	-	-	
Existing ground level (mOD)	3.21	3.21	3.21	3.21	
Base of London Clay level (mOD)	-41.75	-41.75	-41.75	-41.75	
Excavation level (mOD)	-4	-4	-7	-7	
Excavation depth (m)	7.21	7.21	10.21	10.21	
Hydraulic permeability - upper bound (m/s)	5.00E-09	3.00E-09	5.00E-09	3.00E-09	Upper bound values of permeability used
Initial water table. H (m)	42.5	42.5	42.5	42.5	
Lowered water level, h (m)	37.8	37.8	34.8	34.8	Base of excavation
$H^2 - h_w^2$	377.8	377.8	595.2891	595.2891	RT - checked
Distance of influence, Lo	0.5	0.4	0.8	0.6	Calcualted using Sichardt's Formula. RT checked
$\left(\frac{K}{L}\right)$	1.00E-08	7.75E-09	6.11E-09	4.74E-09	RT - checked
x	600.0	600.0	600.0	600.0	Perimeter of excavation RT - checked
q (m3/s/m)	3.781E-06	2.929E-06	3.640E-06	2.819E-06	
Q (m3/s)	2.269E-03	1.757E-03	2.184E-03	1.692E-03	
Q (l/s)	2.27	1.76	2.18	1.69	Effectively no difference in flow to sides of excavation if excavation base lowered to -7mOD from -4mOD RT-checked

Bradwell B - Seepage Model Calculations

Mott MacDonald

File Ref	412799	Version	A
Originator	X Ho	Date	17/12/19
Checker	R Talby	Date	18/12/19

Conceptualisation of analytical solution



Analytical solution and parameters

Base case Scenario

Analytical solution

$Q = Ak\left(-\frac{dh}{dx}\right) = Aki$	Source: CIRIA 570 Groundwater Control: design and practice, 2nd ed. (2016) - Darcy's Law	Assumptions:

Parameters

x	flow length
k	soil/rock permeability
h	head difference
i	rate of decrease of total hydraulic head, h with distance in direction of the flow
A	Cross sectional area of flow
Q	Volumetric flow of water

Groundwater Monitoring

Values

	Excavation base at -4mOD		Excavation base at -7mOD		Notes
	Upper Bound Permeability	Lower Bound Permeability	Upper Bound Permeability	Lower Bound Permeability	
Groundwater level (mOD)	0.71	0.71	0.71	0.71	Water table at top of London Clay
Borehole for which gwl was taken from	-	-	-	-	
Existing ground level (mOD)	3.21	3.21	3.21	3.21	
Base of London Clay level (mOD)	-41.75	-41.75	-41.75	-41.75	
Excavation level (mOD)	-4	-4	-7	-7	
Cross section area of excavation, A (m2)	20000	20000	20000	20000	
Excavation depth (m)	7.21	7.21	10.21	10.21	
Hydraulic permeability - upper bound (m/s)	5.00E-09	3.00E-09	5.00E-09	3.00E-09	Upper bound values of permeability used
Initial water table. H (m)	42.5	42.5	42.5	42.5	
Lowered water level, hw (m)	37.8	37.8	34.8	34.8	Base of excavation
$x = H - h_w$	50.0	50.0	50.0	50.0	Flow length when steady state flow achieved (long term)
h	4.7	4.7	7.7	7.7	Assume that flow is entirely gravity driven
i	0.1	0.1	0.2	0.2	
Q (m3/s)	9.420E-06	5.652E-06	1.542E-05	9.252E-06	
Q (l/s)	0.01	0.01	0.02	0.01	Effectively no basal flow at steady state

$x = H - h_w$	1.0	1.0	1.0	1.0	Transient flow, immediately after excavation (short term)
h	4.7	4.7	7.7	7.7	
i	4.7	4.7	7.7	7.7	
Q (m3/s)	4.710E-04	2.826E-04	7.710E-04	4.626E-04	
Q (l/s)	0.47	0.28	0.77	0.46	Basal flow contribution is minimal.

Bradwell B - Load Test - Estimation of Volume of Nuisance Water

Mott MacDonald

Cover Sheet

File Ref	412799	Version	B
Originator	J Webber	Date	16/01/20
Checker	R Talby	Date	21/01/20

Project Information

Workbook Name:	BRB Load Test Estimation of volume of nuisance water
Project Title:	Bradwell B

Section:		Divn/Dept:	BNI/ BSE
Subject:	Assessment of volume of nuisance water	Project Nr:	
Project Manager:		File Ref:	412799
Originator	J Webber	Calc Nr:	
Checker	R Talby	Nr Sheets:	
Template Version	B		

Design Phase

A) ☑ Concept or preliminary ☑ B) Analysis & detailed design ☐ C) Design verification

D) ☐ Other (specify)

Computer Applications Used	Version/Date
Microsoft Excel	2016

Scope of Checking	
Manual calculations	Computer generated calculations

Sheets	Calculations by			Checked by		
	Name	Signature	Date	Name	Signature	Date
	X Ho		18/12/19	R Talby		21/01/20

Approved by		
Approver	Signature	Date
0		

Version History

Version	Description	Originator	Checker	Date
B	Second Issue	J Webber	R Talby	21/01/20

Key

Item	Description
	Optional Input
	Necessary Input
	Macro entered cell
Black Text	*Inputted Value*
Red Text	*A Default or Assumed Value*
Pink Text	*Expert Judgement Value*
Blue Text	*Calculation*
Green Text	*Data from external sources*
Grey Text	*Copied Value*

All other formatting is used to highlight groupings/values etc.

Bradwell B - Load Test - Estimation of Volume of Nuisance Water

Mott MacDonald

Introduction				
	File Ref	412799	Version	B
	Originator	J Webber	Date	16/01/20
	Checker	Rob Talby	Date	21/01/20

Introduction

An assessment of volume of nuisance water during the construction and operational phases of the project.

Purpose

To inform the design work of the load test pit at Bradwell and to allow estimation of sufficient capacity to size drainage measures. Nature of analyses are extremely conservative, thus reported expected flows are the upper bound.

Required Output

Flow rate to base of excavation and attenuation pond from immediate groundwater discharge and rainfall.

Conclusions

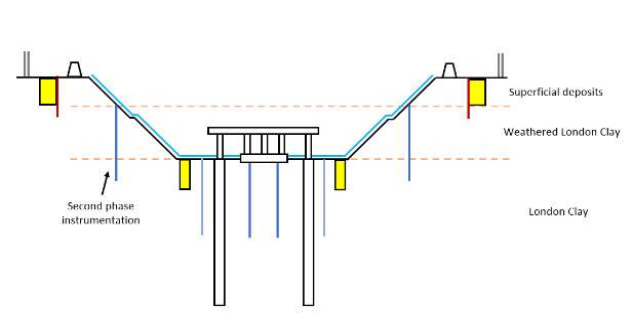
1: In short term (construction phase), immediate groundwater discharge is predicted to be 2.9l/s, whereas runoff from rainfall is predicted to be 0.2l/s. The groundwater component is the dominant contributor to nuisance water in the short term.

2: In long term (operational phase), no groundwater discharge is assumed (due to the presence of an impermeable barrier, whereas runoff from rainfall is predicted to be 0.4l/s.

3: Predicted amounts of nuisance water are conservative due to the conservative nature of assumptions regarding the groundwater level and void ratio.

Basic Design Information or Source and Reference

A cross section of the proposed load test excavation is below, where the depth of the excavation is between 7m to 10.5m, side slope is 1V:2H, excavation size is 114mx220m



Identify documents/technical records where output will be used

Environmental Agency planning application

Model selection and design

Analytical modelling has been used only.

Checking

Testing and calibration

Application Category: Informative ~~/ Important / Critical~~

Sensitivity checks

none

Change control

Bradwell B - Load Test - Estimation of Volume of Nuisance Water

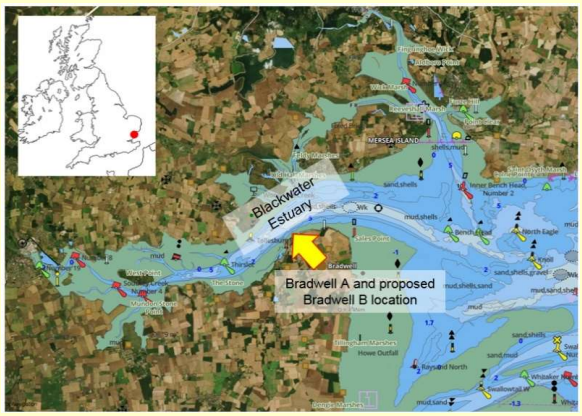
Mott MacDonald

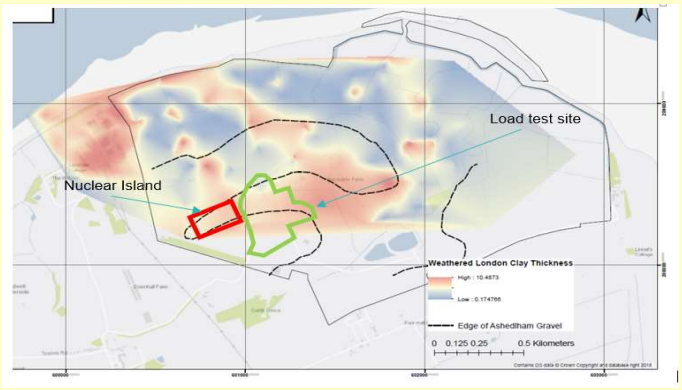
Conceptual Summary

File Ref	412799	Version	B
Originator	J Webber	Date	16/01/2020
Checker	Rob Talby	Date	21/01/2020

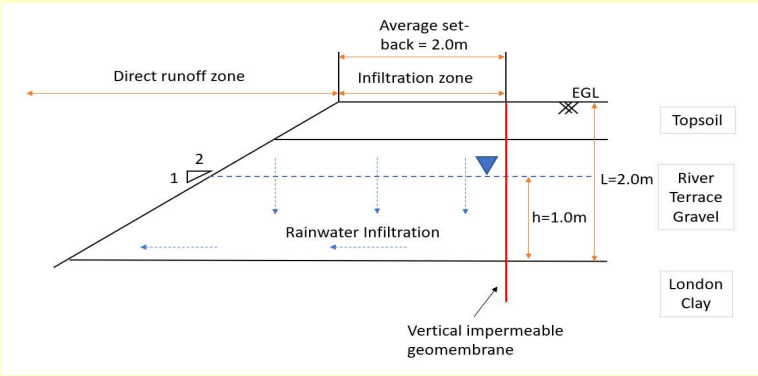
Location / description

The site is located in Bradwell, UK.





Ground model



Ground model

Ground levels based on elevations at western end of cross-section and proposed elevations of design.

Ground level:	Ground level not specified. Relative level of London clay to existing ground level is specified to be 2.0m.
Geology:	Analytical solution will consider a homogeneous and isotropic representative stratum based on ground model
Structures (natural):	None assumed
Structures (artificial):	None present.

Hydrogeology

Groundwater levels / pressures:

Ground levels/pressures:	GWL assumed to be 1000mm above London Clay. Based on findings in the 2017 Ground Investigation Report, whereby groundwater was found in boreholes 207, 212 and 213.
Hydraulic connection between aquifers:	n/a

Section 1 Hydraulic characterisation

Strata	Aquifer/ aquitard?	Unconfined/ confined?	Flow type?	Homogeneous / heterogeneous?
London Clay	Aquifer	Unconfined		
Superficial Deposits	Aquifer	Unconfined		

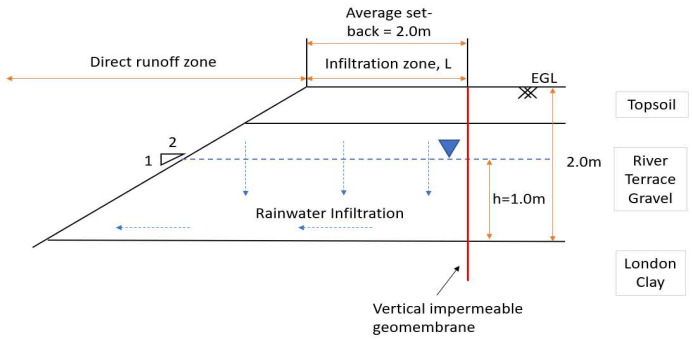
Hydrology

Groundwater recharge processes:	Not sufficient enough data is available to estimate the response of groundwater levels to rainfall. Furthermore, the impermeable blinding assumes that after immediate drainage, the excavation is no longer recharged by groundwater flow within the river terrace deposits.
River (major):	n/a
River (minor) / Ditches:	n/a

Bradwell B - Estimation of Volume of Nuisance Water

File Ref	412799	Version	B
Originator	J Webber	Date	16/01/2020
Checker	R Talby	Date	21/01/2020

Conceptualisation of analytical solution



Analytical solution and parameters

Immediate discharge

	Source:	Assumptions:
$Qt = Ahe$	-	fully saturated voids
		concurrent incidental rainfall/ run-off ignored
		considered as one-off event, once drained down, only precipitation on local catchment generates runoff.

Annual discharge from precipitation

	Source:	Assumptions:
$Q = Lxq$	-	losses from evaporation, transpiration, puddle storage etc. ignored
		vertical impermeable geomembrane prevents recharge of RTS+G from 'external' aquifer

Parameters

Q	total flow
t	time over which total volume of water is discharged
A	plan area of excavation
h	groundwater depth
e	void ratio
L	drained width
q	incident annual rainfall
x	perimeter of excavation

Groundwater Monitoring

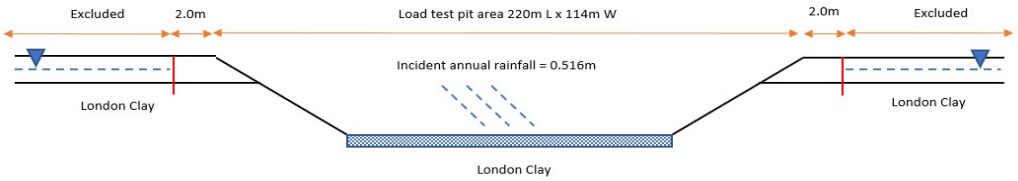
Values

	Immediate discharge	Annual discharge	Notes
Groundwater depth (m)	1.0	-	water table 1.0m above London Clay
Borehole for which gwl was taken from	207, 212, 213	-	
Plan area of excavation, A (m2)	25080	-	
Void ratio, e (-)	0.3	-	
Time over which total volume of water is discharged , t (s)	2592000.0	-	assume total immediate discharge occurs in 1 month
Drained width, L (m)	-	2	
Perimeter of excavation, x (m)	-	668	
Incident annual rainfall, q (m/year)	-	0.516	
Average daily flow, Q (m3/day)	250.8	1.89	
Average discharge rate, Q (l/s)	2.90	0.02	

Bradwell B - Estimation of Volume of Nuisance Water

File Ref	412799	Version	B
Originator	J Webber	Date	16/01/2020
Checker	R Talby	Date	21/01/2020

Conceptualisation of analytical solution



Analytical solution and parameters

Runoff generated by incident rainfall

	Source:	Assumptions:
$Q = Aq$	-	excludes topsoil storage mounds - assumed to drain to existing field drainage systems
		100% runoff from exposed cut/ fill surfaces

Parameters

Q	total flow
A	plan area
q	incident annual rainfall

Groundwater Monitoring

Values

	Volume of runoff generated from rainfall within excavation	Volume of rainfall captured by attenuation pond	Notes
Plan area of catchment, A (m2)	25080.0	72740.0	total site drained for attenuation pond is roughly 7.274Ha
Incident annual rainfall, q (m/year)	0.516	0.516	
Annual rainfall volume (m3/year)	12941.28	37533.84	
Average daily flow, Q (m3/day)	35.5	102.8	
Average discharge rate, Q (l/s)	0.4	1.2	

Appendix C. – Site Plans

The site layout below is the current understanding of site setup at the time of this application. This may be subject to changes according to site and construction constraints. The EA would be informed of any changes to the proposed setup.

Drawing 412657-MMD-00-XX-DR-C-0001
Bradwell 'B' Nuclear Power Plant Project Site Location Plan

Drawing 412657-MMD-00-XX-DR-C-0002
Bradwell 'B' Nuclear Power Plant Project Planning Application Boundary Plan

Drawing 412657-MMD-00-XX-DR-C-0003
Bradwell 'B' Nuclear Power Plant Project Load Test Investigation Site Compound Layout

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We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

1:25,000 0 1000m 2500m

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Notes

1. This drawing is for Planning Purposes only.
2. All heights of structures and facilities within the Site Compound no higher than 10m above ground level.

Key to symbols

- Planning application boundary
- Excluded from Planning Application
- Site Compounds and Load Test area

Reference drawings

412657-MMD-00-XX-DR-C-0001
412657-MMD-00-XX-DR-C-0002
412657-MMD-00-XX-DR-C-0003
412657-MMD-00-XX-DR-C-0004
412657-MMD-00-XX-DR-C-0005

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	07.01.20	GC	SECOND ISSUE FOR PLANNING	JW	RT
P1	13.12.19	GC	FIRST ISSUE FOR PLANNING	JW	RT

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W mottmac.com

Client

Title

BRADWELL 'B' NUCLEAR POWER PLANT PROJECT SITE LOCATION PLAN

Designed	J.WEBBER	JW	Eng check	J.WEBBER	JW
Drawn	G.CHILVERS	GC	Coordination	T.HICKSON	TH
Dwg check	D.VANNECK	DV	Approved	R.TALBY	RT

Scale at A1	Status	Rev	Security
1:25000	PRE	P2	STD

Drawing Number
412657-MMD-00-XX-DR-C-0001

Blackwater River

Bradwell Nuclear Power Station

High Street

Bradwell on Sea

East End Road

Hockley Lane

1:10,000 0 500m 1000m

Notes

1. This drawing is for Planning Purposes only.
2. All heights of structures and facilities within the Site Compound no higher than 10m above ground level.

Key to symbols

- Planning application boundary
- Excluded from Planning Application
- Site Compounds and Load Test area

Reference drawings

412657-MMD-00-XX-DR-C-0001
412657-MMD-00-XX-DR-C-0002
412657-MMD-00-XX-DR-C-0003
412657-MMD-00-XX-DR-C-0004
412657-MMD-00-XX-DR-C-0005

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	07.01.20	GC	SECOND ISSUE FOR PLANNING	JW	RT
P1	13.12.19	GC	FIRST ISSUE FOR PLANNING	JW	RT

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W mottmac.com

Client

BRB CGN EDF ENERGY

Title

BRADWELL 'B' NUCLEAR POWER PLANT PROJECT PLANNING APPLICATION BOUNDARY PLAN

Designed	J.WEBBER	JW	Eng check	J.WEBBER	JW
Drawn	G.CHILVERS	GC	Coordination	T.HICKSON	TH
Dwg check	D.VANNECK	DV	Approved	R.TALBY	RT

Scale at A1	Status	Rev	Security
-	PRE	P2	STD

Drawing Number
412657-MMD-00-XX-DR-C-0002

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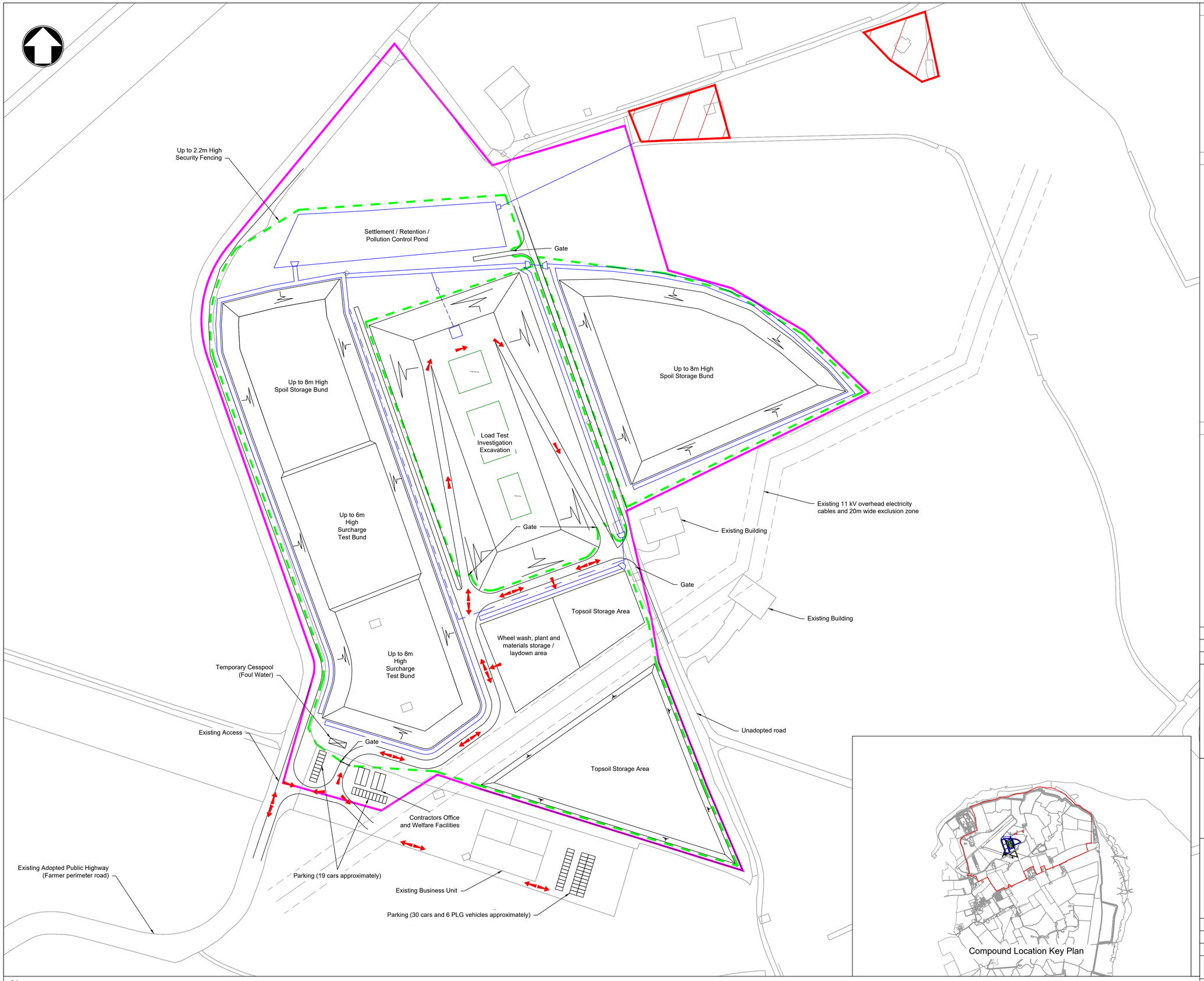

Notes

1. This drawing is for Planning Purposes only.
2. All heights of structures and facilities within the Site Compound no higher than 10m above ground level.
3. The site accommodation, vehicular routes, pedestrian routes and site use is indicative and subject to detailed design by the Appointed Contractor.

Key to symbols

- Planning application boundary
- Excluded from Planning Application
- Site Compound Boundary
- Temporary Security Fence
- Vehicular Route Off-Road

Reference drawings

412657-MMD-00-XX-DR-C-0001
412657-MMD-00-XX-DR-C-0002
412657-MMD-00-XX-DR-C-0003
412657-MMD-00-XX-DR-C-0004
412657-MMD-00-XX-DR-C-0005

1:1250 0 62.5m 125m

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	09.01.20	TA	REVISED FOR PLANNING	JW	TH
P1	13.12.19	GC	FIRST ISSUE FOR PLANNING	JW	RT

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Client

BRB CGN EDF ENERGY

Title

BRADWELL 'B' NUCLEAR POWER PLANT PROJECT
LOAD TEST INVESTIGATION
SITE COMPOUND LAYOUT

Designed	J.WEBBER	JW	Eng check	J.WEBBER	JW
Drawn	G.CHILVERS	GC	Coordination	T.HICKSON	TH
Dwg check	D.VANNECK	DV	Approved	R.TALBY	RT

Scale at A1	Status	Rev	Security
1:1250	PRE	P2	STD

Drawing Number

412657-MMD-00-XX-DR-C-0003

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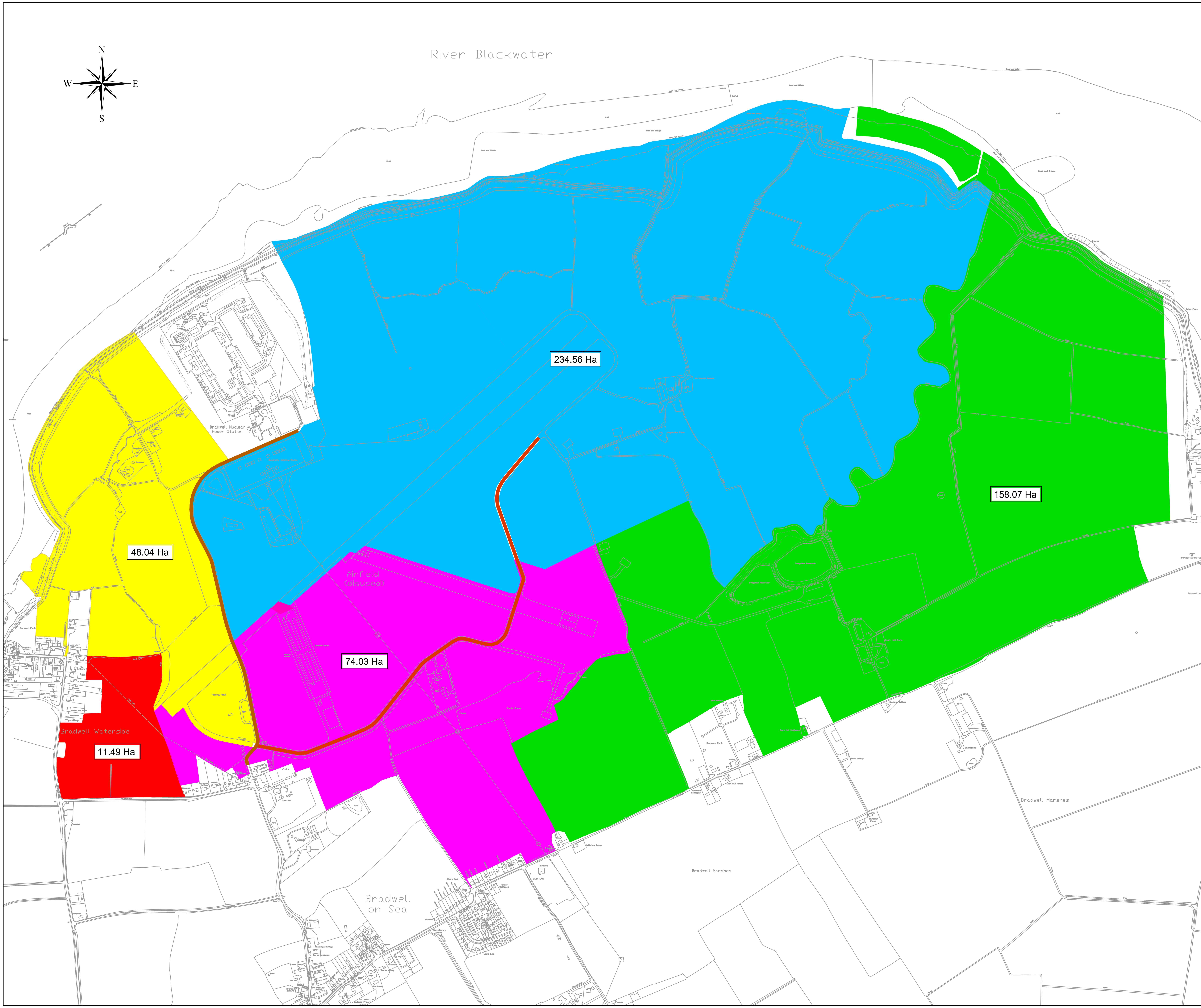
Appendix D. – Land Access Plan

Drawing SZC-NNBPEA-XX-000-DRW-000016 - REV 06



UK PROTECTIVE MARKING:
UK PROTECT

DRAWING GRID / COORDINATE SYSTEM:

SITE LOCAL GRID ☐	NATIONAL GRID OSGB36 X
OTHER GRID ☐	(To be defined in the contract project plan)

CONTRACT PROJECT PLAN DOC. REF. No:

NOTES:

KEY:

- BRB LEASE
- NDA OWNERSHIP
- LONGERGAN
- WALLUM
- STRUTT & PARKER
- ADOPTED ROAD

REV.	DATE	PREPARED BY	CHECKED BY	STATUS	REASONS FOR REVISION	APPROVED BY
0.6	26-09-19	SB	HG	PREL	OPTION AREA'S ADDED	HG
0.5	29-07-16	SB	Georgie Harding-Edgar	PREL	OPTION AREA'S DELETED	Georgie Harding-Edgar
0.4	08-05-14	SB	Georgie Harding-Edgar	PREL	AREA'S ADDED	Georgie Harding-Edgar
0.3	29-10-13	J.S	Georgie Harding-Edgar	PREL	DRAFT FOR DISCUSSION	Georgie Harding-Edgar
0.2	22-10-13	J.S	Georgie Harding-Edgar	PREL	DRAFT FOR DISCUSSION	Georgie Harding-Edgar
0.1	24-09-13	J.S	Georgie Harding-Edgar	PREL	DRAFT FOR DISCUSSION	Georgie Harding-Edgar

	1st partner	2nd partner
NNB GenCo EDF ENERGY	NNB	EDF

CONTRACTOR COMPANY TRADE NAME : NA

CONTRACTOR REF. No. NA

CONTRACT NUMBER : NA

CONTRACTOR WBS CODE : NA

QRA RELATED Yes ☐ No ☐

APPLICABILITY:
1: Document related to Unit 1
2: Document related to Unit 2
9: Document that applies to buildings/systems common to Unit 1 & 2
0: Documents that relate exclusively to buildings or systems that are common to the whole site (e.g. parking, ancillary buildings...)

NUCL/REP/EPR/UKX							
HPC (doc: HK)				SZC (doc: SZ)			
0	1	2	9	0	1	2	9
				X			

BUILDING
NA

SYSTEM
NA

SCALE
1:5000

SIZE A1

PAGE
1/1

DESCRIPTION

SIZEWELL C
BRADWELL
LAND OWNERSHIP DRAWING

DOCUMENT REFERENCE No.

Project	Contract No. / Orig. Co	Asset / Zone	System / Building	Doc. type	Chrono No.
SZC	NNBPEA	XX	000	DRW	000016

DOCUMENT SUB -TYPE
SITE PLAN

EDF CLASSIFICATION CODE

SUBCONTRACTOR COMPANY TRADE NAME

SUBCONTRACTOR DOCUMENT REF. No

This pattern must be entirely readable
For A0 and A1 : ABERPFTHLIJOOCGQUVWMNSZXKY
zsaeocmuvnwxirfkhbdpqgyjlt 71423855690
0 1 2 3 4 5 6 7 8 9 10

INTELLECTUAL PROPERTY:
NNB:
OWNERSHIP
EDF:

UK PROTECTIVE MARKING:
UK PROTECT

Appendix E. – Hydrogeological Impact Assessment

ATKINS
Member of the SNC-Lavalin Group

Technical Note

Project:	Bradwell B Nuclear Power Plant - Load Test Pit		
Subject:	Abstraction Licence Application – Hydrogeological Impact Appraisal		
Author:	Charles Stafford	Checked:	Dan Welch/Sam Williams
Reviewed:	Duncan Cartwright	Authorised:	John Dickson
Date:	29/01/2020	Project No.:	5193653
Distribution:	National Permitting Service Ross Stewart/ Neil Burke	Representing:	Environment Agency BRB GenCo Ltd

Introduction

This document presents a Hydrogeological Impact Appraisal (HIA) in support of an application for a water resources licence for abstraction at the proposed site of Bradwell B Nuclear Power Plant, Bradwell on Sea made by Bradwell Power Generation Company Limited (BRB GenCo Ltd).

It includes a detailed conceptualisation and assessment of the impacts from the proposed dewatering works in the Load Test Pit excavation (referred to as “Bradwell_1”). The work presented here is only in relation to the dewatering of the Load Test Pit excavation at Bradwell on Sea and does not assess impacts from any other aspects of the project.

HIA Methodology

This HIA has been prepared based on the Interim Drainage Strategy prepared by Mott MacDonald [1] in line with the Environment Agency’s guidance document “Hydrogeological impact appraisal for dewatering abstractions”[2]. This guidance uses a series of steps to identify the potential impacts of the dewatering works, to identify the receptors, to quantify the impacts on the receptors and identify potential mitigation measures. The steps are summarised in Table 1.

Table 1 - Summary of HIA Methodology

Step	
1	Establish the regional water resource status.
2	Develop a conceptual model for the abstraction and the surrounding area.
3	Identify all potential water features that are susceptible to flow impacts.
4	Apportion the likely flow impacts to the water features.
5	Allow for the mitigating effects of any discharges, to arrive at net flow impacts.
6	Assess the significance of net flow impacts.
7	Define the search area for drawdown impacts.
8	Identify all features in the search area that could be impacted by drawdown.

Step	
9	For all these features, predict the likely drawdown impacts.
10	Allow for the effects of measures taken to mitigate the drawdown impacts.
11	Assessing the significance of the net drawdown impacts.
12	Assess the water quality impacts.
13	If necessary, redesign the mitigation measures to minimise the impacts.
14	Develop a monitoring strategy.

Source: Hyder Consulting (2015b)

Step 1 – Establish the Regional Water Resource Status

The volume of water available for abstraction is assessed by the Environment Agency using Catchment Abstraction Management Strategies (CAMS). The location of the proposed water resources abstraction from Bradwell_1 is centred on National Grid Reference (NGR) TM 01157 08257 in the Anglian River Basin District (RBD) [3] , covered by the East Anglia CAMS [4].

At the time the East Anglia CAMS was published in May 2017, the resource availability in the area of the proposed abstraction was “water not available”. However, abstractions for non-consumptive uses can still be permissible in catchments where there are sustainability issues.

The HIA study area (demarked by the Site Compounds and Load Test Area hatching in Drawing 412657-MMD-00-XX-DR-C-0001, Appendix A) lies within the Water Framework Directive (WFD) groundwater Essex Gravels water body unit (GB40503G000400), which covers a large part of East Anglia. This area was designated in Cycle 2 as being of Good quantitative status and Poor chemical status [5]. The Poor-quality status relates to agriculture and rural land management.

Based on the CAMS and WFD status and the information presented in the Environment Agency’s HIA guidance, this HIA will concentrate on impacts at a local scale.

Step 2: Develop a conceptual model for the abstraction and the surrounding area

Context

A conceptual site model (CSM) is presented for the HIA study area, based on the following sources of information:

- Bradwell B Preliminary Ground Investigation, Phase 1 Contaminated Land Study. Amec Foster Wheeler Environment & Infrastructure Limited, October 2017 [6]
- Bradwell B Nuclear Power Plant – Load Test, Interim Drainage Strategy. Mott MacDonald, January 2020 [1]
- Bradwell B Ground Investigation Planning Support: Surface Water Sampling (Round 1). Wood Plc, January 2020 [7]
- Bradwell B Ground Investigation Planning Support: Surface Water Sampling (Round 2). Wood Plc, January 2020 [8]
- Bradwell B Marine Studies, Weymarks Stream Low Flows Report TR56. BRB GenCo Ltd/ CEH, December 2019 [9]
- Envirocheck datasheets for Bradwell B, dated 20 January 2020 (Reference 231097789_1_1)

Load Test Area Description

The HIA study area is principally associated with the immediate area around the proposed Load Test Pit excavation (Bradwell_1).

The Load Test Pit excavation (Bradwell_1) will comprise an open cut excavation to expose the top of the unweathered London Clay bedrock to permit assessment of the excavation and foundation settlement for the proposed new nuclear power station. The completed excavation will be approximately 220m long by 114m wide and up to 14m deep (formation level of -7.0 m above Ordnance Datum (AOD)). The test is expected to be undertaken over a two to three-year period.

An important design element is that groundwater ingress to the excavation from the shallow superficial deposits will be controlled via installation of an impermeable cut-off wall tied into the London Clay Formation. This wall will exclude ingress of water into the excavation from the superficial deposits.

Environmental Setting

Geology

Regional Geology

Previous studies by Amec Foster Wheeler (now Wood) [6] indicates the HIA study area (Drawing 412657-MMD-00-XX-DR-C-0001, Appendix A) to be underlain by Flandrian Coastal Zone Deposits in the north and River Terrace Deposits in the south. These deposits are underlain by London Clay. The London Clay is underlain by the Thanet Sand Formation, which is subsequently underlain by the Cretaceous Chalk.

Local Geology

The anticipated geology, local to the Load Test Pit excavation, is considered to comprise the following strata (based on historical 1987 Soil Investigation records):

- Topsoil – to a depth of 0.30m below ground level (bgl), but varies locally, typically 0.25-0.48m bgl;
- Superficial deposits, comprising predominantly Head Deposits, River Terrace Sands and Gravels – Depth varies locally, typically 0.90-1.80m bgl, max 2.50m bgl;
- Weathered London Clay, to a typical depth of 4.80m bgl; and
- Competent London Clay, to a typical depth of 37.70m bgl (base not proven within Load Test Area).

Hydrogeology

Aquifer Designations

The River Terrace Deposits and coarser Glacial Deposits are considered by Wood [6] and Mott MacDonald [1] to support a shallow groundwater body, classified as a secondary (undifferentiated) aquifer, of high leaching potential. The sensitivity of the aquifer in the River Terrace Deposits is assessed as moderate [6] [10].

The remainder of the superficial deposits and underlying London Clay are classified as unproductive strata. The sensitivity of groundwater in these strata is assessed as very low [6] [10], given the low permeability of the strata.

The Thanet Sand and Chalk aquifers are both designated as principal aquifers [6], although the available information indicates the Chalk at the point at which it underlies the site is located some 40km from the aquifer recharge point and, as such, groundwater quality in the Chalk aquifer beneath the site is likely to be diminished and with the potential for saline groundwater, given the geographical location of the site.

Given the proposed construction of the Load Test Pit excavation, which will be founded at the base of the weathered upper horizon of the London Clay, the sensitivity of the Thanet Sand and Chalk aquifers is assessed as negligible and is ignored.

Source Protection Zones

No groundwater Source Protection Zones (SPZ) are recorded within 1km of the proposed water resources abstraction [10].

Groundwater Abstractions

The Envirocheck datasheet indicates that there are no (public or private) groundwater abstraction licences within 1km of the site (Appendix B). The nearest abstraction well is approximately 1,268m north-east of the Load Test Pit excavation:

Table 2 - Summary of groundwater abstractions

Grid Reference	Location	Proximity to the Site	Purpose	Max Daily Abstraction (cubic metres)	Licence Number
E: 602200 N: 208900 (TM 02200 08900)	Eastlands Farm, Bradwell-on-Sea	1,268m South East	General farming and domestic	Not supplied	8/37/43/*G/0022

The Envirocheck records do not indicate which aquifer the abstraction is related however, based on publicly available British Geological Survey online borehole records, it is considered groundwater is drawn from the Thanet Sands or Chalk aquifer, underlying the London Clay.

Hydrology

Surface Water Features

An extensive network of drains and ditches is present across the study area protected by a Tidal Defence Embankment, located between the study area and Blackwater Estuary approximately 1km to the north and the North Sea approximately 2km to the East.

The nearest surface water feature is an unnamed Ordinary Watercourse, located approximately 100m to the east. Flow in the Ordinary Watercourse is understood to be south east, discharging into Weymarks River, which flows north/ north east approximately 200m south east of the study area at its closest point.

Based on the surrounding topography, geography and understanding of the drainage network, the overall direction of surface water flow is understood to be north/north-east, akin to Weymarks River, toward Blackwater Estuary / the North Sea.

Discharge from the surrounding drainage network into Blackwater Estuary and the North Sea is via two tidal outfalls, behind the flood defence embankment, at NGR TM 01576 09434 and TM 02996 08930 respectively. It is understood these are closed an high tide, and open at low tide.

Surface Water Abstractions

The Envirocheck datasheet indicates that there are four surface water abstraction licences within 1km of the site (Appendix B). The nearest abstraction is approximately 385m south of the Load Test Pit excavation:

Table 3 - Summary of surface water abstractions

ID	Grid Reference	Operator/ Location	Proximity to the Site	Purpose	Max Daily Abstraction (cubic metres)	Licence Number
1	E: 601300 N: 207895 (TM 01300 07895)	Strutt & Parker (Farms) Ltd Weymarks Ditch, East Hall Farm	385m South	Spray irrigation	7	8/37/39/*S/047
2	E: 601900 N: 208195 (TM 01900 08195)	Strutt & Parker (Farms) Ltd Weymarks Ditch, East Hall Farm	743m East	Spray irrigation	50	8/37/39/*S/047

ID	Grid Reference	Operator/ Location	Proximity to the Site	Purpose	Max Daily Abstraction (cubic metres)	Licence Number
3	E: 601920 N: 208615 (TM 01920 08615)	Strutt & Parker (Farms) Ltd Weymarks Ditch, East Hall Farm	842m North East	Spray irrigation	80	8/37/39/*S/047
4	E: 601400 N: 209100 (TM 01400 09100)	Strutt & Parker (Farms) Ltd Weymarks Ditch, East Hall Farm	880m North	Spray irrigation	7	8/37/39/*S/047

None of the above surface water abstractions are located on the Ordinary Watercourse, to which abstracted water from the Load Test Pit excavation will be discharged.

Abstraction No.1 is from a point on Weymarks River, 385m south of the abstraction and upstream of the confluence of Weymarks River and the Ordinary Watercourse.

Abstraction No.2 is from a surface water pond, fed by Weymarks River, approximately 743m east of the abstraction downstream of the confluence of the Ordinary Watercourse and Weymarks River.

Abstractions No.3 and No.4 are located 842m north east and 880m north respectively, from Weymarks River, downstream of the Ordinary Watercourse.

Flood Risk

Flood risk mapping indicates that the site is located in an area that benefits from flood defences. These defences comprise the sea wall located off-site between the site and the Blackwater Estuary located to the north and the North Sea located to the east. The proposed Load Test Pit and associated abstraction is located outside the flood zone, on the inside (landward side) of the flood defence embankment.

Sources of water ingress

For the purpose of this HIA, two sources of water ingress are considered in the CSM for the Load Test Pit excavation:

Rainfall

Direct precipitation and run-off from the exposed excavation side slopes and base of the excavation will be captured by perimeter ditches at the base of excavation and routed to a temporary Pumping Station (Pump Sump), where it will be elevated to the lined perimeter drainage system within the site area. The water from all sump pumps will be connected to the same discharge line, prior to connection with the lined perimeter drainage system and monitored using an inline flow meter so that the abstraction rate can be recorded.

Assuming a Standard Annual Average Rainfall (SAAR) depth of 516mm, direct rainfall to the Load Test Pit excavation is estimated to be approximately 12,940 m^3/annum (0.4 l/s).

Groundwater

Groundwater ingress to the Load Test Pit excavation is divided between two principal components:

Nuisance groundwater

Nuisance groundwater principally relates to shallow groundwater, present in the superficial deposits, which may initially be encountered during the construction of the excavation during progressive deepening of the excavation. Due to the installation of an impermeable vertical geomembrane cut-off wall, the majority of this water would come from groundwater residing in the superficial within the area enclosed by the cut-off wall. It is expected that any perched groundwater encountered within the superficial deposits will rapidly dissipate and will not be recharged by the remaining surrounding aquifer due to the cut off wall that will preclude groundwater flow

The total volume of nuisance groundwater from the superficial deposits is estimated to be 7,524 m^3. Assuming a programmed construction period of 30 days, this equates to a dewatering rate of 2.9 l/s during construction.

Subsequently, nuisance water may arise via the infiltration of incident rainfall upon the narrow (2 m wide) crest catchment, percolating into the superficial deposits and emerging from the excavation cut face. The rate of nuisance water seepage is calculated to be approximately 690 m^3/annum (0.02 l/s).

Long-term seepages
Due to the preclusion of groundwater inflow from the superficial deposits outside the area defined by the impermeable vertical geomembrane around the perimeter of the Load Test Pit excavation, long-term groundwater seepage is confined to between 53,611-72,533 m^3/annum (1.7-2.3 l/s); this is calculated to arise from the cut faces and basal area of the excavation within the weathered and competent London Clay.

Summary

Total water ingress during the 3-year operational period of the Load Test Pit excavation can be summarised as follows:

Construction Period (30 days)

- Nuisance superficial groundwater = 7,524 m^3 (2.9 l/sec)
- Nuisance infiltration from crest = 690 m^3/annum (0.02 l/s)
- Seepage from London Clay = 53,611-72,533 m^3/annum (1.7-2.3 l/s)
- Direct rainfall = 12,940 m^3/annum (0.4 l /s)

Long-term Abstraction Volume (30+ days)

- Nuisance superficial groundwater = 0 (due to impermeable barrier)
- Nuisance infiltration from crest = 690 m^3/annum (0.02 l/s)
- Seepage from London Clay = 53,611-72,533 m^3/annum (1.7-2.3 l/s)
- Direct rainfall = 12,940 m^3/annum (0.4l /s)

The rates presented above are considered to be highly conservative and are based on the worst-case, upper bound assumed porosity and permeability estimates for the underlying strata. Realised rates are likely to be substantially less.

Step 3: Identify all potential water features that are susceptible to flow impacts

The following water features within 1km have been identified as being potentially susceptible to flow impacts:

- Groundwater in the superficial secondary (undifferentiated) aquifer;
- An unnamed Ordinary Watercourse (tributary of Weymarks River);
- Weymarks River (also referred to locally as Weymarks Ditch); and
- Four surface water abstractions by Strutt & Parker (Farms) Ltd from Weymarks River for the purpose of spray irrigation:
  - 385m south east (E: 601300, N: 207895)
  - 743m east (E: 601900, N: 208195)
  - 842m north east (E: 601920, N: 208615)
  - 880m north (E: 601400, N: 209100).

Step 4: Apportion the likely flow impacts to the water features

Superficial Deposits Groundwater

Groundwater flow in the superficial deposits is considered to be principally driven by rainfall. Installation of a vertical impermeable geomembrane barrier will result in localised redirection of groundwater flow in the aquifer around the Load Test Pit.

Other than the short-term removal of nuisance water during the Load Test Pit construction phase the flow impacts to groundwater flow in the surrounding superficial aquifer are considered to be **Negligible**.

Surface Water – Ordinary Watercourse

In the absence of any proposed abstraction from the surrounding superficial aquifer, the potential impact on groundwater baseflow discharge to the Ordinary Watercourse, due to the limited short-term disruption of groundwater flow by the installation of the cut off wall, is considered **Very Low**. Removal of nuisance water within the area of the Load Test Pit will have **no net impact** on flow as it will be discharged to the water course within greenfield run-off limits.

Baseflow discharge to the Ordinary Watercourse from the London Clay is considered negligible due to the low permeability of the strata. Any groundwater seepages into the excavation from the sides and base within the London Clay **will not have any impact** on long term groundwater flow (and therefore baseflow contribution to the water course) within the London Clay.

Surface Water – Weymarks River and Downstream Abstractions

Baseflow discharge to Weymarks River from either the superficial deposits or the London Clay is considered to be of **Negligible** risk, due to the small proportion of the drained area of the works that reside within the direct catchment of the Weymarks River, upstream of the confluence with the ordinary water course.

Downstream surface water abstractions are considered to be at **Negligible** risk of impact from the proposed dewatering activity, due to all abstracted water being discharged into the ordinary water course and ultimately the wider drainage network.

Step 5: Allow for the mitigating effects of any discharges, to arrive at net flow impacts

Superficial Deposits Groundwater

It is considered there will be no change in long-term net flow impacts as a result of the proposed dewatering abstraction of the Load Test Pit, due to the installation of the impermeable geomembrane barrier. Short-term net flow impacts associated with abstraction of nuisance water during construction of the pit will have limited flow effects as the total abstraction volume is small and the the load test pit is located close to the eastern, down gradient extent of the shallow aquifer.

Surface Water – Ordinary Watercourse

The net flow impact on flow in the Ordinary Watercourse is likely to be to be positive, due to discharge of abstracted water from the Load Test Pit excavation, which will include both additional rainfall incident to the lined drainage across the site and input of groundwater from the London Clay – that is not likely to otherwise form baseflow to the water course.

Surface Water – Weymarks River and Downstream Abstractions

As explained above, net flow impact on flow is considered to be positive gain, due to the increase in flow from the ordinary watercourse at its confluence with Weymarks River at NGR TM 01645 08067.

Step 6: Assess the significance of the net flow impacts

Low Flows Assessment

An assessment of natural low flows for the Ordinary Watercourse was prepared by the UK Centre for Ecology and Hydrology on behalf of BRB GenCo Ltd [9].

The flow duration curve for the ordinary watercourse is shown in Figure 1. This shows the annual flow duration and the variation in flow duration.

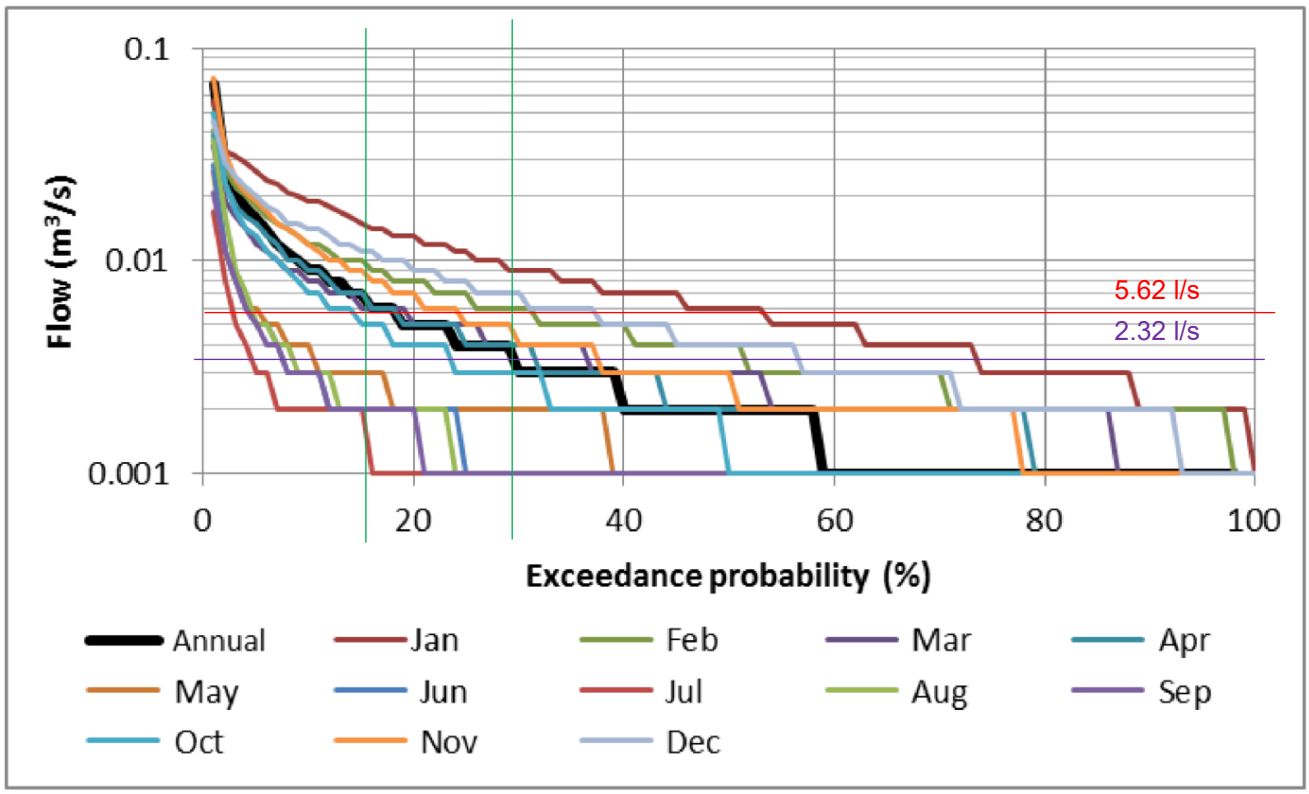


Figure 1 - Calculated flow duration curve for the Ordinary Watercourse

A peak discharge rate of 15 l/s is proposed; however, the average rate of discharge will be significantly less and in-line with the calculated average abstraction rates (Step 2). The average abstraction rate of 5.62 l/s during the construction phase is comparable to back ground flow conditions in the water course, with an exceedance probability of 18%. The operational phase abstraction rate (2.32 l/s) has an exceedance probability of 30%. The maximum discharge rate of 15l/s remains lower than peak flow events during the dry season (July) circa 18/ls. While there may be a slight increase in net flow in the ordinary water course, these are well within the flows observed within this water feature over the year.

Step 7: Define the search area for drawdown impacts

The impermeable perimeter cut off wall will negate any groundwater flow into the Load Test Pit excavation from the superficial aquifer. Accordingly, it is considered that the radius of influence within this formation will not extend beyond the cut off wall.

The drainage strategy prepared by Mott MacDonald [1] calculated the radius of influence of the dewatering activity, for the London Clay, to be extremely steep; with a radius of less than 10m. There are no relevant features within 10m of the Load Test Pit that could be impacted by drawdown within the London Clay.

Based on the above conceptualisation and drainage design, , it is considered that Steps 8 to 11 are not required.

Step 8: Identify all features in the search area that could be impacted by drawdown

No features impacted by drawdown.

Step 9: For all these features, predict the likely drawdown impacts

Not applicable for this HIA

Step 10: Allow for the effects of measures taken to mitigate the drawdown impacts

Not applicable for this HIA

Step 11: Assess the significance of the net drawdown impacts

Not applicable for this HIA

Step 12: Assess the water quality impacts

Discharge of abstracted water

It is proposed to discharge mixed groundwater and rainfall during the construction and operational phases to the Ordinary Watercourse.

It is considered, in the absence of any site-specific information on groundwater quality, that due to the degree of existing baseflow discharge from the superficial aquifer to the Ordinary Watercourse and Weymarks River, that the quality of surface water therein is largely representative of background groundwater quality conditions.

Three surface water samples have been collected by Wood Plc [7] from selected locations on the Ordinary Watercourse and Weymarks River (Drawing extract "Figure 2 – Surface water – sampled locations", Appendix A). Two rounds have been completed to date; 19 December 2019 and 8 January 2020. A further two rounds are to be completed at weekly intervals in January 2020.

- **Sample Point 1** is located on a drainage ditch located due east of the proposed Load Test Area. The drainage ditch flows in a southerly direction before converging with the Weymarks River located south/south-east of the Load Test Area.
- **Sample Point 2** is located to the south-east of the proposed Load Test Area, at a location immediately downstream of the point at which the aforementioned ditch converges with the Weymarks River.
- **Sample Point 3** is located to the south east of the proposed Load Test Area, at a location upstream of the point at which the ditch converges with Weymarks River.

In order to assess the background quality, surface water chemical analyses from three locations have been compared to Generic Assessment Criteria (GACs) based on published Environmental Quality Standards (EQS) values for freshwaters [11].

Additionally, concentrations of bioavailable determinands (copper, lead, manganese, nickel and zinc) have been assessed against Predicted No Effect Concentrations (PNECs) using the Water Framework Directive UK Technical Advisory Group metal bioavailability assessment tool (M-BAT) [12].

Exceedances of GACs are listed in Table 4.

Table 4 – Water quality exceedances

Determinand	GAC		Round 1			Round 2		
			SW1	SW2	SW3	SW1	SW2	SW3
Ammoniacal Nitrogen as N	0.2	EQS	0.252	<0.2	0.426	<0.2	0.659	0.37
Ammoniacal Nitrogen as NH4	0.26	EQS	0.324	<0.3	0.548	<0.3	0.847	0.476
Benzo(a)pyrene	0.00000017	EQS	0.000044	0.000034	0.00026	<0.000002	<0.000002	0.000008
Fluoranthene	0.0000063	EQS	0.000056	0.000043	0.000466	0.000005	0.000006	0.000015

Note:

All concentrations in mg/l
Pink shading denotes GAC exceedances

Ammoniacal nitrogen is likely to be naturally occurring and/or associated with surrounding agricultural land use and the groundwater discharge is likely to be similar or less than those recorded in surface water.

The presence of PAH compounds, benzo(a)pyrene and fluoranthene, are not considered to be representative of background groundwater conditions as these compounds are highly recalcitrant and effectively immobile in groundwater systems. PAH compounds in surface waters are considered to be likely associated with direct inputs to surface water via run-off rather than groundwater baseflow.

It is also noted that groundwater abstractions from the London Clay will also be subject to dilution with direct rainfall and therefore, the water discharge to the Ordinary Watercourse will likely result in no net impact, or a marginal improvement in quality.

Step 13: If necessary, redesign the mitigation measures to minimise the impacts

If through subsequent site investigation, there is any unexpected contamination that could lead to deterioration or surface water due to the discharge associated with the Load Test Pit, suitable treatment would be specified for the discharge.

Step 14: Develop a monitoring strategy

The outline monitoring strategy set out below is proposed for the works. BRB GenCo Ltd can provide a more detailed monitoring strategy as required in advance of construction.

Baseline monitoring

Surface Water

Surface water chemical analyses, including in-situ monitoring, will continue to be taken in order to extend the current dataset and characterise the Ordinary Watercourse and Weymarks River.

Flow gauging along the Ordinary Watercourse and Weymarks River will be undertaken in order characterise the baseline flow regime in these watercourses.

Groundwater

Groundwater level and chemical analyses, including in-situ monitoring, will be taken from within the excavation area in order to confirm the assumptions made above with respect to groundwater levels and baseline quality.

Construction phase monitoring

Surface Water

Surface water flow gauging and water chemical analyses as described above will be continued into the construction phase.

Groundwater

Groundwater level and water chemical analyses as described above will be continued into the construction phase.

Abstraction rates (and subsequent discharge rates) from the Load Test Pit excavation will be monitored using appropriate in-line flow meters.

Operational phase monitoring

The monitoring described above for surface water and groundwater will be continued following construction.

Post operational phase monitoring

The monitoring described above for surface water and groundwater will be continued for three months post completion.

References

[1] M. MacDonald, “Interim Drainage Strategy,” 2020.

[2] Environment Agency, “Hydrogeological impact appraisal for dewatering abstractions,” 2007.

[3] Environment Agency, “South Ead River Basin District - River Basin Management Plan,” 2015.

[4] Environment Agency, “Essex abstraction licensing strategy,” 2017.

[5] Environment Agency, “Catchment Data Explorer,” 16 October 2017. [Online]. Available: https://environment.data.gov.uk/catchment-planning/. [Accessed January 2020].

[6] A. F. W. E. &. I. Limited, “Bradwell B Preliminary Ground Investigation, Phase 1 Contaminated Land Study,” 2017.

[7] W. PLC, “Bradwell B Ground Investigation Planning Support - Surface Water Sampling (Round 1),” 2020.

[8] W. PLC, “Bradwell B Ground Investigation Planning Support: Surface Water Sampling (Round 2),” 2020.

[9] C. B. G. Ltd, “Bradwell B Marine Studies, Weymarks Stream Low Flows Report TR56,” 2019.

[10] Envirocheck, “Site Sensitivity Report (Ref 231097789_1_1),” 2020.

[11] E. Agency, “Surface water pollution risk assessment for your environmental permit,” [Online]. Available: https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit. [Accessed 29 January 2020].

[12] W. F. D. U. K. T. A. Group, “Rivers & Lakes - Metal Bioavailability Assessment Tool (M-BAT),” [Online]. Available: http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat. [Accessed 29 January 2020].

Appendix A. – Drawings

Drawing 412657-MMD-00-XX-DR-C-0001
Bradwell 'B' Nuclear Power Plant Project Site Location Plan

Extracted Figure 2
Bradwell B Nuclear Power Plant Project. Ground Investigation Planning Support. Surface Water Sampling Locations

Notes

1. This drawing is for Planning Purposes only.
2. All heights of structures and facilities within the Site Compound no higher than 10m above ground level.

Key to symbols

- Planning application boundary
- Excluded from Planning Application
- Site Compounds and Load Test area

Reference drawings

412657-MMD-00-XX-DR-C-0001
412657-MMD-00-XX-DR-C-0002
412657-MMD-00-XX-DR-C-0003
412657-MMD-00-XX-DR-C-0004
412657-MMD-00-XX-DR-C-0005

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	07.01.20	GC	SECOND ISSUE FOR PLANNING	JW	RT
P1	13.12.19	GC	FIRST ISSUE FOR PLANNING	JW	RT

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Client

BRB CGN EDF ENERGY

Title

BRADWELL 'B' NUCLEAR POWER PLANT PROJECT
SITE LOCATION PLAN

Designed	J.WEBBER	JW	Eng check	J.WEBBER	JW
Drawn	G.CHILVERS	GC	Coordination	T.HICKSON	TH
Dwg check	D.VANNECK	DV	Approved	R.TALBY	RT

Scale at A1	Status	Rev	Security
1:25000	PRE	P2	STD

Drawing Number

412657-MMD-00-XX-DR-C-0001

1:25,000 0 1000m 2500m

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601300 601400 601500 601600 601700 601800 601900

208400 208300 208200 208100 208000 207900

N

SW1

SW2

SW3

Key

Sample location

Bradwell Waterside

Bradwell on Sea

0 20 40 60 80 100 120 m

Scale at A3: 1:2,000

Bradwell B Nuclear Power Plant Project
Ground Investigation Planning Support
Surface Water Sampling

Figure 2
Surface water - sampled locations

January 2020

wood.

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