

Technical Note

Project:	Bradwell B Nuclear Power Plant - Load Test Pit		
Subject:	Discharge Consent Application – Supporting Information		
Author:	██████████	Checked:	██████████
Reviewed:	██████████	Authorised:	██████████
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Introduction

This document supports the application for an Environmental Permit for a water discharge activity at the proposed site of a Load Test Investigation, 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 B2 and B6 of the application as well as references to additional documentation of relevance to the application, as detailed in Table 1.

Table 1 - Summary of supporting information for discharge consent application

Part	Question	Supporting information included in this document	Referenced documents
A	5c	Company Directors	Within text of this document
B2	3d	Management systems	Mott MacDonald Interim Drainage Strategy (Appendix A)
	5a	Plan for site	Drawing 412657-MMD-00-XX-DR-C-0001 (Appendix B)
	5c	Non-technical summary of application	Within text of this document
	6	Environmental risk assessment	Surface water pollution risk assessment (Appendix C) Ecological Appraisal, including Section 6: Habitats Regulation Assessment (Appendix D)

Part	Question	Supporting information included in this document	Referenced documents
B6	2, 3	Discharge effluent duration and volume	Mott MacDonald Interim Drainage Strategy (Appendix A)
	6	Discharge quality achieved by treatment	Surface water pollution risk assessment (Appendix C)
	7	Effluent contents	Within text of this document and Surface water pollution risk assessment (Appendix C)
	8	Environmental risk assessments and modelling	Surface water pollution risk assessment (Appendix C)
	10	Monitoring Arrangements	Within text of this document

Part A

Question 5c – Company Directors

Directors, additional to Alan Paul Raymant and Humphrey Alan Edward Cadoux-Hudson are listed below:

- Dr Qing Mao
- Patrick Pruvot
- Yu Qi
- Dongshan Zheng
- Minhong Zhu

Part B2

Question 3d – Management system

The drainage strategy for the Load Test Pit excavation is detailed in Mott MacDonald's Interim Drainage Strategy, which is included as a supporting document with this Environmental Permit application (Appendix A).

A Water Management System (WMS) for the site will be provided in line with the requirements of ISO 14001 before the start of construction.

Question 5a – Plan for site

A plan of the site is included as Drawing 412657/MMD/SK/DG/0002 Rev B entitled "Figure 1: Surface Water Drainage Strategy" in Appendix B.

Question 5c – Non-technical summary of application

BRB Gen Co are conducting a Load Test Investigation on the proposed site of Bradwell B Nuclear Power Plant. The purpose of the Load Test Investigation is to enable excavation, loading and foundation settlement assessments to be completed for the new nuclear power station. All testing will be completed within the Load Test Area, defined in Drawing 412657-MMD-00-XX-DR-C-0001 (Appendix B).

The Load Test Area comprises several distinct zones, each requiring specific long-term drainage systems to prevent water from accumulating on site, over a test period of up to 3 years. These zones are grouped into two broad categories:

- **Load Test Pit Excavation**

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.

- **Surcharge Test, Soil Storage Bund and Peripheral Areas**

The excavation for the Load Test Pit will generate a significant volume of arisings. The arisings will be placed and recompacted to form a controlled engineered embankment, above an instrumented zone, to further inform the foundation settlement assessment. Excess soil will be stored in the form of a bund.

Details of the proposed drainage strategy to be employed for the duration of the proposed works has been prepared by Mott MacDonald (Appendix A).

This application is for an Environmental Permit to discharge water arising from the dewatering and drainage of the Load Test Area. The water to be discharged arises from the following sources.

Any groundwater seepages, direct rainfall to the excavation and run-off from the exposed excavation side slopes 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 remainder of the Load Test Area which will be directed to the Settlement/Attenuation Retention Pond.

Unaltered surface water run-off from the surcharge test area, soil storage bund and peripheral areas will be directed via an on-site surface water interception system to a single Settlement/Attenuation Retention Pond to the north, prior to discharge to an existing Ordinary watercourse located to the east at National Grid Reference (NGR) TM 01249 08474.

All other undisturbed areas of the Load Test Area will remain as existing without any formal drainage (Appendix A). Contribution to the discharge from these areas is considered to be zero.

Atkins consider that the quality of water discharged from the Load Test Area will be of equivalent quality to the surface watercourses and groundwater baseflow and will therefore not have an adverse effect on water quality in the receiving watercourse.

Further information: the assessment of effects on the receiving watercourse and connected designated sites is provided in the application (see Appendix D: Ecological Appraisal, Section 6: Habitats Regulation Assessment Document prepared by Wood Plc on behalf of BRB GenCo Ltd [1]).

Question 6 – Environmental Risk Assessment

A surface water pollution risk assessment has been carried out for the proposed discharge activity. This risk assessment is presented in the form of a Technical Note as a supporting document with this application (Appendix C). The risk assessment should also be read in conjunction with the accompanying Habitats Regulation Assessment Document [1].

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

As the activity is not for a waste or installation permit, a climate change risk screening and assessment is not required.

Part B6

Questions 2 and 3 – Discharge effluent duration and volume

A maximum daily discharge volume of 1,296 m³/day is sought, based on the interim drainage strategy designed by Mott MacDonald (Appendix A). Where necessary, water will be temporarily stored in an on-site Settlement/Attenuation Pond (capacity 4,000 m³) to ensure the daily discharge volume is not exceeded. The Settlement/Attenuation Pond is designed to buffer the peak storm flows anticipated from 1 in 30-year storm events, to mitigate high peak flows on the receiving watercourse.

Question 6 – Discharge quality achieved by treatment

The water discharged from the Load Test Area will be in line with the existing receiving water quality (Appendix C). It is considered that dilution of groundwater abstracted from the Load Test Pit excavation with direct rainfall and unaltered surface water run-off from the Surcharge Test, Soil Bund and Peripheral Areas will sufficiently mitigate any potential impacts to the quality of water in the Ordinary Watercourse.

In-line with the Interim Drainage Strategy (Appendix A), the water is not expected to require treatment. However, the combined Settlement/Attenuation Pond will include preventative measures for silt removal through lagoon settlement (code 10) and measures to intercept light liquids (oils and hydrocarbon substances).

The proposed treatment is shown in Table 2.

Table 2 – Proposed treatment

Activity	Pre-treated Source	Proposed Treatment
Load Test Investigation	Abstraction from Load Test Pit excavation Direct rainfall to Load Test Area Surface water run-off from surcharge test, soil storage bund and peripheral areas	Settlement/ Attenuation Pond, desilting unit (e.g. silt buster unit) and oil water separator

Question 7 – Effluent contents

It is assumed that the only substances present in the effluent will be those already contained in the groundwater of the superficial alluvium and London Clay. No substances are added to the effluent.

Given the Baseflow Index of the Waymarks River is 0.52 – based on BRB GenCo Ltd/ Centre for Ecology and Hydrology report entitled “Weymarks Stream Low Flows Report TR56”, dated December 2019 - it is considered that in the absence of any site-specific information on groundwater quality, the quality of surface water in the Ordinary Watercourse and Weymarks River is representative of background groundwater quality conditions.

The surface water pollution risk assessment (Appendix C) identified the presence of a number of potential pollutants in surface water. It is considered that PAH compounds will not be present in the groundwater component of the discharge due to the absence of a credible source in the Load Test Area and the highly recalcitrant nature of these substances in groundwater systems. Other substances present in the rainfall and run-off component of the discharge are assumed to reflect the existing background quality in the receiving water course and therefore their presence will not result in any impact to the water courses downstream of the site.

Further, all abstracted groundwater from the Load Test Pit excavation will be subject to dilution with direct rainfall and unaltered surface water run-off from the Surcharge Test, Soil Bund and Peripheral Areas. It is considered that this dilution will sufficiently mitigate any potential impacts to the quality of water discharged to the Ordinary Watercourse.

Question 8 – Environmental risk assessments and modelling

A surface water pollution risk assessment has been carried out for the proposed discharge activity. This risk assessment is presented in the form of a Technical Note as a supporting document with this application (Appendix C).

The risk assessment was prepared based on the interim drainage strategy designed by Mott MacDonald (Appendix A). It provides an assessment of the potential impacts from the dewatering system.

Question 10 – Monitoring Arrangements

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

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

During the discharge activity, water samples will be collected for chemical analyses to confirm the quality of the water being discharged. The discharge will also be monitored using an inline flow meter to ensure compliance with the agreed discharge rates.

References

- [1] W. Plc, "Habitats Regulation Assessment," 2020.
- [2] M. MacDonald, "Interim Drainage Strategy," 2020.
- [3] W. PLC, "Bradwell B Ground Investigation Planning Support - Surface Water Sampling (Round 1)," 2020.
- [4] W. PLC, "Bradwell B Ground Investigation Planning Support: Surface Water Sampling (Round 2)," 2020.

Appendix A. – Interim Drainage Strategy

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 4.6km² 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.

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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 (25,080m²)
- Spoil storage area (16,400m²)
- Plant Storage and Materials Lay-down Area (3,000m²)
- Topsoil storage area (12,400m²)
- Topsoil storage area (2,000m²)
- Surcharge Test Area (+6m above GL) (5,500m²)
- Surcharge Test Area (+8m above GL) (23,500m²)
- 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 m³/day from the Superficial Deposits

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

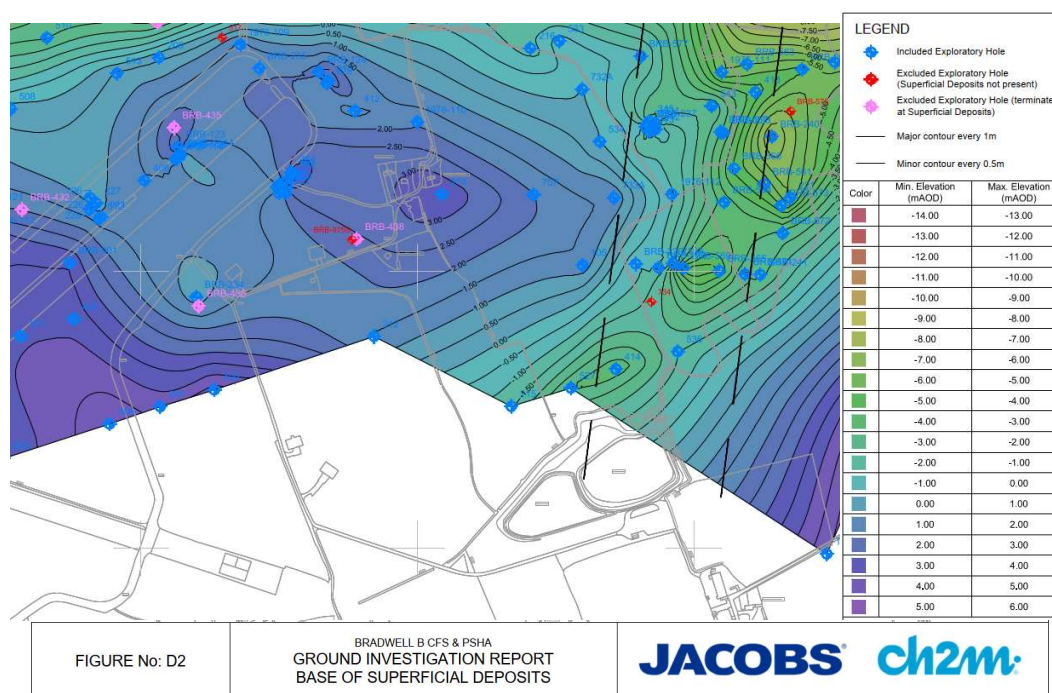


Figure 6 : Contour Plan of Base of Superficial Deposits
Source : Ground Investigation (2017) (Jacobs)

*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 :
 - o 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 = 7524m³, 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) = 690m³/year, 0.02l/sec

Direct rainfall = 12,940m³/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) = 690m³/year, 0.02l/sec

Direct rainfall = 12,940m³/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

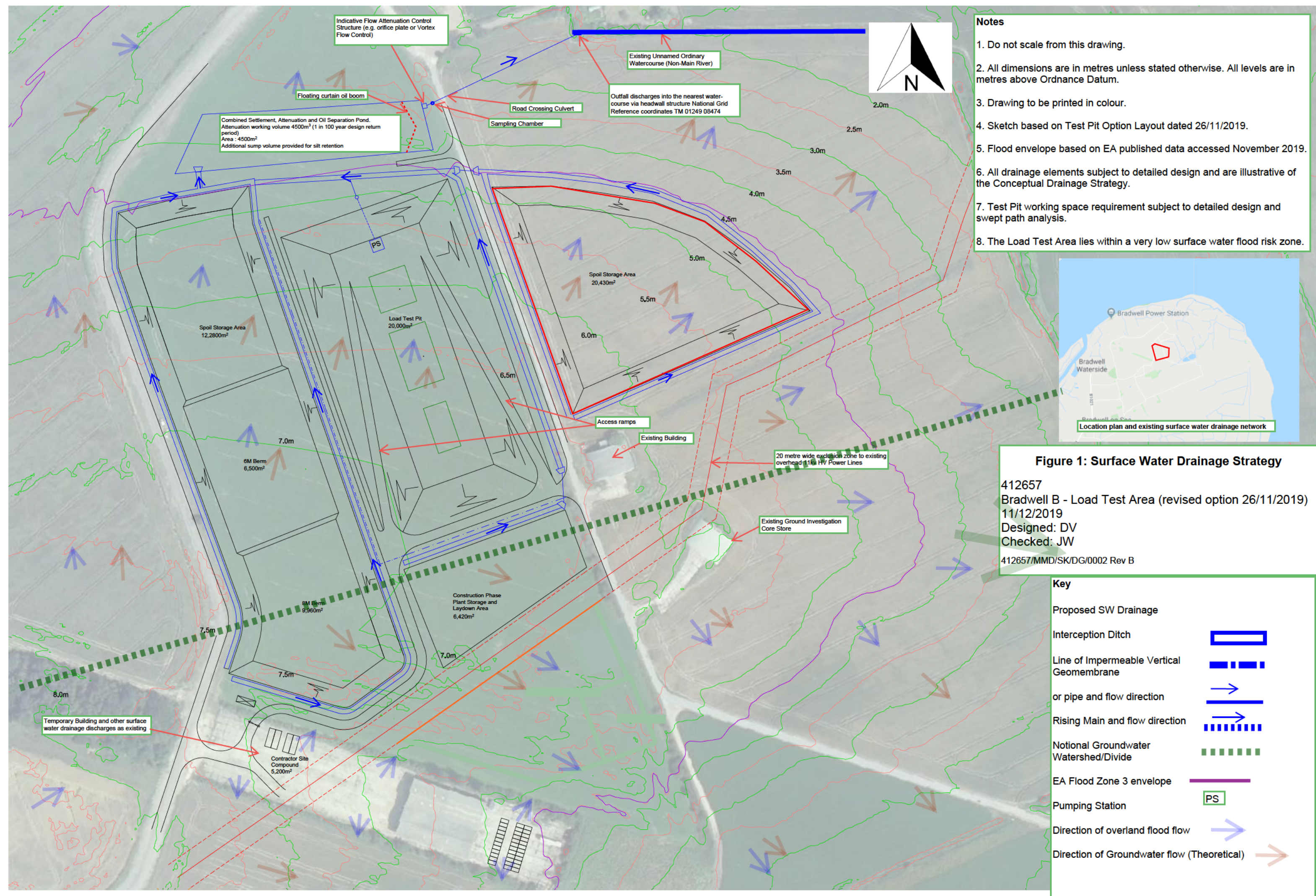
The indicative programme is as follows:

- 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





Excavation of load test area (2)



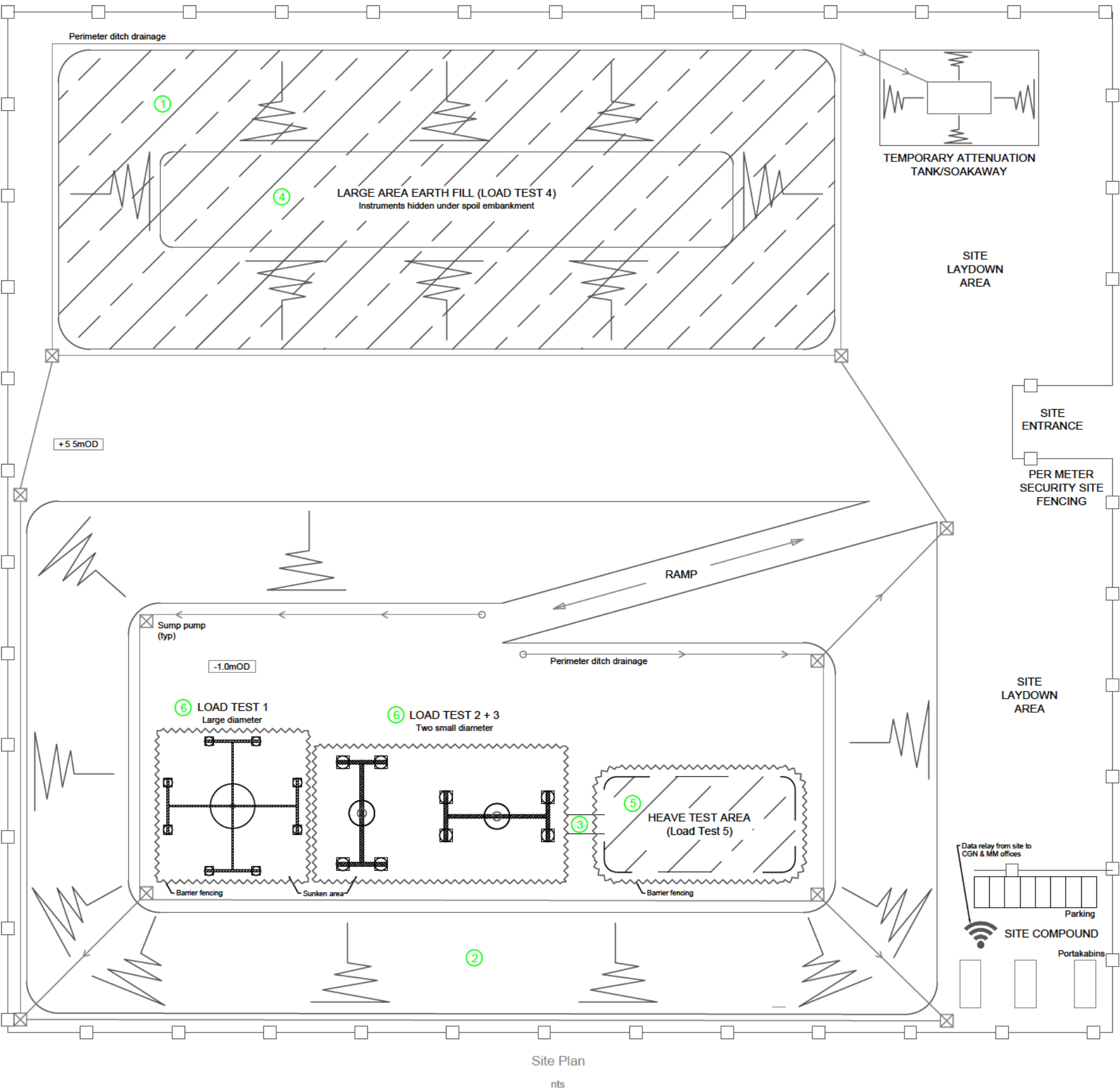
Horizontal inclinometer installed below earth fill (1)



Plate load test (Load Test 2) (6)



Logging exposed excavated surfaces (2)



Location plan



Bradwell-on-Sea
UK

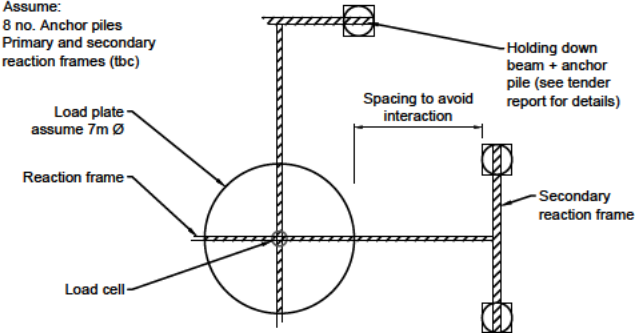
Workflow

- 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

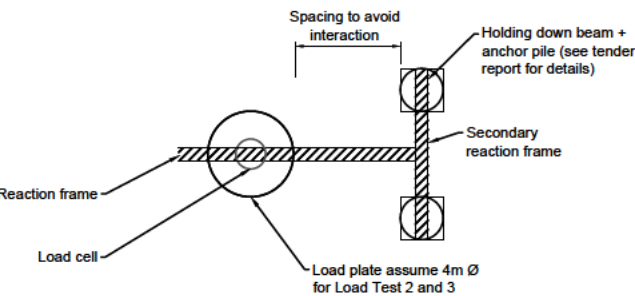


Figure 2: Example of a Similar
Load Test Installation

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

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.

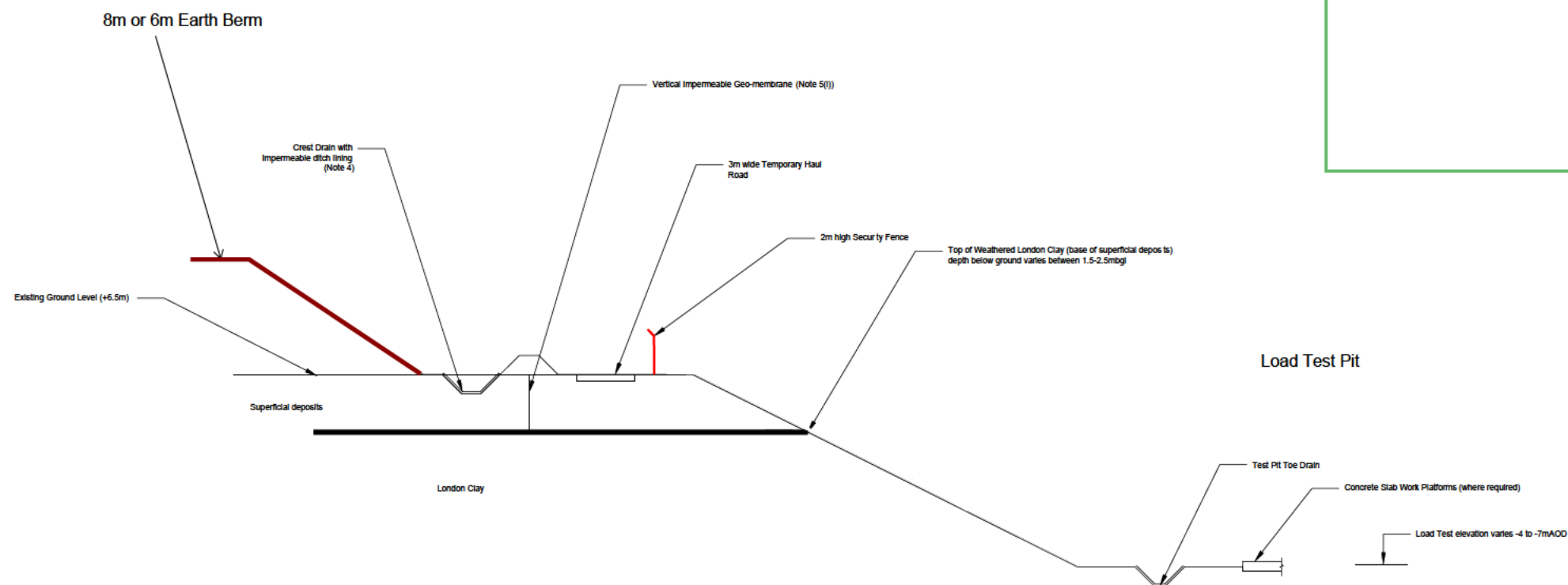
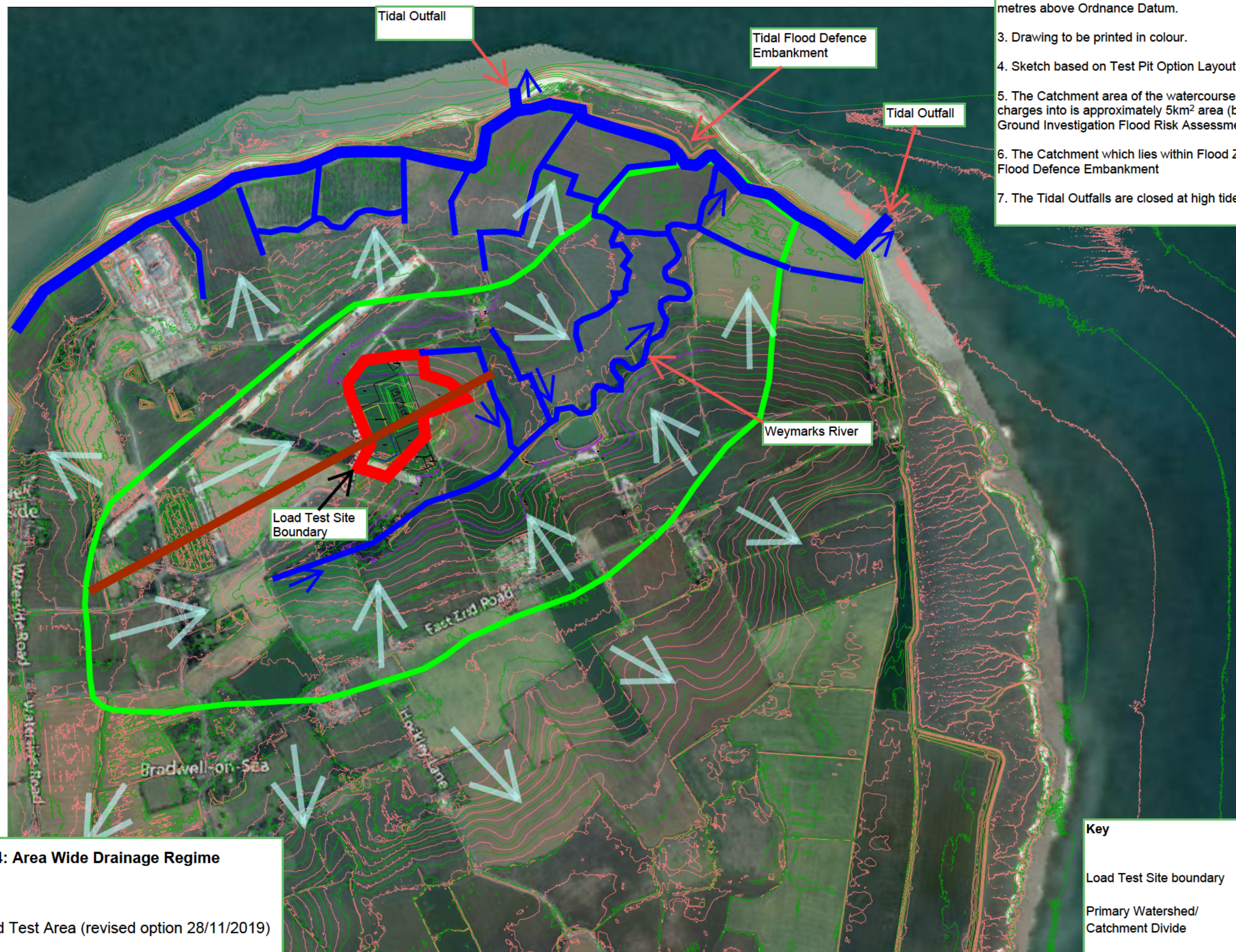


Figure 3: Typical Section of Test Pit and Surcharge Test Earth Berm

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. 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 5km² 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



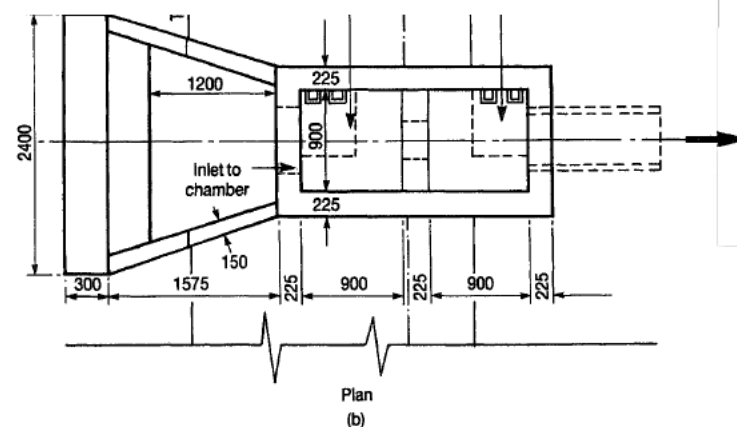


Figure 7.12 Typical orifice control chamber for a small onstream reservoir. (a) Section through chamber.

Attenuation Pond Typical Outlet Control

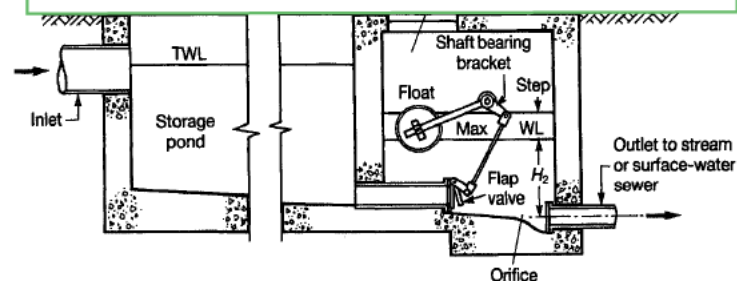
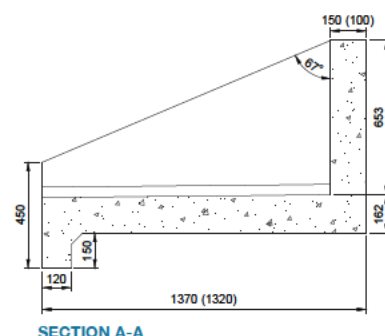
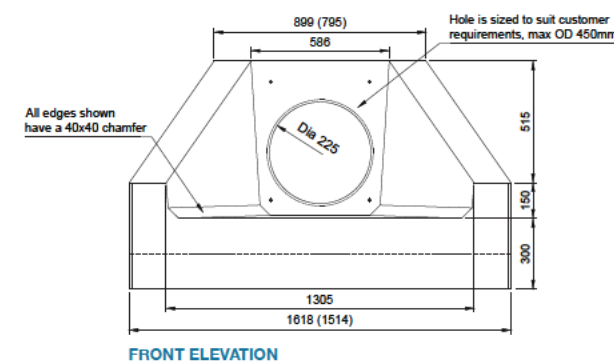
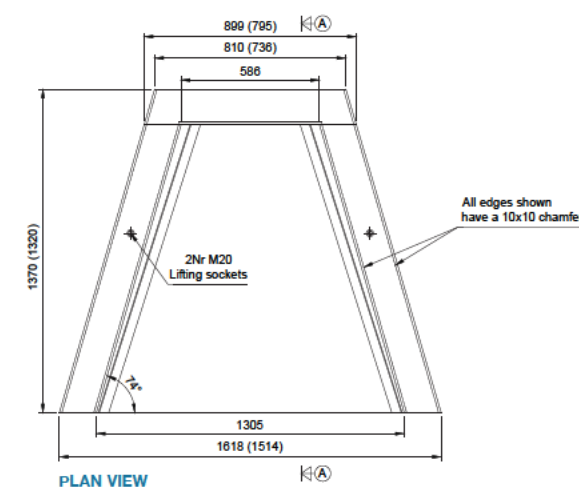
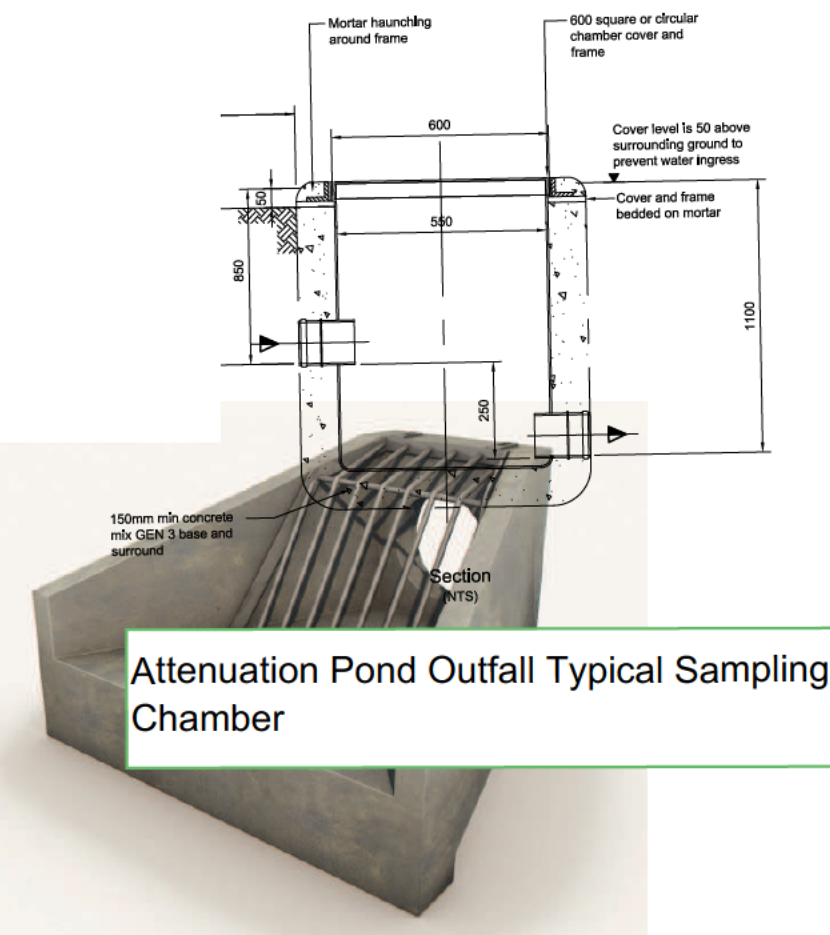
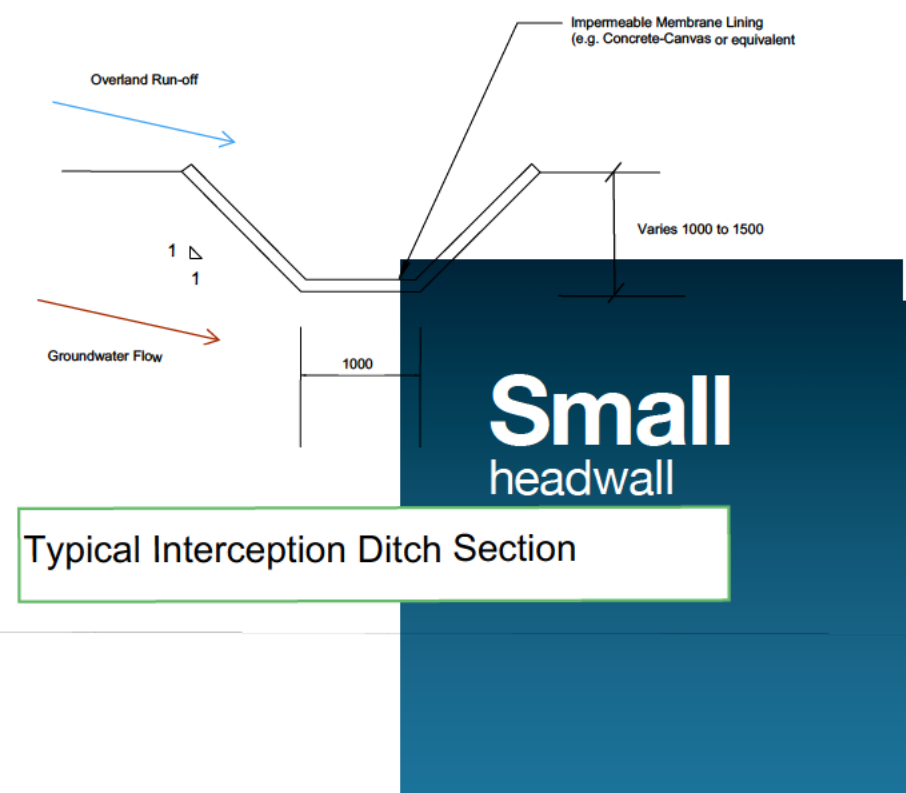


Figure 7.13 Module chamber outlet control for small reservoir (by courtesy of Adams Hydraulics Ltd)



Precast Concrete Outfall Headwall/Connection to Non-Main River

Floor Thickness	Approx. weight kg
162	1100
162	1390

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

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



Cover Sheet

File Ref 412799
Originator X Ho
Checker R Talby

Version A
Date 17/12/19
Date 18/12/19

Project Information

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

Section:
Subject: Seepage Assessment Model
Project Manager:
Originator X Ho
Checker
Template Version A

Divn/Dept:
Project Nr:
File Ref: 412799
Calc Nr:
Nr Sheets:

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



Introduction

File Ref 412799
Originator Xinjin Ho
Checker Rob Talby

Version A
Date 17/12/201
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

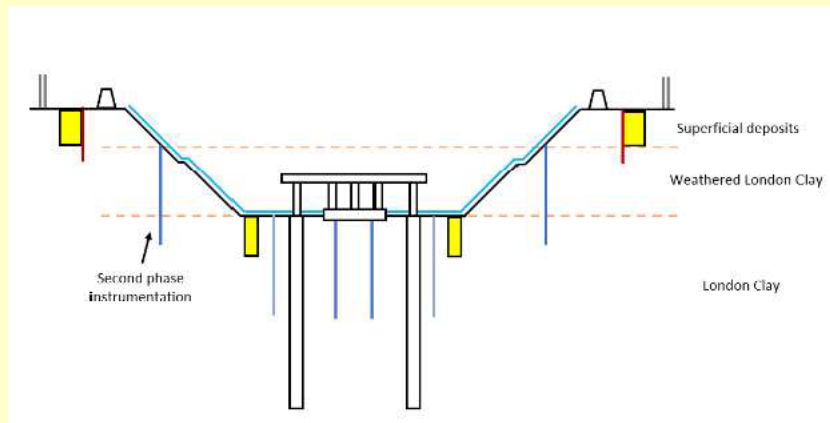
Groundwater flow rate to perimeter drains; Groundwater flow to base of excavation

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 Calculation



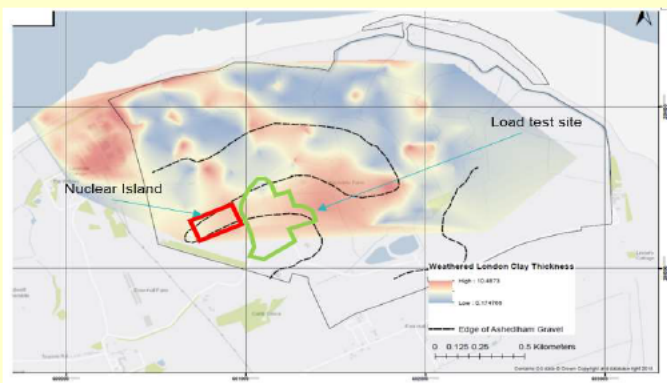
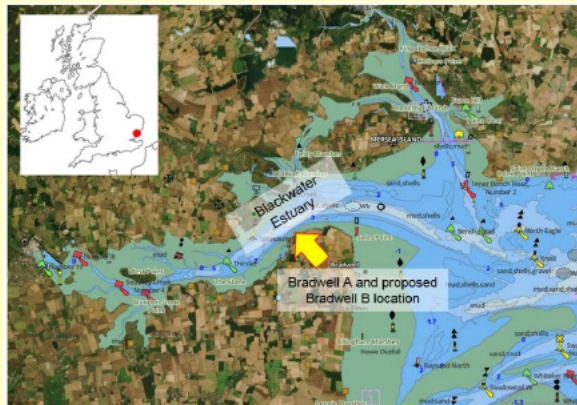
Conceptual Summary

File Ref 412799
Originator Xinjin Ho
Checker Rob Talby

Version A
Date 17/12/2019
Date 18/12/2019

Location / description

The site is located in Bradwell, UK.



Ground model

Load test - BRB-234			
Strata	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 estimate 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

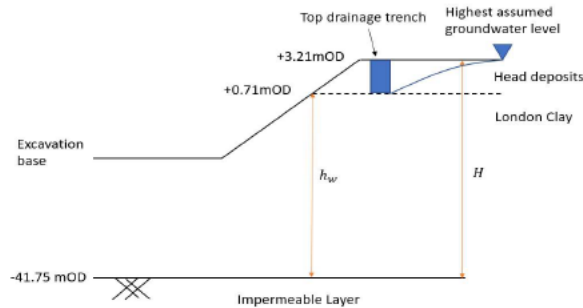
Bradwell B - Seepage Model Calculations



File Ref **412799**
 Originator X Ho
 Checker R Talby

Version A
 Date 17/12/19
 Date 18/12/19

Conceptualisation of analytical solution



Analytical solution and parameters

Base case Scenario

Analytical solution

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

Distance of influence, L_0

$L = 1500(H - h_w)\sqrt{k}$	Source Sichardt's Formula	Assumptions - 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
h_w	lowered water level in an equivalent well
L_0	distance of influence (calculated using Sichardt 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, L_0	5.9	Calculated 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

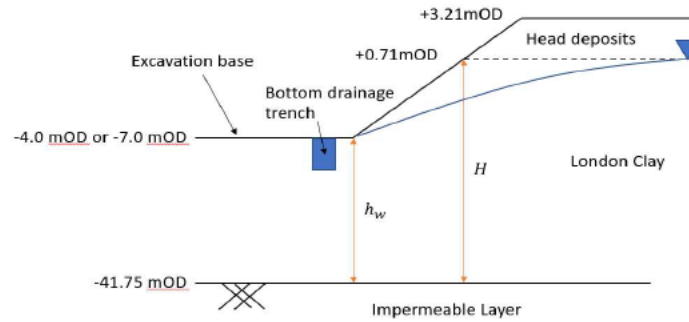
Bradwell B - Seepage Model Calculations



File Ref
412799
Originator
X Ho
Checker
R Talby

Version
A
Date
17/12/19
Date
18/12/19

Conceptualisation of analytical solution



Analytical solution and parameters

Base case Scenario

Analytical solution

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

Distance of influence, L_o

$L = 1500(H - h_w)\sqrt{k}$	Source Sichardt's Formula	Assumptions - 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
h _w	lowered water level in an equivalent well
L _o	distance of influence (calculated using Sichardt 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 gwI 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, L_o	0.5	0.4	0.8	0.6	Calculated 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



File Ref
412799

Originator
X Ho

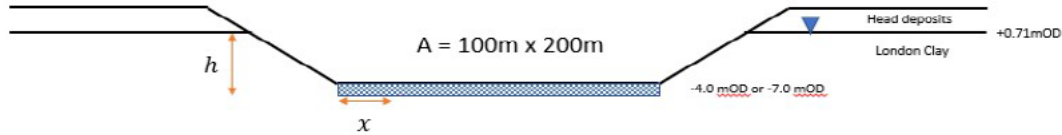
Checker
R Talby

Version
A

Date
17/12/19

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 gw level 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



Cover Sheet

File Ref	412799
Originator	J Webber
Checker	R Talby

Version	B
Date	16/01/20
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



Introduction

File Ref 412799
Originator J Webber
Checker Rob Talby

Version B
Date 16/01/20
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

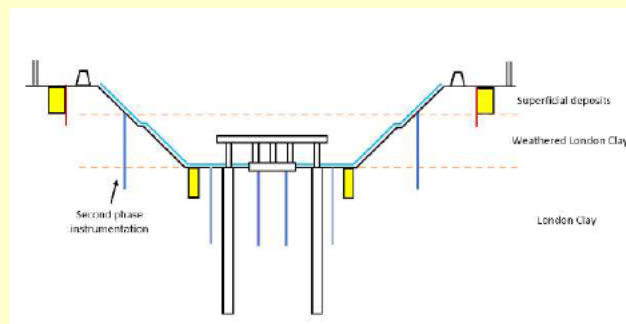
Flow rate to base of excavation and attenuation pond from immediate groundwater discharge and rainfall.

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



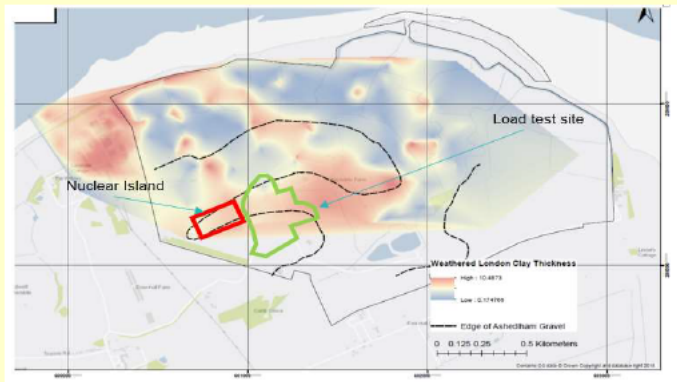
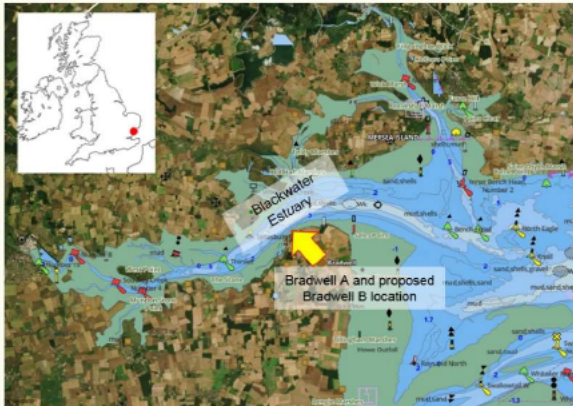
Conceptual Summary

File Ref 412799
 Originator J Webber
 Checker Rob Talby

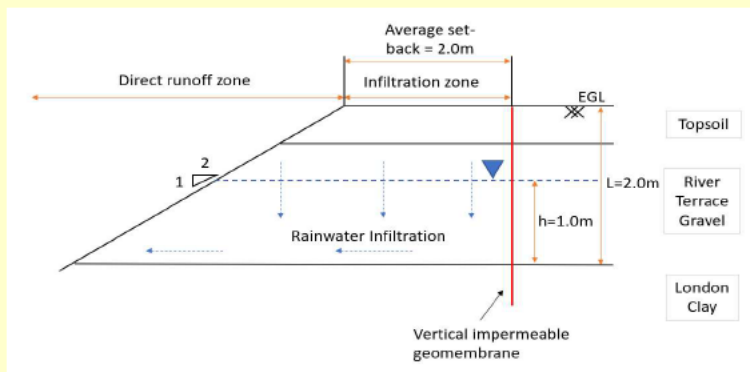
Version B
 Date 16/01/2020
 Date 21/01/2020

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

Originator
J Webber

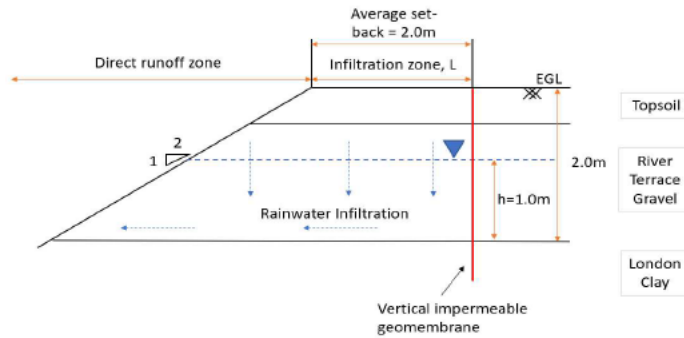
Checker
R Talby

Version
B

Date
16/01/2020

Date
21/01/2020

Conceptualisation of analytical solution



Analytical solution and parameters

Immediate discharge

$Q_t = Ahe$	Source	Assumptions
	-	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

$Q = Lxq$	Source	Assumptions
	-	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 (m ²)	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 (m ³ /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

Originator
J Webber

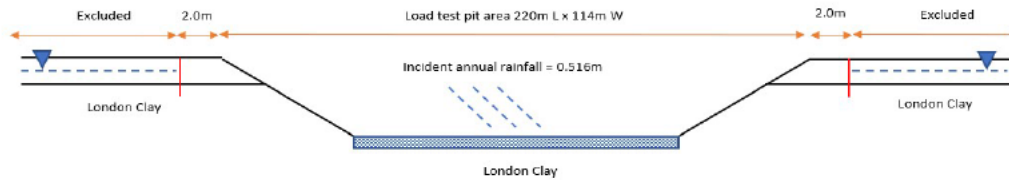
Checker
R Talby

Version
8

Date
16/01/2020

Date
21/01/2020

Conceptualisation of analytical solution



Analytical solution and parameters

Runoff generated by incident rainfall

$Q = Aq$	Source	Assumptions
	-	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

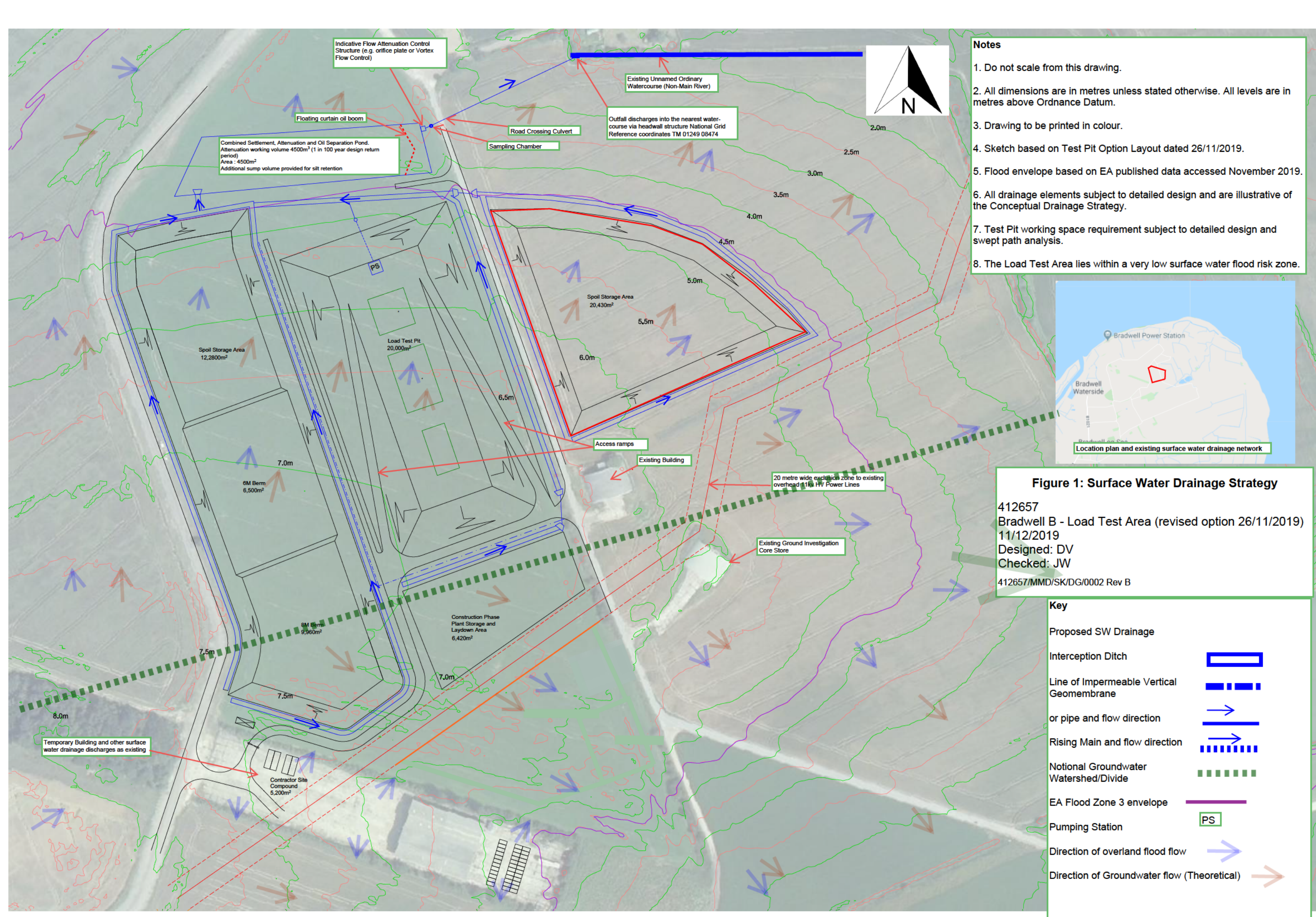
	Volume of runoff generated from rainfall within excavation	Volume of rainfall captured by attenuation pond	Notes
Plan area of catchment, A (m2)	25080.0	72740.0	total site drained for attenuation pond is roughly 7.274Ha
incident annual rainfall, q (m/year)	0.516	0.516	
Annual rainfall volume (m3/year)	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 B. – 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/SK/DG/0002 Rev B
“Figure 1: Surface Water Drainage Strategy”

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





- 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

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

M

MOTT
MACDONALD

Mott MacDonald House
8-10 Sydenham Road
Croydon
CR0 2EE
United Kingdom
T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W mottmac.com

Client

BRB

CGN

edfENERGY

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

Appendix C. – Surface Water Pollution Risk Assessment

Appendix D. – Ecological Appraisal