

Thames Tideway Tunnel
Thames Water Utilities Limited



Application for Development Consent

Application Reference Number: WWO10001

Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.06**

Cremorne Wharf Depot

APFP Regulations 2009: Regulation **5(2)(q)**

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January 2013

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Thames Tideway Tunnel

Navigational Issues and Preliminary Risk Assessment: Cremorne Wharf Depot

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Main Report

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1 Executive summary

1.1 Purpose

- 1.1.1 This report documents the activities and assessments undertaken to identify the navigational issues, risks and mitigation measures for the proposed permanent and temporary structures at the site known as Cremorne Wharf Depot as part of the Thames Tideway Tunnel project.
- 1.1.2 It was developed through liaison and consultation with Port of London Authority (PLA) and the other key stakeholders. It is intended to support the application for development consent and identify the navigational issues at the site and how these are to be managed. The process was used to inform the design of the permanent and temporary works and a number of measures to address navigational hazards have been embedded into the design.
- 1.1.3 The preliminary risk assessment follows the methodology proposed by the PLA rather than the methodology detailed within the PLA Safety Management System. The risk assessment reflects the level of development of the design in the application for development consent, that is, an outline design. The Contractor would be required to prepare detailed risk assessments and method statements and submit these to the PLA for approval before commencing any works in the river at this site.
- 1.1.4 The assessment was divided into three distinct project phases to assess hazards and develop risk reduction measures commensurate with the risk posed by different operations associated with the project. These phases were specific to this assessment and comprise:
- a. Phase A: site set up
 - b. Phase B: construction of drop shaft/connection culvert/connection tunnel
 - c. Phase C: permanent works site.

1.2 Issues to be addressed

- 1.2.1 The proposed Cremorne Wharf Depot site lies adjacent to the Lots Road power station (disused and subject to redevelopment), Chelsea Creek and an existing jetty on the north bank of the River Thames in the Battersea to Chelsea Reach area of the river (PLA Chart 314).
- 1.2.2 The site's navigation characteristics would suit the types of vessels already serving similar wharves along this stretch of the river.
- 1.2.3 The issue to be addressed for this site is:
- a. interaction with existing river traffic:
 - i freight
 - ii commercial
 - iii leisure.

1.3 Interaction with existing river traffic

- 1.3.1 During construction activities excavated material would be transported away from the site by barge. The interaction of project movements with existing river users was identified as a potential hazard that requires further analysis and assessment.
- 1.3.2 Several freight operators transit past this site, transporting aggregates and waste on a regular basis. One operator, Cory Environmental Ltd, uses mooring facilities opposite the site to lay-up barges.
- 1.3.3 Recreational river users were also taken into consideration during this assessment. Project representatives liaised with the Cremorne Riverside Activity Centre in order to understand their operating procedures, area of activity, existing schedules and concerns.

2 Site overview

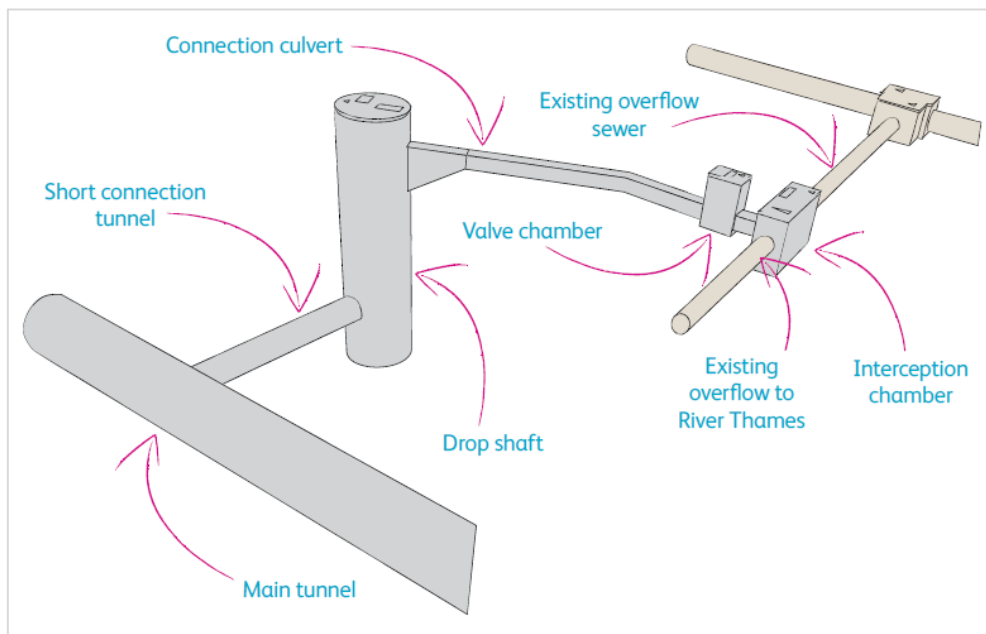
2.1 Purpose of this report

- 2.1.1 The purpose of this report is to provide information on the navigational issues, risk assessment and mitigation measures associated with the proposed Cremorne Wharf Depot site. The report informs the *Transport Assessment and Environmental Statement* and the PLA approval process.

2.2 Introduction

- 2.2.1 The Thames Tideway Tunnel project (the ‘project’) comprises tunnels to store and transfer discharges from combined sewer overflows (CSOs) from West to East London for treatment at Beckton Sewage Treatment Works. The primary objective of the project is to control CSO discharges in order to meet the requirements of the EU Urban Waste Water Treatment Directive (91/271/EEC) (UWWTD) and the related UK Urban Waste Water Treatment Regulations.
- 2.2.2 The project comprises the following elements:
- a. a main tunnel from Acton Storm Tanks to Abbey Mills Pumping Station requiring five main tunnel sites (one of the sites would also intercept flows from one CSO)
 - b. control of 18 CSOs by diverting intercepted flows into the main tunnel requiring 16 CSO sites; two long connection tunnels (Frogmore connection tunnel and Greenwich connect tunnel) and 11 short connection tunnels
 - c. control of two CSOs by locally modifying the sewerage system requiring two system modification sites
 - d. works to drain down the system at Beckton Sewage Treatment Works.
- 2.2.3 The main tunnel would connect to the Lee Tunnel at Abbey Mills Pumping Station. All the flows from the Thames Tideway Tunnel and the Lee Tunnel would be transferred to Beckton Sewage Treatment Works via the Lee Tunnel.
- 2.2.4 The Cremorne Wharf Depot CSO site would be required to intercept the Lots Road Pumping Station CSO, and to connect to the main tunnel. The proposed structures at this site are illustrated in Figure 2.1.

Figure 2.1 Elements of below ground infrastructure



- 2.2.5 It is proposed that the site at Cremorne Wharf Depot will accommodate:
- a CSO drop shaft – 8m internal diameter, approximately 42m deep
 - a connection to the Lots Road Pumping Station CSO outfall
 - connection culverts and valve chambers
 - air management structures.

- 2.2.6 The site would include the following areas to enable construction of the permanent structures:
- excavated material storage and handling facilities
 - cranes
 - maintenance workshop and storage
 - internal site roads
 - site support and welfare.

2.3 Limits of land to be acquired or used

- 2.3.1 The proposed limits of land to be acquired or used (LLAU) for this site runs along the foreshore of Cremorne Wharf Depot. This area would not encroach into the authorised channel. The permanent works structure for this site would be on land, allowing the project to return the site as a safeguarded wharf and designated waste transfer site.
- 2.3.2 The LLAU encompasses the maximum working area required during construction. A cofferdam would be constructed within this area during the construction phases. The permanent river wall works would take place within the cofferdam.

2.3.3 The LLAU would be used intermittently, depending on the progress, method and phasing of construction.

2.3.4 Appendix A details the various design, construction and site layout drawings and highlights the LLAU.

2.4 Project phases

2.4.1 This assessment was divided into three distinct project construction phases to assess hazards and develop risk reduction measures commensurate with the risk posed by different operations associated with the project. These phases were identified for use during the navigation risk assessment and comprise:

- a. Phase A: site set up
- b. Phase B: construction of drop shaft/connection tunnel/ other structures
- c. Phase C: site restoration/permanent works site

2.5 Construction methodology

2.5.1 All works would be undertaken in accordance with the project's *Code of Construction Practice (CoCP)*.

2.5.2 The code sets out a series of objectives and measures to protect the environment and limit disturbance from construction activities as far as reasonably practicable. The topics covered by the *COCP* include but are not limited to; working hours, traffic management, noise and vibration, air quality, waste management, recycling, ecology, archaeology and settlement.

2.5.3 The methodologies, layouts and plant requirements outlined in this document are for illustrative purposes only and may be varied by subsequent design and build construction contractors.

2.6 Phase A: Site set-up

2.6.1 Existing land-based structures would be demolished to create construction space.

2.6.2 Following demolition works the site would be set up to provide office and welfare facilities. Typically these consist of prefabricated units.

2.6.3 The existing campshed in the foreshore would be refurbished if required, to enable the use of barges for removal of excavated material.

2.7 Phase B: Construction of drop shaft, connection tunnel, and other structures

2.7.1 The CSO drop shaft would be constructed by sprayed concrete lining or by precast segmental lining using caisson and underpinning. The connection

tunnel would be constructed by sprayed concrete linings and the interception chambers by traditional reinforced concrete structures.

- 2.7.2 An attendant excavator would load the excavation material into a dumper, which would deposit excavated material into the excavated material muck bin. A long reach excavator would load the excavated material into a barge moored alongside the cofferdam wall.

2.8 Phase C: Site restoration/permanent work site

- 2.8.1 Site restoration work will occur on land and is not considered to impact on the river.

3 Study aim and area

3.1 Introduction

- 3.1.1 The aim of this assessment is to identify and assess navigational hazards project-specific to construction activities at the Cremorne Wharf Depot site and assess how the proposed phases of the project would likely impact on existing river users.
- 3.1.2 This assessment considers all river users and the hazards that project activities could pose to navigation on the River Thames.
- 3.1.3 In compiling this assessment, the project undertook extensive consultation with the PLA and current river users, along with observations of current river operations.
- 3.1.4 In order to consider the navigation impact on the wider river community, the scope of this assessment comprised an area from Battersea Road Bridge to Battersea Rail Bridge. This study area captures the majority of vessel types likely to transit this section of the river and pass the worksite.
- 3.1.5 Cremorne Wharf is a safeguarded river facility and the proposed development site is in close proximity to mooring facilities used by freight operators and the Cremorne Riverside Activity Centre. The effects of project activities on these were considered within this assessment.

3.2 General navigation

- 3.2.1 The Cremorne Wharf Depot site is located within the Battersea to Chelsea Reach section of the River Thames and is included on PLA Chart No 314.
- 3.2.2 Safety is the responsibility of all river users; however, overall responsibility for facilitating the safety of navigation on the River Thames rests with the PLA.
- 3.2.3 As part of its activities in maintaining navigational safety, the PLA produces Notices to Mariners (NTMs), which provide essential, up-to-date information and advice to those navigating within the Port of London. NTMs can range from information on special events, notifications of works (eg, the Network Rail works on Blackfriars Bridge), and notification of new and updated navigation rules and regulations. A full list of extant NTMs is available on the PLA website, <http://www.pla.co.uk/notice2mariners/index.cfm/site/navigation>.
- 3.2.4 The River Thames becomes tidal downriver of Teddington Lock, with a tidal range of between five and seven metres at different locations.
- 3.2.5 On the flood tide, the tidal current flows up-river (ie, predominantly east to west) whereas on the ebb tide, the tidal current flows downriver (ie, predominantly west to east).

3.3 Bridges

3.3.1 Battersea Road Bridge has 5 arches. Arch No1 is permanently closed to navigation. Arches No2 and 3 are the normal working arches and are indicated by the usual pair of horizontal amber lights. Arch No4 should be used by smaller outward bound vessels, always making an allowance for height of tide.

Table 3.1 Individual arch bridge clearances above Mean High Water Springs (Battersea Road Bridge)

Bridge Arch	1	2	3	4	5
Arch Clearance	2.5 m	4.0 m	5.6 m	3.9 m	2.5 m

Table 3.2 Main navigational arch bridge height clearance above (Battersea Road Bridge)

Tide Set	Chart Datum	MHWN	MLWN	MLWS	HAT
Arch Clearance	11.8m	6.7m	11.2m	11.7m	5.0m

3.3.2 Westminster Bridge has the lowest available navigational arch clearance heights of the remaining bridges in the Central Pool area of London.

3.3.3 Westminster Bridge has seven main arches, all of which are available for navigation with arches No3, 4, 5 and 6 designated as working arches.

Table 3.3 Individual arch bridge clearances above Mean High Water Springs (Westminster Bridge)

Bridge Arch	1	2	3	4	5	6	7
Arch Clearance	4.2 m	4.8 m	5.2 m	5.4 m	5.2 m	4.8 m	4.2 m

Table 3.4 Main arch No4 bridge clearance heights above (Westminster Bridge)

Tide Set	Chart Datum	MHWN	MLWN	MLWS	HAT
Arch Clearance	12.2 m	6.5 m	11.1 m	11.8 m	4.8 m

3.4 The authorised channel

3.4.1 The authorised channel is marked on both Admiralty and PLA charts as a pair of pecked lines that define where the majority of commercial vessels

generally navigate. However, vessels cannot always be expected to navigate 'within' the authorised channel.

3.4.2 The authorised channel in the Cremorne Wharf area is approximately 70m wide, extending to approximately 90m through Battersea Road and Battersea Rail Bridges.

3.4.3 The document General Directions for Navigation in the Port of London 2011 states the following:

"36. REQUIREMENT TO USE THE AUTHORISED CHANNEL

(1) This Direction applies only to vessels navigating between the Margaretness Limit and Putney Bridge.

"(2) Except in an emergency or for the purposes of overtaking, or with the permission of the Harbourmaster, or when manoeuvring to or from piers, wharves, anchorages or other berths, all Reporting Vessels and vessels of 13.7 metres or more in Length Overall shall normally navigate only in the authorised channel as identified on PLA charts.

"(3) Where there is sufficient room, vessels less than 13.7 metres in Length Overall should normally navigate outside the authorised channel unless constrained by their draught or otherwise restricted in ability to manoeuvre, or in an emergency"

3.5 Tide set

3.5.1 During consultation for this and other sites associated with the project, the project determined that the 'tide set' in this area of the River Thames should be taken into consideration when assessing navigational hazards.

3.5.2 The term 'tide set' is used to describe the movement of water in into the bight or outside edge of a bend of a river. In a tidal river like the River Thames, which is embanked in the central area, it also leads to an increase in velocity.

3.5.3 Every vessel is affected by tide set in varying degrees. Smaller, faster-moving craft are affected less than larger, slow-moving vessels such as tugs and tows, which have to make course and steering adjustments to counteract the impact of tide set.

3.5.4 The embankments of the River Thames deflect the water flow towards the outside of the next bend. This effect manifests itself particularly in the section of the river that contains the various bridges.

3.5.5 The tide set in and around Battersea Road Bridge is assessed as 'Slight to the North' on the flood tide and 'Moderate to the North' on the ebb tide.

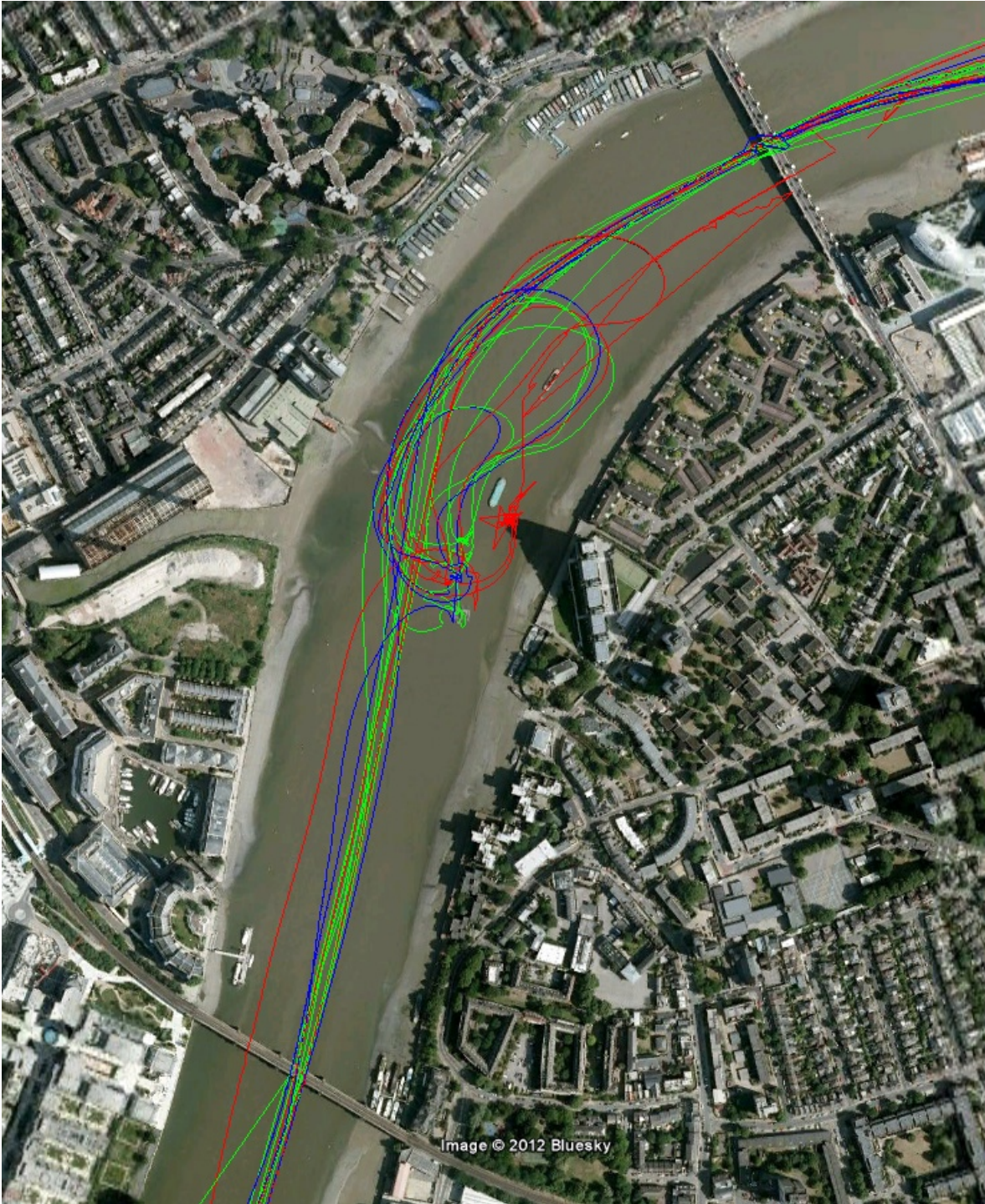
3.6 Existing river users

3.6.1 The proposed site at Cremorne Wharf Depot is situated between Chelsea Harbour Marina and the Chelsea Yacht and Boat Club at Cheyne Walk. Passing traffic is mainly leisure, recreational and sightseeing river users. Charter traffic reaches a peak during the summer months and in the lead up to the Christmas party season.

3 Study aim and area

- 3.6.2 The nearest commuter pier in frequent use is Chelsea Harbour Pier, which is used from Monday to Friday during peak hours and is approximately 500m upriver of the site. Thames Clippers have just begun an AM/PM peak-only commuter service from central London to Putney that transits past the Cremorne Wharf Depot site. Timetables are available from www.thamesclippers.com.
- 3.6.3 Chelsea Harbour Marina, a 60 berth marina, is lock operated from approximately one and a half hours before High Water with leisure craft using the marina on a daily basis.
- 3.6.4 Chelsea Yacht and Boat club has 60 licensed residential berths for vessels up to a maximum length of 30m, with an additional eight small craft moorings.
- 3.6.5 Timetabled passenger services, sightseeing tours and party boat tours all operate within the study area.
- 3.6.6 Complete Pleasure Boats operate a Putney to Blackfriars river bus service that passes through the Heathwall area. This service is typically only running during AM/PM peak times.
- 3.6.7 Westminster Passenger Services Association runs a river tours service from Hampton Court through to Westminster.
- 3.6.8 Thames Clippers have extended their services upriver as far as Putney Pier and to include a new pier at Plantation Wharf.
- 3.6.9 Freight traffic consists predominantly of Cory Environmental Ltd waste transfer services to the Smugglers Way waster transfer facility and GPS Marine Ltd's aggregates delivery services to Pier Wharf.
- 3.6.10 Figure 3.1 shows Cory Environmental Ltd tug and tow tracks through the study area.

Figure 3.1 GPS tracks of Cory Environmental Ltd traffic in study area



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4 Stakeholder consultation

4.1 Consultation meetings

- 4.1.1 Several meetings were held with Cory at their Farringdon Office and Cringle Dock Waste Transfer Facility. The site at Cremorne Wharf, along with navigational issues, was discussed during that meeting and no objections were raised by Cory.
- 4.1.2 At a meeting with the PLA on Monday 2 July 2012, the marine issues associated with the site were presented and agreed in principle.
- 4.1.3 Project representatives met with the Cremorne Activity Centre on 13 July 2012 to present the project's operations and to discuss potential impacts and joint operations within the area.
- 4.1.4 Liaison with Cory, Thames Clippers, PLA and other stakeholders are ongoing.

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5 Summary of navigational issues

5.1 Interaction with existing river traffic - freight

- 5.1.1 The interaction of project vessel movements with existing freight operators has been identified as a potential navigational hazard.
- 5.1.2 It is expected that a maximum of one barge per day would access this site.
- 5.1.3 Given the low number of vessel movements per day and the relatively low frequency of additional freight traffic through the study area, it is considered that a berth master at this site would be unnecessary.

Figure 5.1 Lots Road Power Station and Cremorne Wharf



5.2 Interaction with existing river traffic - commercial

- 5.2.1 The interaction of project vessel movements with existing commercial vessel operators has been identified as a potential navigational hazard at the Cremorne Wharf Depot site.
- 5.2.2 The promulgation of Notice to Mariners, scheduling of barge movements and passage planning is considered an operational mitigation that would assist future project marine contractors in maintaining this potential hazard to a level that is acceptable to the PLA.

5.3 Interaction with existing river traffic - leisure

- 5.3.1 A number of recreational and leisure users, including the Cremorne Riverside Activity Centre and Kayaking London, operate all year round within the study area.

5 Summary of navigational issues

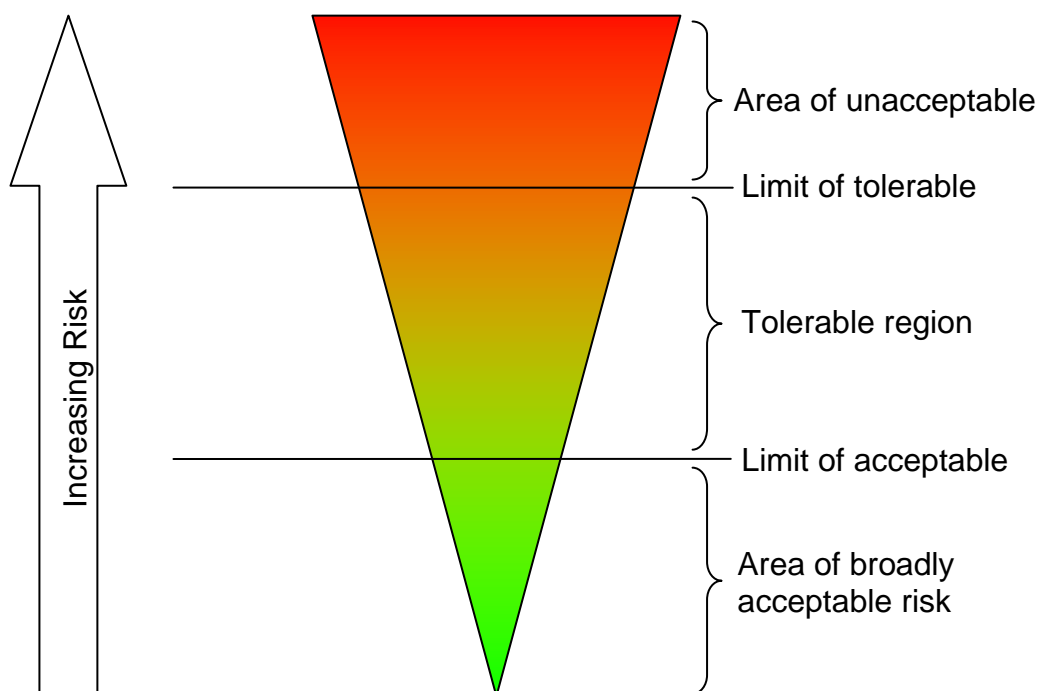
- 5.3.2 The interaction of project vessel movements and construction activities with existing recreational river users has been identified as a potential navigational hazard at Cremorne Wharf Depot.

6 Risk assessment

6.1 Risk assessment: Methodology

- 6.1.1 For each of the identified hazards, the associated risk was assessed and classified. The following definitions were applied for the purposes of this report:
- Hazard: eg, an object, activity or phenomenon that can cause an adverse effect.
 - Risk: a relative measure of harm or loss, derived from the combination of the severity of a particular consequence together with the probability of the consequence occurring.
 - Consequence: a particular scenario (expressed as harm to people, damage to the environment, an operational impact and/or negative media attention) that result from a hazardous situation.
 - Probability: the 'chance' of a particular hazard consequence occurring, measured as a frequency (per year).
- 6.1.2 The assessment used the principle of reducing navigational risks to a level that is As Low As Reasonably Practicable (ALARP). ALARP is part of the Health and Safety at Work Act 1974 and involves assessing the acceptability of a risk against the difficulty, time and expense needed to control it. The ALARP concept is illustrated in Figure 6.1.

Figure 6.1 The ALARP Principle



- 6.1.3 At the lower end of the ALARP triangle, risks are small due to either low probability or insignificant consequences. These risks can generally be

accepted provided that common safeguards are implemented. Moving up the ALARP triangle to the tolerable region, risks increase in magnitude due to either an increase in probability or an increase in severity of consequences. Risks in the tolerable region can be accepted provided that risk controls are implemented that demonstrate that the risk is reduced to a level deemed to be ALARP; where any further risk reduction would be disproportionate in terms of cost, time and resources required to implement it compared to the benefit it would introduce. At the top of the ALARP triangle is a region of unacceptable risk that cannot be accepted without risk controls to reduce the risk to a tolerable and ALARP level.

6.1.4 This risk assessment was undertaken on a qualitative basis, using the engineering and operational judgement of representatives from the project team and representatives from river users and operators. Hazard consequences were considered based on most likely outcomes.

6.2 Risk assessment: Criteria

6.2.1 When commencing the assessment of the risk posed by the project’s activities, the project’s marine consultant recommended using the risk assessment criteria and methodology within the existing PLA Safety Management System (SMS). The rationale behind this recommendation was to provide the project team and the PLA with a consistent assessment score that could be transferred across into the PLA’s existing SMS and enable an appreciation of the increase in risk resulting from the project’s temporary and permanent works.

6.2.2 Consultation with the PLA highlighted the PLA’s desire to use an alternative risk terminology, and an alternative assessment matrix and risk classification scorecard. These changes have now been incorporated.

6.2.3 This section details the risk criteria used throughout this assessment. The assessment process identifies four distinct areas of risk and the probable consequences associated with each hazard assessed in terms of harm or loss to:

- a. people (life)
- b. environment
- c. operational impact
- d. media attention.

6.2.4 Table 6.1 details the ‘probability’ criteria used to assess how likely each hazard is to occur in terms of average frequency in the PLAs jurisdiction.

Table 6.1 Probability Criteria

	Frequency	Score
Rare	Has not occurred in the in the last ten years	1
Unlikely	Has not occurred in the in the last three years	2
Possible	Has not occurred in the in the last year	3
Likely	Has occurred in the in the last year	4

- | | | |
|----------------|-------------------------------|---|
| Almost certain | Occurs several times per year | 5 |
|----------------|-------------------------------|---|
- 6.2.5 Table 6.2 details the severity criteria applied to the safety- related consequences of each hazard.

Table 6.2 Severity Criteria: People		Level
First aid case / Medical treatment case		1
Restricted work case		2
Lost Time Injury / Moderate permanent partial disability injury		3
Single Fatality / Severe permanent partial disability		4
Multiple fatalities		5

- 6.2.6 Table 6.3 details the severity criteria applied to the environmental loss related consequences of each hazard.

Table 6.3 Severity Criteria: Environment		Level
Low impact with no lasting effect		1
Temporary effect / Minor effect to small area		2
Short to medium term impact		3
Medium to long term effect / large area affected		4
Long term impact / severe impact on sensitive area		5

- 6.2.7 Table 6.4 details the severity criteria applied to the property loss/damage related consequences of each hazard.

Table 6.4 Severity Criteria: Operational Impact		Level
Insignificant or no damage to vessel / equipment		1
Minor or superficial damage to vessel / equipment		2
Moderate damage to vessel / equipment requiring immediate repairs		3
Major damage to vessel / equipment and detention		4
Very serious damage to vessel or equipment possible criminal proceedings		5

- 6.2.8 Table 6.5 details the severity criteria applied to negative media attention/coverage consequences of each hazard.

Table 6.5 Severity Criteria: Media Attention		Level
No Coverage		1
Local coverage		2
Regional coverage		3
National coverage		4
International coverage		5

6.3 Risk matrix

6.3.1 The risk matrix in Table 6.6 was used to provide a risk score, combining severity of a particular consequence with the likelihood (probability) of the consequence occurring.

Table 6.6 Risk Assessment Matrix

Likelihood	Rare	1	2	3	4	5
	Unlikely	2	4	6	8	10
	Possible	3	6	9	12	15
	Likely	4	8	12	16	20
	Almost certain	5	10	15	20	25
	Severity	Level 1	Level 2	Level 3	Level 4	Level 5

6.3.2 The risk score in Table 6.7 indicates the magnitude and acceptability of the risk in accordance with the ALARP principle. The PLA method applies this to both individual and average risk.

Table 6.7 Risk Classification

Score	Classification	Definition
1 to 2	Slight	No action is required.
3 to 4	Minor	No additional controls are required, monitoring is required to ensure no changes in circumstances.
5 to 9	Moderate	Efforts should be made to reduce risk to ALARP level. Job can be performed under direct supervision of Senior Officer.
10 to 14	High	Efforts should be made to reduce risk to ALARP level. Job can only be performed after authorisation from Harbour Master and after further additional controls required under the circumstances.
15 to 25	Extreme	Intolerable risk. Job is not authorised.

6.4 Hazard identification

- 6.4.1 A hazard can be defined as ‘the potential for an adverse consequence’, and may be associated with a situation that could cause harm to people, damage to the environment, an operational impact or negative media attention.
- 6.4.2 In order to facilitate a comprehensive overview of potential maritime hazards, various river users and operators were consulted throughout the risk assessment process, including:
- a. Thames Clippers
 - b. Cory Environmental Limited
 - c. City Cruises
 - d. Livett’s Launches
 - e. Bennett’s Barges
 - f. London Duck Tours
 - g. Metropolitan Police Marine Policing Unit
 - h. Royal National Lifeboat Institute (RNLI).
- 6.4.3 The project also made several site visits to HR Wallingford’s physical model during the risk assessment process. This provided Captain David Phillips (at the time, PLA Harbour Master (Upper)), freight (Cory Environmental) and commercial (Thames Clippers) operators with the opportunity to understand the impact of the proposed developments on the river flow patterns and to visualise the scale of the temporary and permanent work at various locations. However, the site at Cremorne Wharf Depot was not included in this physical model.

6.5 Mitigation strategy

- 6.5.1 Throughout the assessment process, it was evident that potential hazards presented by the project would require mitigation measures throughout the project lifecycle.
- 6.5.2 The following section will identify and detail the navigational issues and proposed mitigation measures.

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7 Navigational issues and mitigation measures

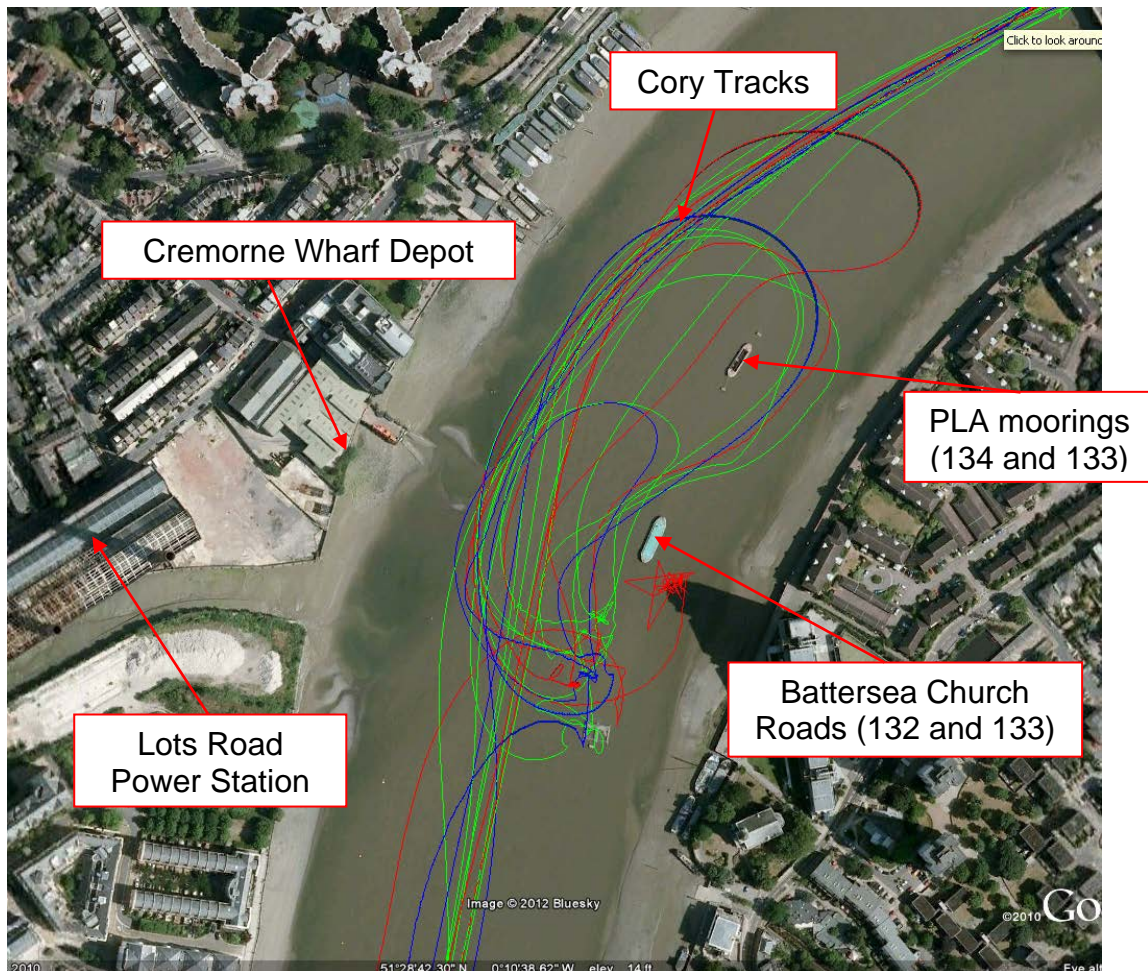
7.1 General

- 7.1.1 It is acknowledged that mitigation measures may themselves introduce further hazards that also require mitigation. Where appropriate, these have been considered.
- 7.1.2 Mitigation measures were developed with an emphasis on measures that are within the project's control (e.g. design of in-river structures).
- 7.1.3 For the purpose of this assessment, mitigation measures (risk control options) were classified as three types;
- a. Design: measures that can be implemented by the project at the design stage.
 - b. Physical: measures that the project can implement during the construction and operational phases.
 - c. Operational: measures that the project can implement in conjunction with the PLA at all stages of the project.
- 7.1.4 Of course, some proposed mitigation measures would be beyond the project's control, such as emergency plans, operating procedures and NtMs.
- 7.1.5 The navigational issues are presented in section 4 of this report. The mitigations proposed are listed below.

7.2 Interaction with existing river traffic: Freight

- 7.2.1 The site encompasses Cremorne Wharf which is designated as a Safeguarded Wharf.
- 7.2.2 There are a number of moorings directly opposite the Cremorne Wharf Depot site that are used regularly by Cory Environmental Ltd.
- 7.2.3 GPS Marine Ltd also passes the site, delivering aggregates to Pier Wharf 3-4 times a week.
- 7.2.4 It is proposed that barges used for the project would berth alongside the river wall on the existing campshed, which would be refurbished if required prior to use by the project.
- 7.2.5 The possible interaction of project vessel movements with existing freight operators has been identified as presenting a potential navigational hazard at this site.

Figure 7.1 Freight tracks



Actions required

- 7.2.6 A number of actions, specific to the issue, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:
- conduct analysis of Cory freight movements operating within the study (AIS data)
 - identify typical river traffic that uses this section of the river and its frequency
 - analyse other freight vessel movements through this section of the river.
- 7.2.7 The following sections set out the proposed mitigation measures to address the residual risks.

Mitigation of issues: Physical

- assessment and understanding of operating procedures to ensure minimum disruption/interaction with existing freight users.

Mitigation of issues: River operations

- scheduling of barge movements / passage planning and publication of planned operations.

- b. Notice to Mariners informing operators and river users of planned operations in area and highlighting times when project barges are likely to be servicing the site.

7.3 Interaction with existing river traffic: Commercial

- 7.3.1 Chelsea Harbour Pier is the closest commuter pier to Cremorne Wharf. A Monday to Friday service operates from this pier during peak hours only. The service, conducted by Complete Pleasure Boats, operates between Putney Pier and Blackfriars Pier and can be expected to pass Cremorne Wharf seven times per day.

Figure 7.2 Chelsea Harbour Pier



- 7.3.2 Sightseeing and charter operators would also be in transit past Cremorne Wharf however the number of vessels operating within the study area of this assessment is considerably lower than that of the Central Pool area of London between London and Tower Bridge.
- 7.3.3 The possible interaction of project vessel movements with existing commercial operators has been identified as presenting a potential navigational hazard at this site.

Actions required

- 7.3.4 A number of actions, specific to the issue, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:
 - a. identify typical river traffic that uses this section of the river and its frequency
 - b. analyse other passenger vessel movements through this section of the river.

Mitigation of issues: Design

7.3.5 Designing the project has been an iterative process, influenced by the ongoing navigational risk assessment process. Measures to eliminate or reduce navigational hazards identified in early risk assessments were embedded into the design of the temporary and permanent works to eliminate or reduce navigational hazards. This assessment therefore assesses the residual risk assuming the effective implementation of these measures. The embedded measures include:

- a. At phase one consultation, a permanent structure was proposed in the river to house the drop shaft and other structures. Since phase one consultation, the permanent works were moved onto land, removing the need for permanent structures in the river and providing greater distance between moored construction barges and the authorised channel.

7.3.6 The following sections identify proposed mitigation to address the residual risks.

Mitigation of issues: Physical

- a. assessment and understanding of operating procedures to ensure minimum disruption/interaction with existing commercial users.

Mitigation of issues: River operations

- a. scheduling of barge movements, passage planning and publication of planned operations.
- b. Notice to Mariners informing operators and river users of planned operations in area and highlighting times when barges are likely to be servicing the site.

7.4 Interaction with existing river traffic: Leisure

7.4.1 Leisure traffic within the study area can be split into two broad categories. The first category consists of generally larger, motorised vessels visiting the various marinas and berths along the Thames.

7.4.2 The second category consists of non motorized vessels, such as sailing boats, kayaks and canoes.

7.4.3 The Cremorne Riverside Activity Centre, based at Cremorne Gardens, operates all year round and offers facilities for 9 to 19 year olds. In addition, Kayaking London also operates from the centre.

7.4.4 The centre is open during the following times:

- a. seven days a week from April to September
- b. five days a week from October – March.

7.4.5 The centre operates primarily downriver using the faster flowing tides to offer trips as far as Tower Bridge. Currently, sessions also incorporate Chelsea Creek and other waters further upstream however this may be less frequent once the area around Chelsea Creek has been developed.

Figure 7.3 Chelsea Yacht and Boat Club



Figure 7.4 Cremorne Riverside Activity Centre



- 7.4.6 It is proposed that barges used for the project would berth alongside the river wall on the existing campshed, which would be refurbished if required prior to use by the project. The interaction of project vessel movements with existing leisure river users has been identified as presenting a potential navigational hazard at this site.

Actions required

- 7.4.7 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:
- i identify typical river traffic that uses this section of the river and its frequency;
 - ii meet with representatives from Cremorne Riverside Activity Centre.

Mitigation of issues: Design

- 7.4.8 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:
- a. At phase one consultation, a permanent structure was proposed in the river to house the drop shaft and other structures. Since phase one consultation, the permanent works were moved onto land, removing the need for permanent structures in the river and providing greater distance between moored construction barges and the authorised channel..
- 7.4.9 The following sections identify proposed mitigation to address the residual risks.

Mitigation of issues: Physical

- a. assessment and understanding of operating procedures to ensure minimum disruption/interaction with existing freight users.

Mitigation of issues: River operations

- b. scheduling of barge movements, passage planning and publication of planned operations.
- c. regular communication with Cremorne Riverside Activity Centre representatives prior to, and throughout the construction phase;
- d. Notice to Mariners - informing operators and river users of planned operations in area and highlighting times when project barges are likely to be servicing the site.

8 General navigational hazards

- 8.1.1 In addition to the 'navigation issues' considered within this report, navigational hazards associated with day-to-day river operations were also identified. These hazards relate to the interaction of the project-related marine traffic with existing river users.
- 8.1.2 'Worst Credible' consequences and the probability of the consequences were considered in the assessment. As a result, in some cases the Worst Credible score was lower than the 'Most Likely' score. This is explained by the probability that a 'moderate injury', for example, is higher than the probability of a 'single fatality'.
- 8.1.3 Full hazard details contained in Annex A through to Annex C as follows:

8.2 Project phase A: Most likely

Table 8.1 Most likely hazard log summary

Hazard Id	Hazard Title	Hazard Description	Score			
			People	Environment	Operational	Media
1A	Collision - between existing river users and freight	Collision with Freight Operator - A vessel involved in project construction / material removal activities collides with a freight operator in the vicinity of Cremorne Wharf	4	4	4	4
2A	Collision - between existing river users (commercial)	Collision between a commercial passenger vessel and a vessel involved in project construction / material removal activities in the vicinity of Cremorne Wharf.	6	4	6	6
3A	Collision – between existing river users (recreational)	Collision between a recreational/private leisure vessel and a vessel involved in project construction/material removal activities in the vicinity of Cremorne Wharf.	6	2	6	6
4A	Mooring breakout	A vessel involved in project construction / material removal activities breaks free from moorings.	2	2	2	2
5A	Contact – project vessel with existing river infrastructure	A vessel involved in project construction / material removal activities makes contact with existing river infrastructure.	4	4	6	4

8.3 Project phase B: Worst credible

Table 8.2 Worst credible hazard log summary

Hazard Id	Hazard title	Hazard description	Score			
			People	Environment	Operational	Media
1A	Collision - between existing river users (freight)	Collision between freight operator and a vessel involved in project construction/material removal activities in the vicinity of Cremorne Wharf.	8	6	8	6
2A	Collision - between existing river users (commercial)	Collision between a commercial passenger vessel and a vessel involved in project construction/material removal activities in the vicinity of Cremorne Wharf.	4	2	4	4
3A	Collision - between existing river users (recreational)	Collision between a recreational/private leisure vessel and a vessel involved in project construction/material removal activities in the vicinity of Cremorne Wharf.	5	1	5	4
4A	Mooring breakout	A vessel involved in project construction / material removal activities breaks free from moorings.	2	3	2	3
5A	Contact – project vessel with existing river infrastructure	A vessel involved in project construction / material removal activities makes contact with existing river infrastructure	6	4	8	6

9 Mitigation measures

9.1 Existing mitigation

9.1.1 Existing safeguards (measures that manage the risk) in the form of control measures and relevant PLA guidance, are set out in Table 9.1 together with any additional controls deemed desirable or necessary to reduce risk to a level that is ALARP. The risk is assessed taking account of the impact of these various safeguards and controls.

Table 9.1 Existing safeguards

• Boat Masters License	• Vessel Master Experience
• MCA - MGN 199 (M) Dangers of Interaction	• Permanent/Temporary Notice to Mariners
• Aids to Navigation	• Passage Planning
• Safe Systems of Work	• Tug Operator Procedures
• Contractors Risk Assessment	• BML Local Knowledge Endorsement
• River Bylaws	• General Directions
• VTS Qualification	• VHF Communications
• Bridge Special Signal Lights	• Ship Towing Code of Practice
• VTS Navigational Broadcast	• Emergency Plans and Procedures
• Thames AIS	• Oil Spill Contingency Plan
• PLA Bridge Guide	• Maintenance / Inspection Routines
• Admiralty Charts	• COLREGs
• Tide Gauges	• Qualified Crew
• Tide Tables	• Barge Operators daily check lists
• Accurate Tidal Information	• High Speed Craft Code

9.1.2 The above list is not exhaustive but was used to highlight the measures that are most relevant to the project's operations.

9.2 Proposed mitigation

9.2.1 The proposed risk reduction/mitigation measures were divided into three categories: design, physical and river operations. This is to provide the PLA with assurance that the measures proposed throughout this assessment have regard to the project's responsibility to reduce risk rather than focussing on local authorities' and existing river users' liabilities.

9.3 Design

- 9.3.1 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:
- a. At phase one consultation, a permanent structure was proposed in the river to house the drop shaft and other structures. Since then, the permanent works were moved onto land, removing the need for permanent structures in the river and providing greater distance between moored construction barges and the authorised channel.
- 9.3.2 On completion of the works at Cremorne Wharf Depot, the project would restore the site to enable council operations to be reinstated.
- 9.3.3 The following sections identify proposed mitigation to address the residual risks.

9.4 Physical

- a. assessment and understanding of operating procedures to ensure minimum disruption and interaction with all existing users.

9.5 River operations

- a. scheduling of barge movements, passage planning and publication of planned operations
- b. regular communication with Cremorne Riverside Activity Centre representatives prior to, and throughout the construction phase
- c. Issue Notice to Mariners informing operators and river users of planned operations in area and highlighting times when barges are likely to be servicing the site.

Table 9.2 Mitigation measures within the project's control

Procedural	Informational	Qualifications / Personnel	Guidance / Publications	Site Specific
Safe Systems of Work	Sound Warnings	Berth Master (term to be defined)	Temporary Notice to Mariners	Grab Chains
Contractors Risk Assessment	Light Warnings	Qualifications / Competence of on site personnel	Permanent Notice to Mariners	Fendering
Site Working Practises	Anemometer at site			New Tide Gauges / Markers
Scheduling of barge movements to assist with existing river events				

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10 Conclusion

10.1 Assessment

- 10.1.1 This *Navigation Issues and Preliminary Risk Assessment* assessed the potential impact of the proposed works at Cremorne Wharf Depot on existing users.
- 10.1.2 The project's approach to this assessment comprised stakeholder engagement, analysis of Automatic Identification System (AIS) data, observation of current river operations including a desktop review of hazards, and development of potential mitigation measures.
- 10.1.3 The risk assessment criteria, assessment matrix, terminology and risk classification were provided by the PLA. The assessment also follows the Formal Safety Assessment (FSA) methodology:
- a. stakeholder consultation
 - b. identification of hazards
 - c. hazard analysis.
- 10.1.4 There would be no temporary or permanent works inside the river at this site.
- 10.1.5 It is the project's intention to transport materials by road from this CSO site however the option for contractors to use the river, where practicable and cost effective, remains.

10.2 Risk analysis

- 10.2.1 Hazards at various stages of the project were assessed and scored using the risk matrix and scorecard provided by the PLA and in terms of 'Most Likely' and 'Worst Credible' scenarios.
- 10.2.2 Annexes A and B provide full details of the hazards identified and their overall score. The analysis is summarised below in Table 10.1 and Table 10.2.

Table 10.1 Hazard overview: Most Likely

Most Likely	Phase B
Extreme: Intolerable risk. Job is not authorised.	0
High: Efforts should be made to reduce risk to 'As Low As Reasonably Practicable' (ALARP). Job can only be performed after authorisation from Harbour Master and after further additional controls required under the circumstances	0

Moderate: Efforts should be made to reduce risk to ALARP level. Job can be performed under direct supervision of Senior Officer.	7
Minor: No additional controls are required, monitoring is required to ensure no changes in circumstances.	8
Slight: No action is required.	5

Table 10.2 Hazard Overview: Worst Credible

Worst Credible	Phase B
Extreme: Intolerable risk. Job is not authorised	0
High: Efforts should be made to reduce risk to ALARP level. Job can only be performed after authorisation from Harbour Master and after further additional controls required under the circumstances.	0
Moderate: Efforts should be made to reduce risk to ALARP level. Job can be performed under direct supervision of Senior Officer.	11
Minor: No additional controls are required, monitoring is required to ensure no changes in circumstances.	5
Slight: No action is required.	4

10.3 Overall

- 10.3.1 An issue was identified throughout the risk assessment process:
 - a. interaction with existing river users.
- 10.3.2 This report sought to provide an independent, evidence-based assessment of current river operations and the likely impact that project operations would have on existing river users.
- 10.3.3 The overall responsibility for safety on the River Thames lies with the Port of London Authority, which needs to determine whether the issues and hazards set out in this report present a ‘tolerable’ navigational risk.

11 Recommendations

- 11.1.1 The project recommends implementing the mitigations measures set out in Section 7. Additionally, the below should be given consideration:

Continued communication: The project should continue to maintain communication and liaison with leisure users and recreational in order to disseminate information relevant to the project.

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Abbreviations

AIS	Automatic Identification System
ALARP	As low as reasonably practicable
CSO	Combined sewer overflow
LLAU	Limits of land to be acquired or used
NtM	Notice to Mariners
PLA	Port of London Authority

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Appendices

List of appendices in order

Appendix A: Project Drawings

Appendix B: Freight tracks and AIS analysis

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Thames Tideway Tunnel
Thames Water Utilities Limited



Application for Development Consent

Application Reference Number: WWO10001

Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.06**

Cremorne Wharf Depot

Appendix A

APFP Regulations 2009: Regulation **5(2)(q)**

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January 2013

**Thames
Tideway Tunnel**



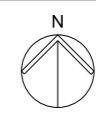
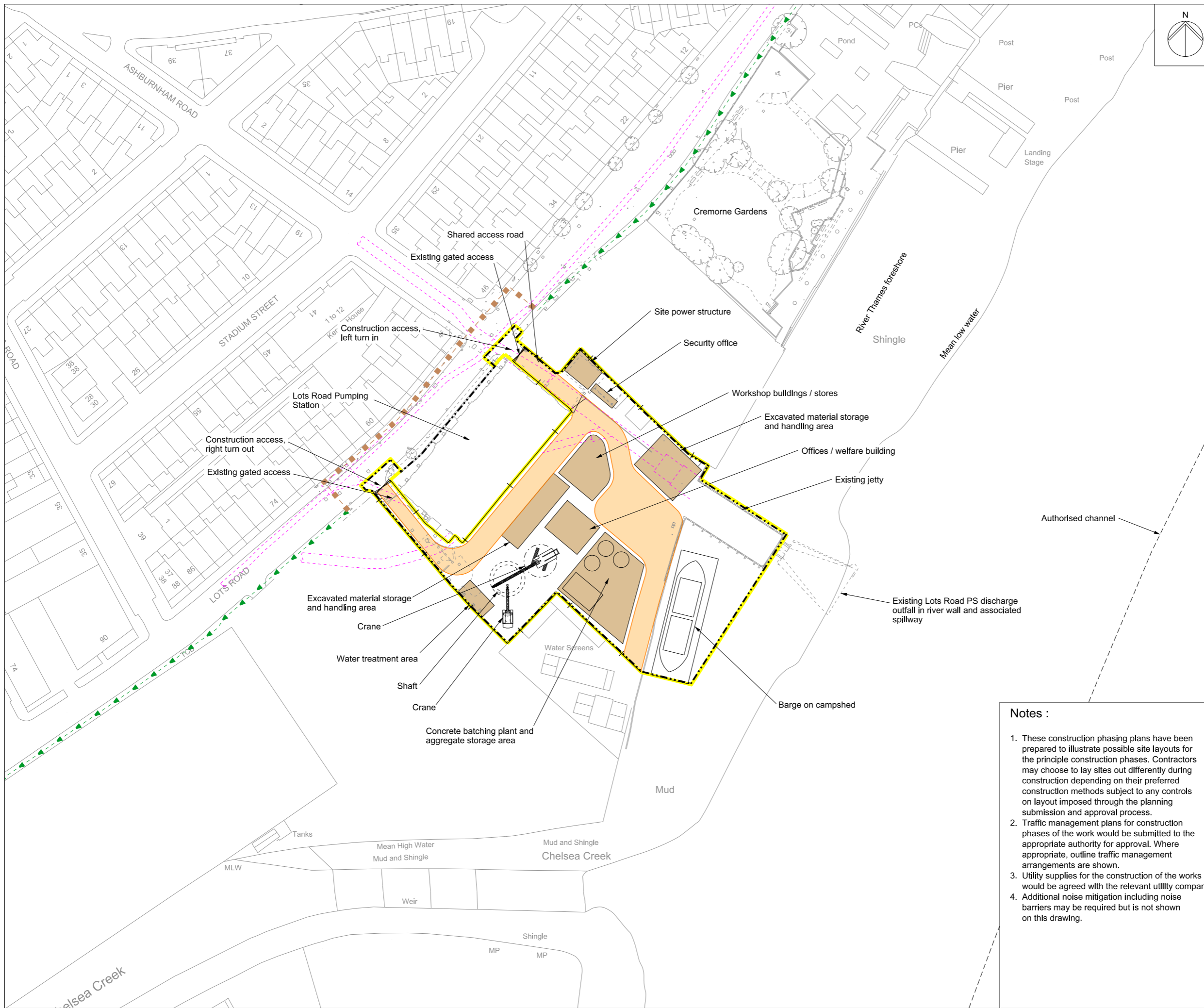
Creating a cleaner, healthier River Thames

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Appendix A: Project drawings

Drawing Title	Phase
Construction phases - Site setup, shaft construction & tunnelling	Phase A
Construction phases - Construction of other structures	Phase B
Permanent works layout	Phase C
River foreshore zones of working	

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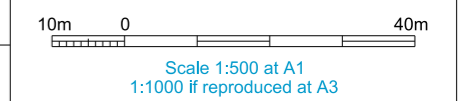


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Coordinates are to be Ordnance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

- Key:**
- Limits of land to be acquired or used (LLAU)
 - Hoarding
 - Maximum extent of working area
 - Existing public right of way
 - Route of temporary diversion of right of way
 - Site access
 - Access / haul route
 - Existing sewers



Notes :

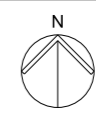
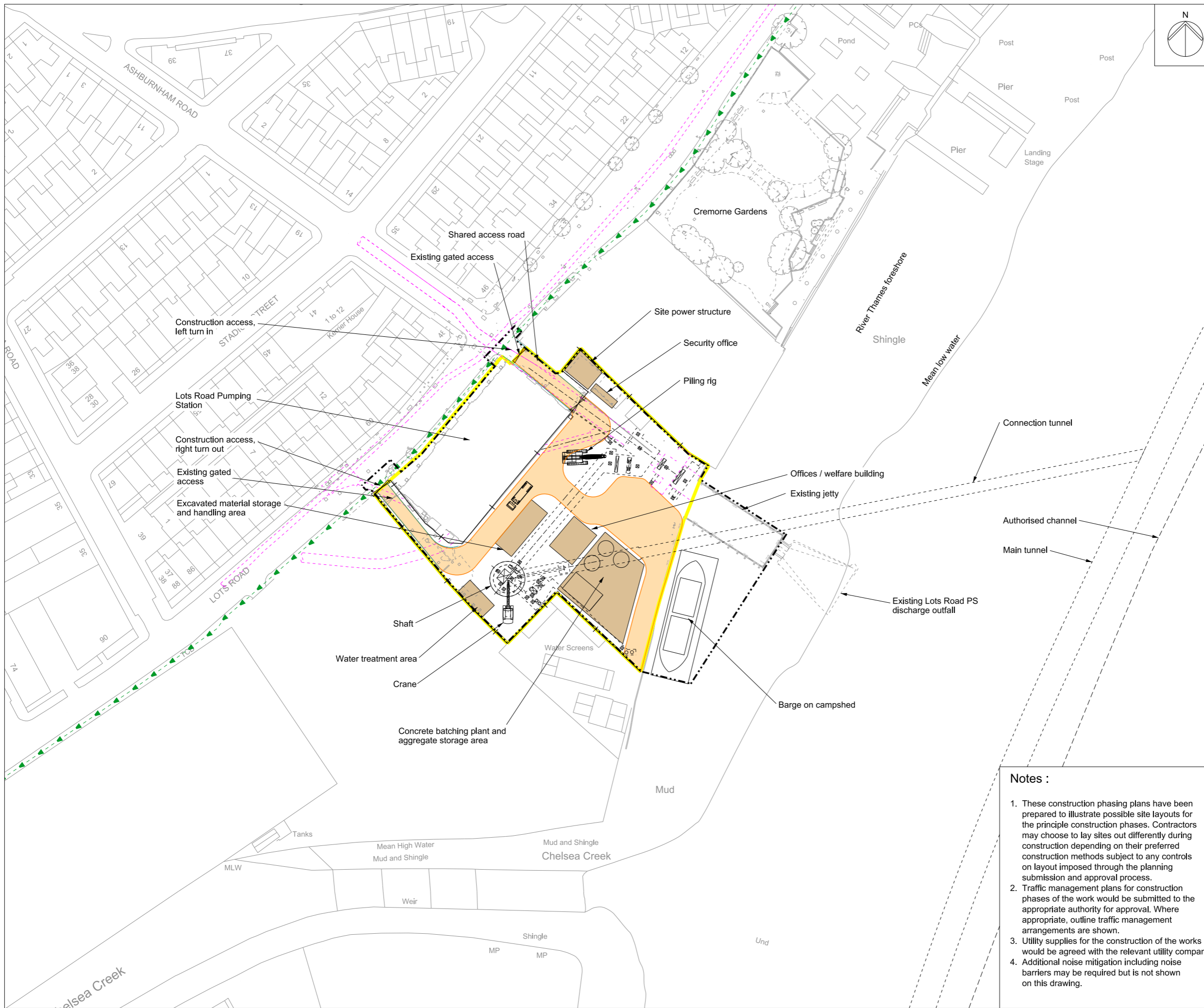
1. These construction phasing plans have been prepared to illustrate possible site layouts for the principle construction phases. Contractors may choose to lay sites out differently during construction depending on their preferred construction methods subject to any controls on layout imposed through the planning submission and approval process.
2. Traffic management plans for construction phases of the work would be submitted to the appropriate authority for approval. Where appropriate, outline traffic management arrangements are shown.
3. Utility supplies for the construction of the works would be agreed with the relevant utility company.
4. Additional noise mitigation including noise barriers may be required but is not shown on this drawing.

ILLUSTRATIVE

Location
Cremorne Wharf Depot
 Royal Borough of Kensington & Chelsea

Document Information
Application for Development Consent
 Construction phases - phase 1
 Site setup, shaft construction & tunnelling
 Book of plans - section 13
 DCO-PP-11X-CREWD-130013
 January 2013



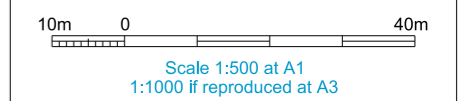


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- Key:**
- Limits of land to be acquired or used (LLAU)
 - Hoarding
 - Maximum extent of working area
 - Existing public right of way
 - Route of temporary diversion of right of way
 - Site access
 - Access / haul route
 - Existing sewers



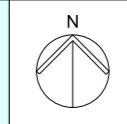
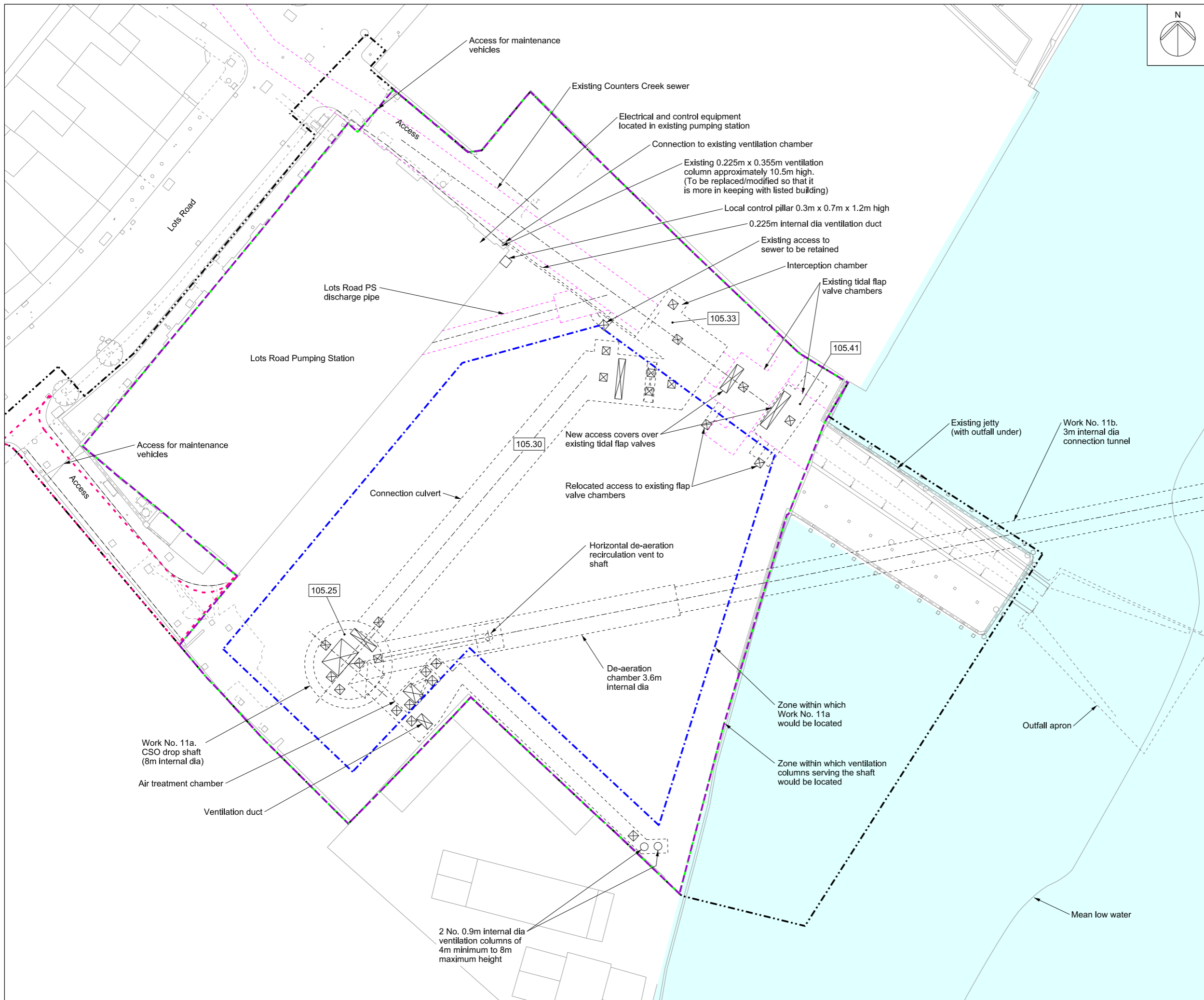
ILLUSTRATIVE

- Notes :**
1. These construction phasing plans have been prepared to illustrate possible site layouts for the principle construction phases. Contractors may choose to lay sites out differently during construction depending on their preferred construction methods subject to any controls on layout imposed through the planning submission and approval process.
 2. Traffic management plans for construction phases of the work would be submitted to the appropriate authority for approval. Where appropriate, outline traffic management arrangements are shown.
 3. Utility supplies for the construction of the works would be agreed with the relevant utility company.
 4. Additional noise mitigation including noise barriers may be required but is not shown on this drawing.

Location
Cremorne Wharf Depot
 Royal Borough of Kensington & Chelsea

Document Information
Application for Development Consent
 Construction phases - phase 2
 Construction of other structures
 Book of plans - section 13
 DCO-PP-11X-CREWD-130014
 January 2013





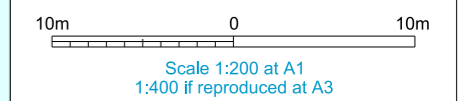
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- Key:**
- Limits of land to be acquired or used (LLAU)
 - Existing sewers
 - ☒ Proposed access cover
 - 104.50 Proposed level (shown in metres above tunnel datum)
 - Zone within which all permanent site structures would be located
 - Zone within which the shaft would be located
 - Zone within which permanent above ground structures would be located
 - Limits of permanent access

- Notes:**
1. All dimensions and levels are approximate.
 2. Any discrepancy between the location of structures and the parameters marked on the drawings are due to differences between the Ordnance Survey base and topographical survey base, both of which have been used in the preparation of this drawing.
 3. This drawing shows permanent site structures only. Landscaping hard works and soft works are shown on the Proposed landscape plan and/or Proposed site features plan.



ILLUSTRATIVE

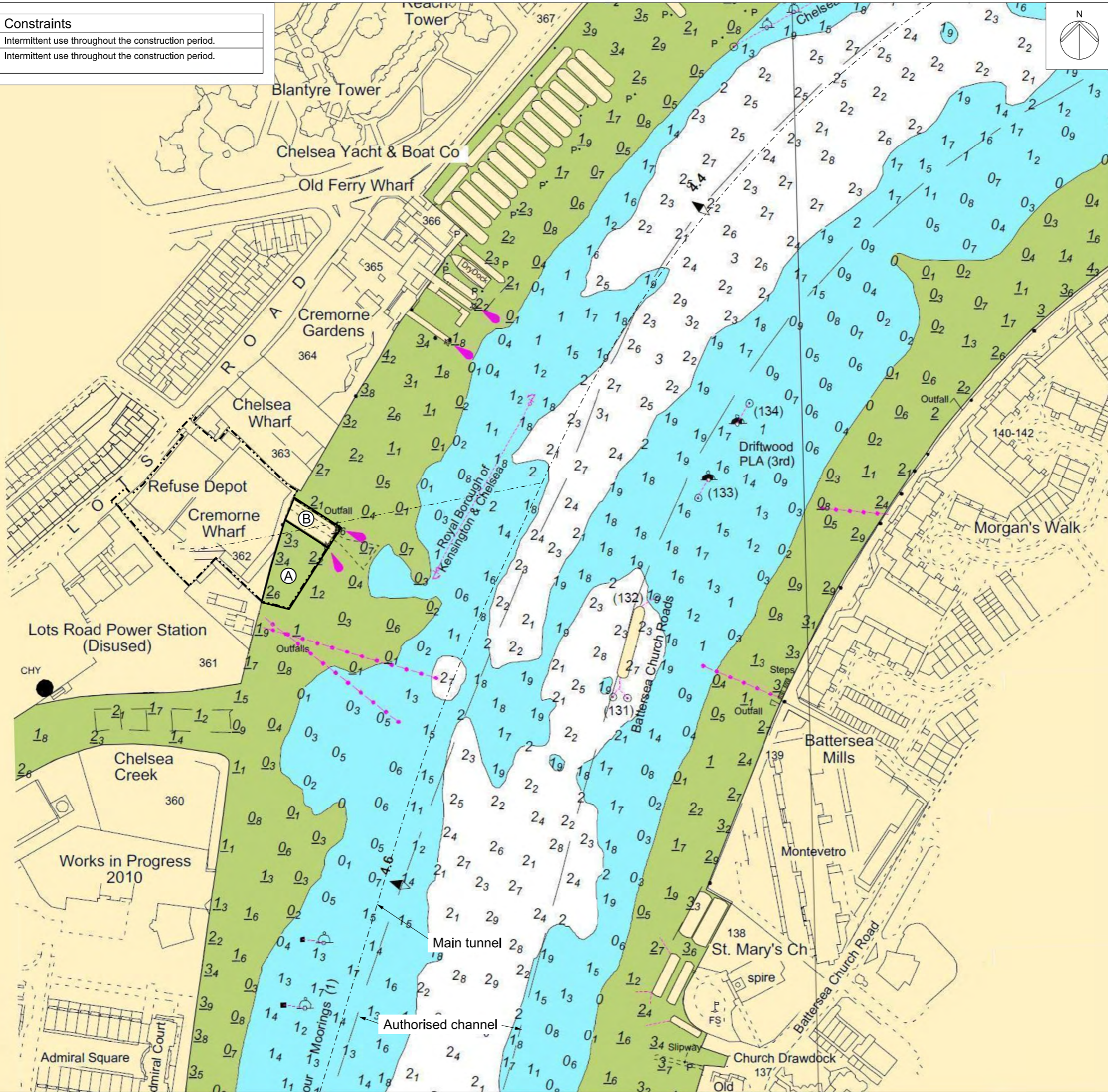
Location
Cremorne Wharf Depot
 Royal Borough of Kensington & Chelsea

Document Information
Application for Development Consent
 Permanent works layout

Book of plans - section 13
 DCO-PP-11X-CREWD-130007
 January 2013

Thames Tideway Tunnel
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Zone	Description	Constraints
A	Barge loading/campshed	Intermittent use throughout the construction period.
B	Access to existing outfall located under the jetty	Intermittent use throughout the construction period.



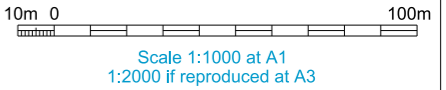
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Coordinates are to be Ordnance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

Key:
 - - - - - Limits of land to be acquired or used (LLAU)

- Notes:
- All levels are in metres and relate to chart datum.
 - Background information shown on this drawing is taken from:
 River Thames - Battersea Reach to Chelsea Reach
 Port of London Authority Hydrographic Service
 H.O. Ref. No....113-314-062....Date....22/12/2010



FOR INFORMATION

[Location](#)
Cremorne Wharf Depot
 Royal Borough of Kensington & Chelsea

[Document Information](#)
Application for Development Consent
 River foreshore zones of working

DCO-PP-11X-CREWD-130016
 January 2013



Thames Tideway Tunnel
Thames Water Utilities Limited



Application for Development Consent

Application Reference Number: WWO10001

Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.06**

Cremorne Wharf Depot

Appendix B

APFP Regulations 2009: Regulation **5(2)(q)**

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January 2013

**Thames
Tideway Tunnel**



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Appendix B: Freight tracks & AIS analysis

B.1 Introduction & summary

- B.1.1 The project proposes to use the site at Cremorne Wharf for construction work and to accommodate permanent structures required to operate the main tunnel. The site would be used to connect the existing Lots Road Pumping Station CSO to the main tunnel. A connection culvert would link the interception chamber to the drop shaft (approximately 45m deep) through which flows would pass down a short connection tunnel, joining the main tunnel.
- B.1.2 As the drop shaft and associated construction activities are scheduled to be conducted from the existing council depot site there would be no requirement for any permanent or temporary structures to extend into the river.
- B.1.3 A review of Global Positioning System (GPS) track information of inbound freight movements passing through this section of the river was undertaken. The track data was captured in November 2011 and provided by Cory Environmental Ltd. An AIS transponder was sited on the starboard rear quarter of the rearmost rank of barges, enabling analysis of vessel track data for the entire duration of the journey.

B.2 Cory Environmental Ltd

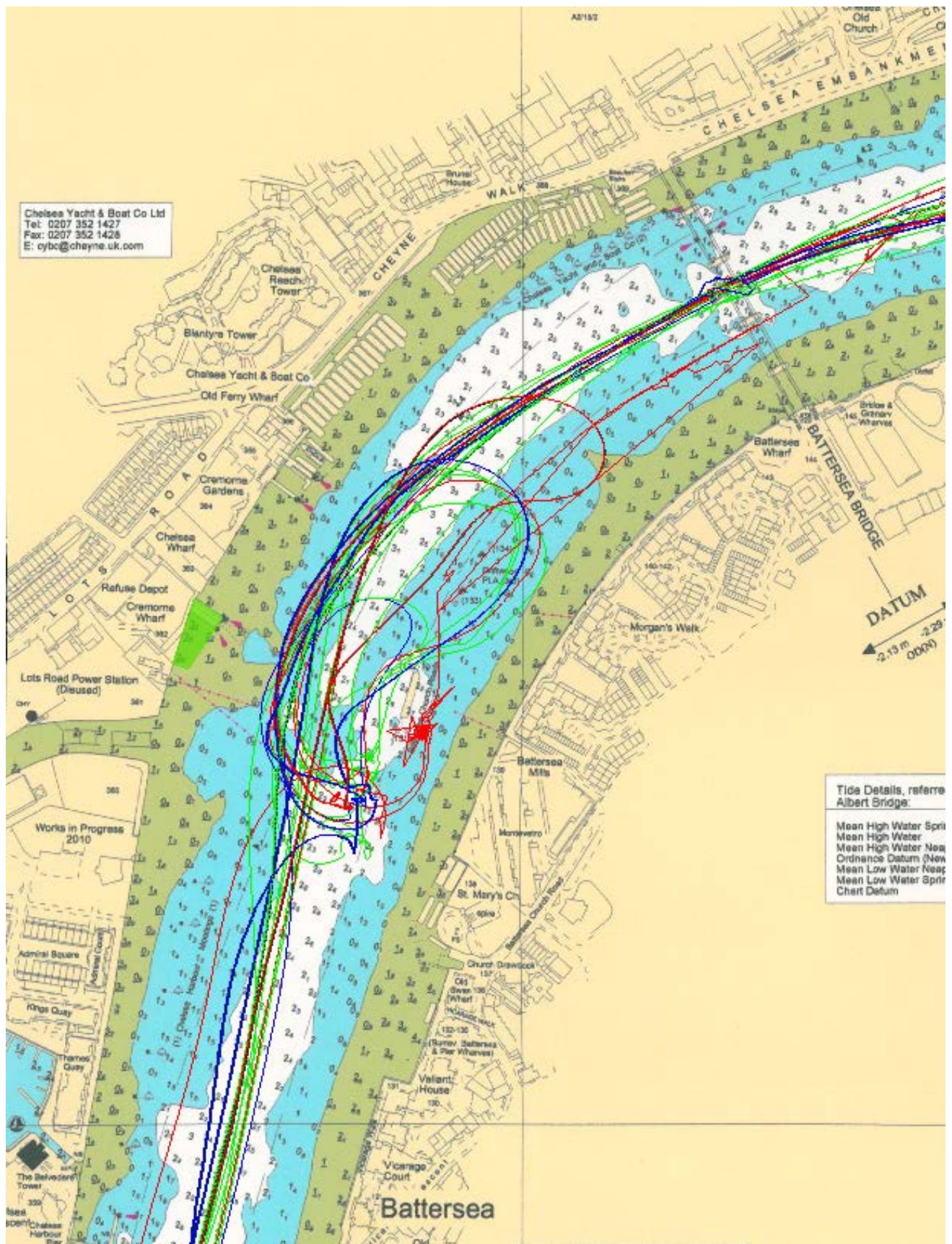
Cory Tug & Tow Inbound GPS Tracks

- B.2.1 Cory environmental supplied the project with a set of GPS data showing the movements of their tugs and barges. The data covered 14 days in November 2011, a total of 35 tug movements. This data was analysed and visualised to inform various sections of this report. Included below in Figure B.1 and Figure B.2 are GIS outputs of all tracks overlaid over a chart of the Cremorne Wharf area.
- B.2.2 By individually investigating each of the tracks supplied it was possible to speculate on the potential impacts of the various phases of development.
- B.2.3 For each track supplied, an image was created displaying a line that represents the location of the GPS transponder. The transponder was located on the starboard quarter of the rear most barge.
- B.2.4 Due to the similarities between the vast majority of tracks through this area, only six individual images have been produced for this report. These six (highlighted yellow in Table B.1) represent a good cross section of possible routes taken by Cory Environmental Ltd.

Figure B.1 GPS Tracks of Cory tugs and barges



Figure B.2 GPS Tracks of Cory tugs and barges



Cory Track Summary

- B.2.5 Table B.1 - Cory AIS Data has the following headings:
- a. Date – Date the GPS data was collected
 - b. Colour – colour system assigned by Cory tugs to enable identification of individual tugs
 - c. Tug – The name of the tug in question
 - d. Head Rank Port – The name of the barge being towed in the port position
 - e. Head Rank stb'd - the name of the barge being towed in the starboard position
 - f. Second rank – the name of the barge being towed in the rear position (where applicable)
 - g. Wind Direction - Approximate Wind Direction
 - h. Wind Speed - Wind speed in m/s
 - i. High tide – time at which high tide was (taken from the PLA 2011 tide times booklet)
 - j. Tidal height – projected height of tide at Tower Bridge (taken from the PLA 2011 tide times booklet)
 - k. Figure – reference in this document for the image of the GPS tracks.

Table B.1 Cory AIS Data

Date	Colour	Tug	Head rank port	Head rank stb'd	Second rank	Wind direction	Wind Speed (m/s)	High tide at	Tidal height (m)	Figure
07/11/11	Green	Recovery	Cringle	Wangas		NE	3	11:21	6.2	
09/11/11	Blue	Recovery	Cringle	Wangas	Wangas	SE	3	12:51	6.7	Figure B.3
09/11/11	Green	Redoubt	Cringle	Cringle	Wangas	SE	5	12:51	6.7	
10/11/11	Red	Resource	Cringle	Cringle	Wangas	E	3	13:27	6.8	
10/11/11	Blue	Regain	Cringle	Cringle	Wangas	E	4	13:27	6.8	Figure B.4
11/11/11	Red	Reclaim	Cringle	Cringle	Wangas	E	4	14:00	6.9	
11/11/11	Green	Resource	Cringle	Cringle	Wangas	SE	4	14:00	6.9	Figure B.5
14/11/11	Green	Regain	Wangas	Cringle		E	4	15:39	6.9	Figure 6
18/11/11	Blue	Recovery	Cringle	Cringle		S	4	18:33	6.4	
22/11/11	Green	Reclaim	Cringle	Cringle		E	2	10:34	6.5	
23/11/11	Red	Reclaim	Wangas	Wangas		SW	2	11:35	6.8	Figure B.7
23/11/11	Green	Regain	Transponder on tug			SW	2	11:35	6.8	Figure B.8
24/11/11	Red	Resource	Wangas	Wangas		SW	4	12:31	7.1	
24/11/11	Green	Recovery	Cringle	Cringle	Cringle	SW	4	12:31	7.1	
25/11/11	Blue	Recovery	Wangas	Wangas		W	10	13:22	7.2	

Cory Individual Tracks

Figure B.3 09/11/2011 – Blue track image

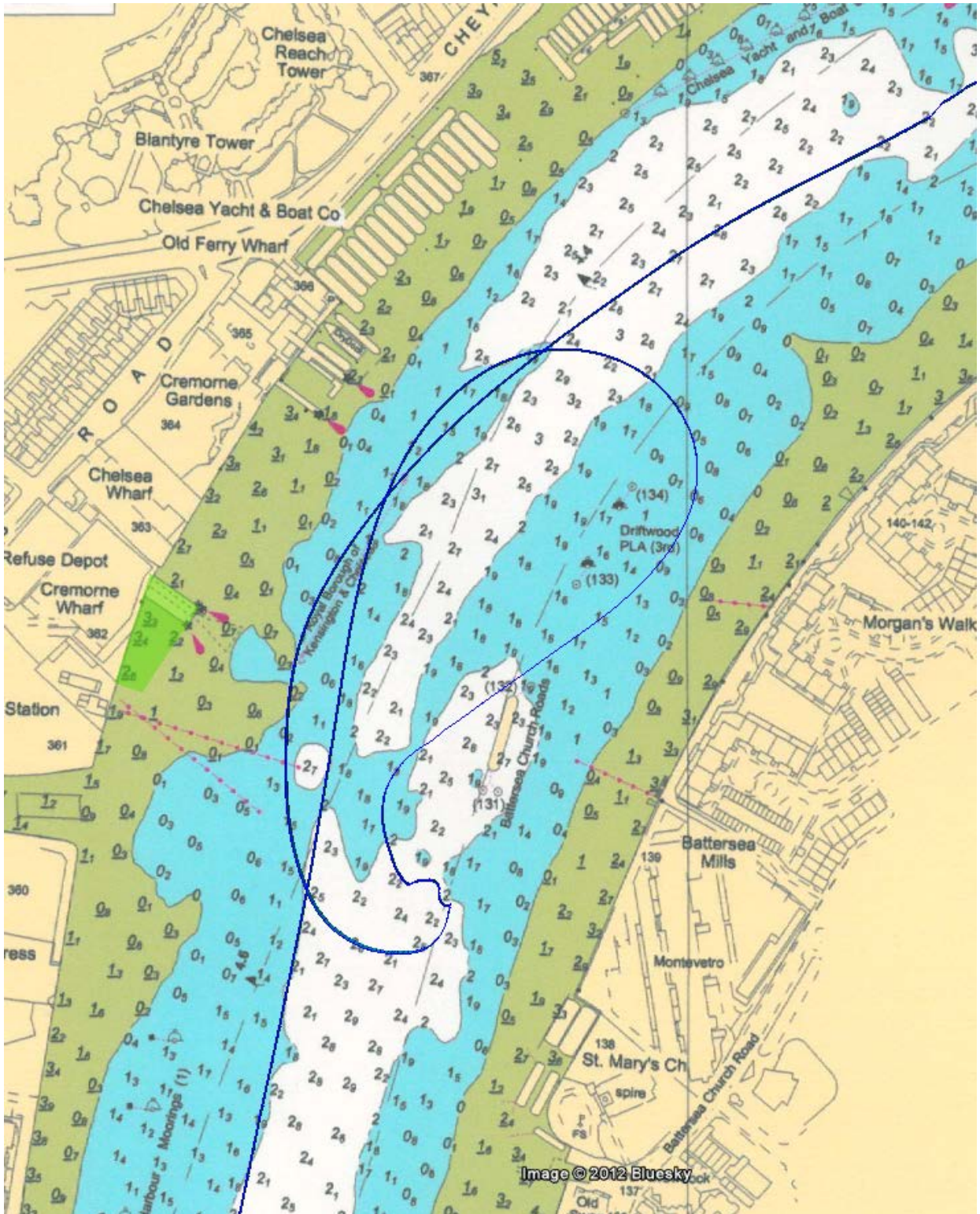


Figure B.4 10/11/2011 - Blue track image

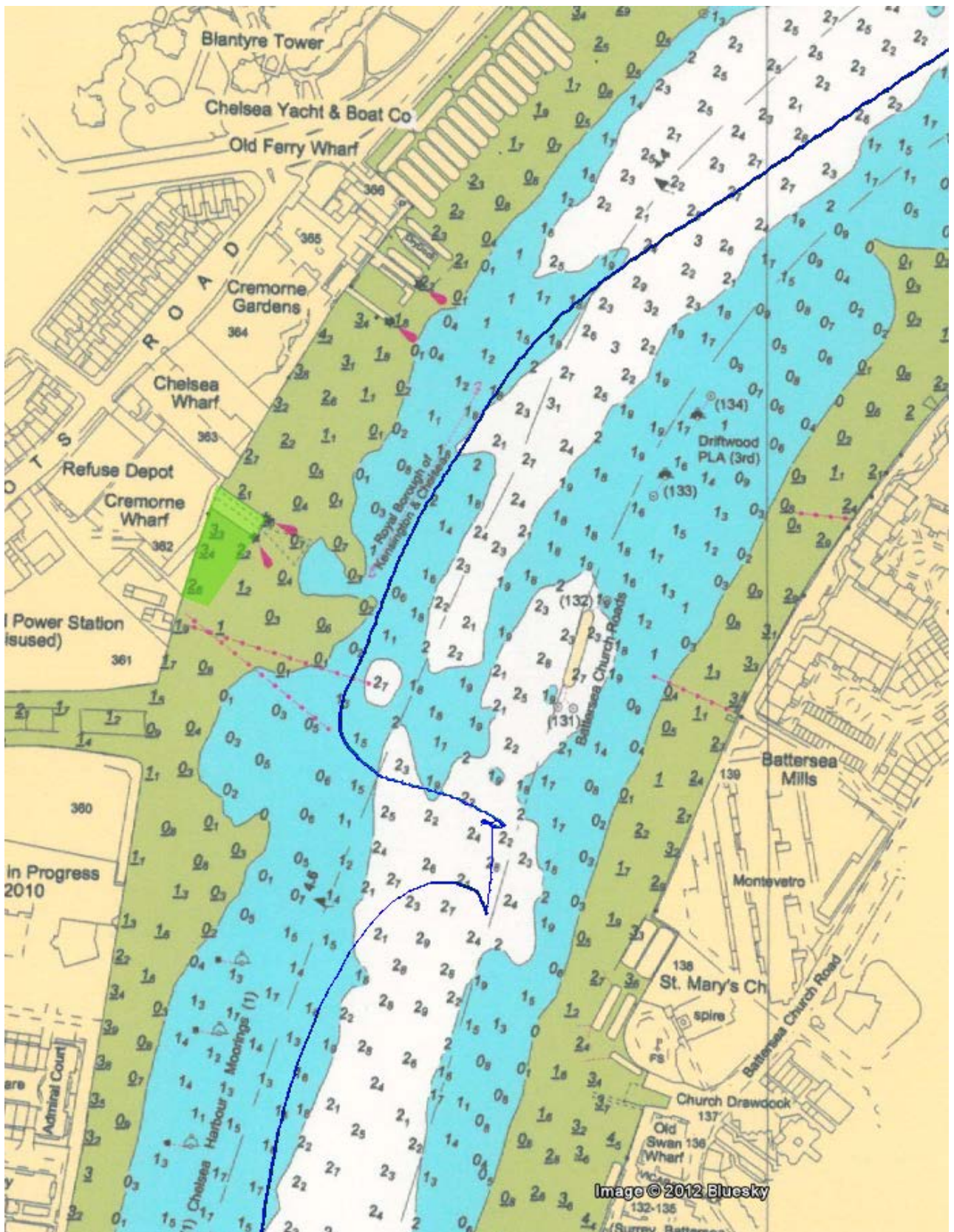


Figure B.5 11/11/2011 - Green Track image

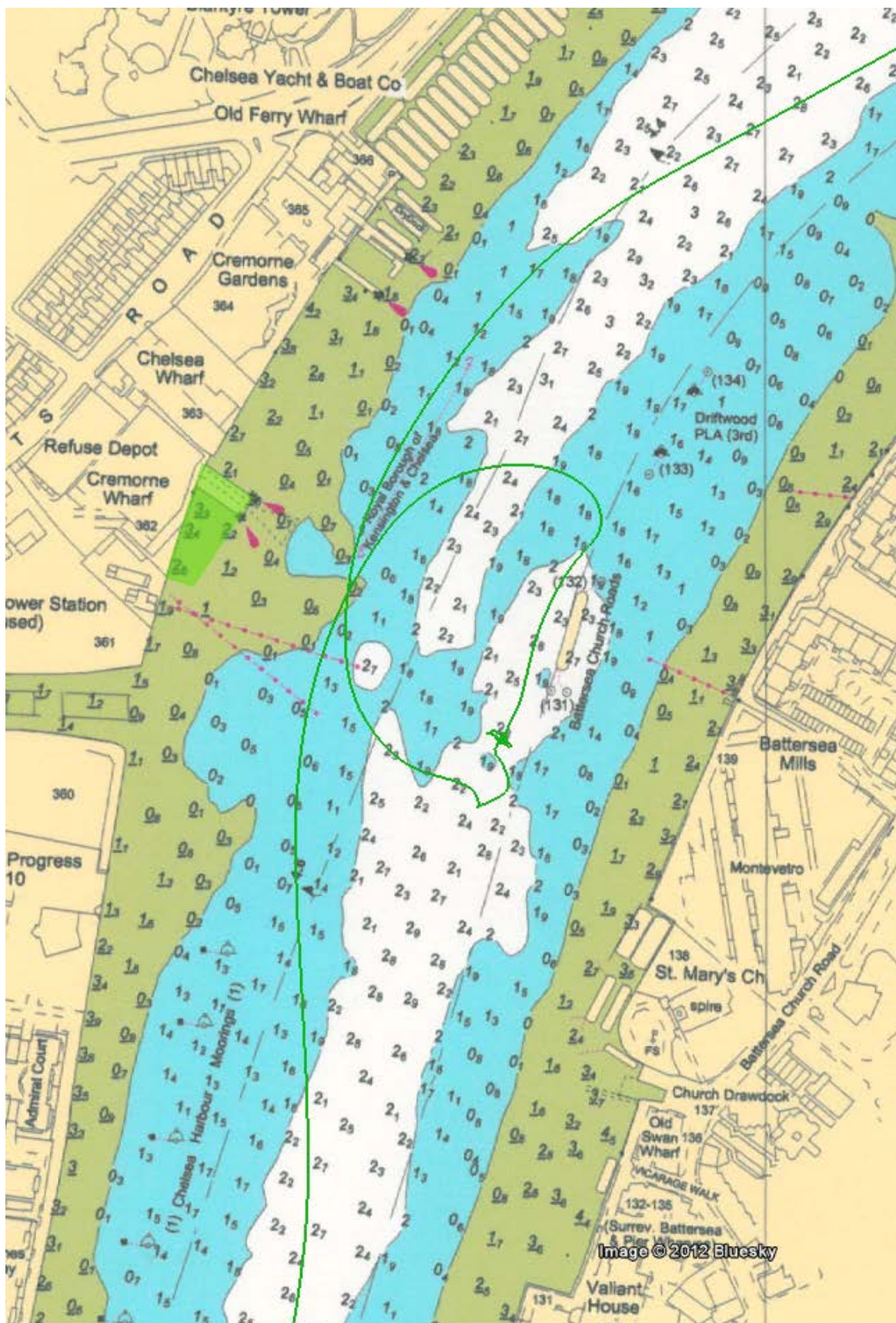


Figure B.6 14/11/2011 - Green Track image

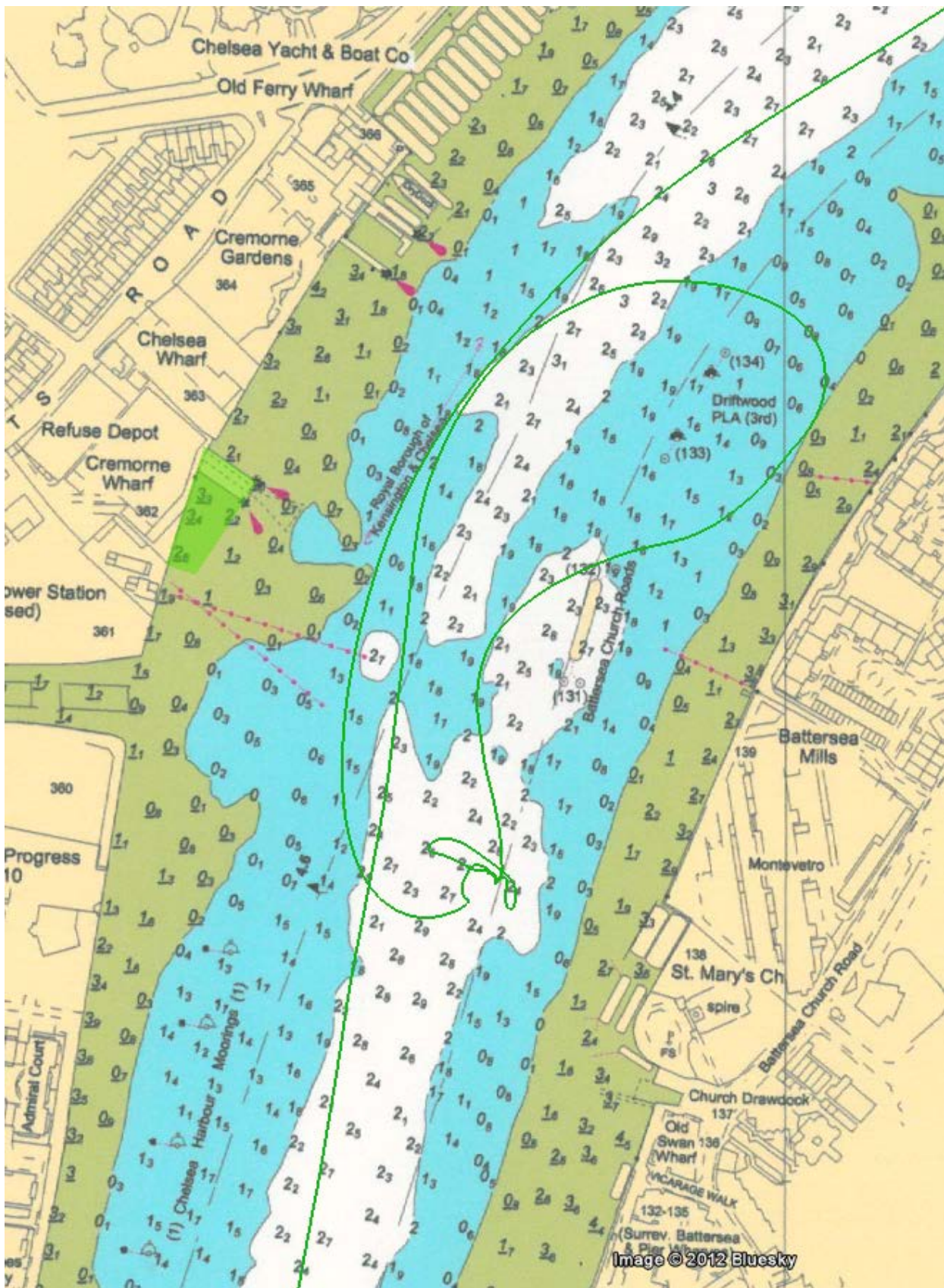


Figure B.7 23/11/2011 – Red Track image

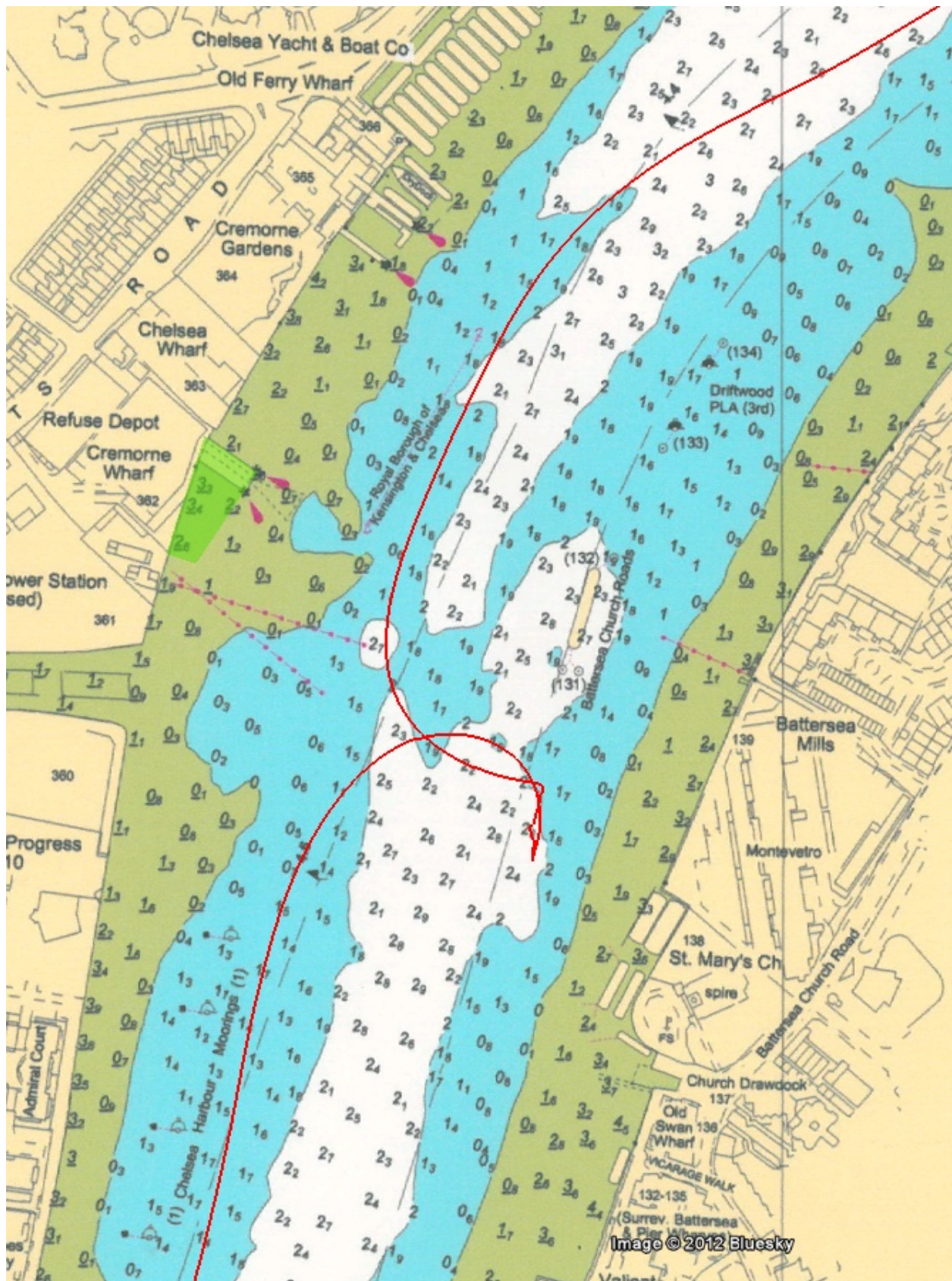
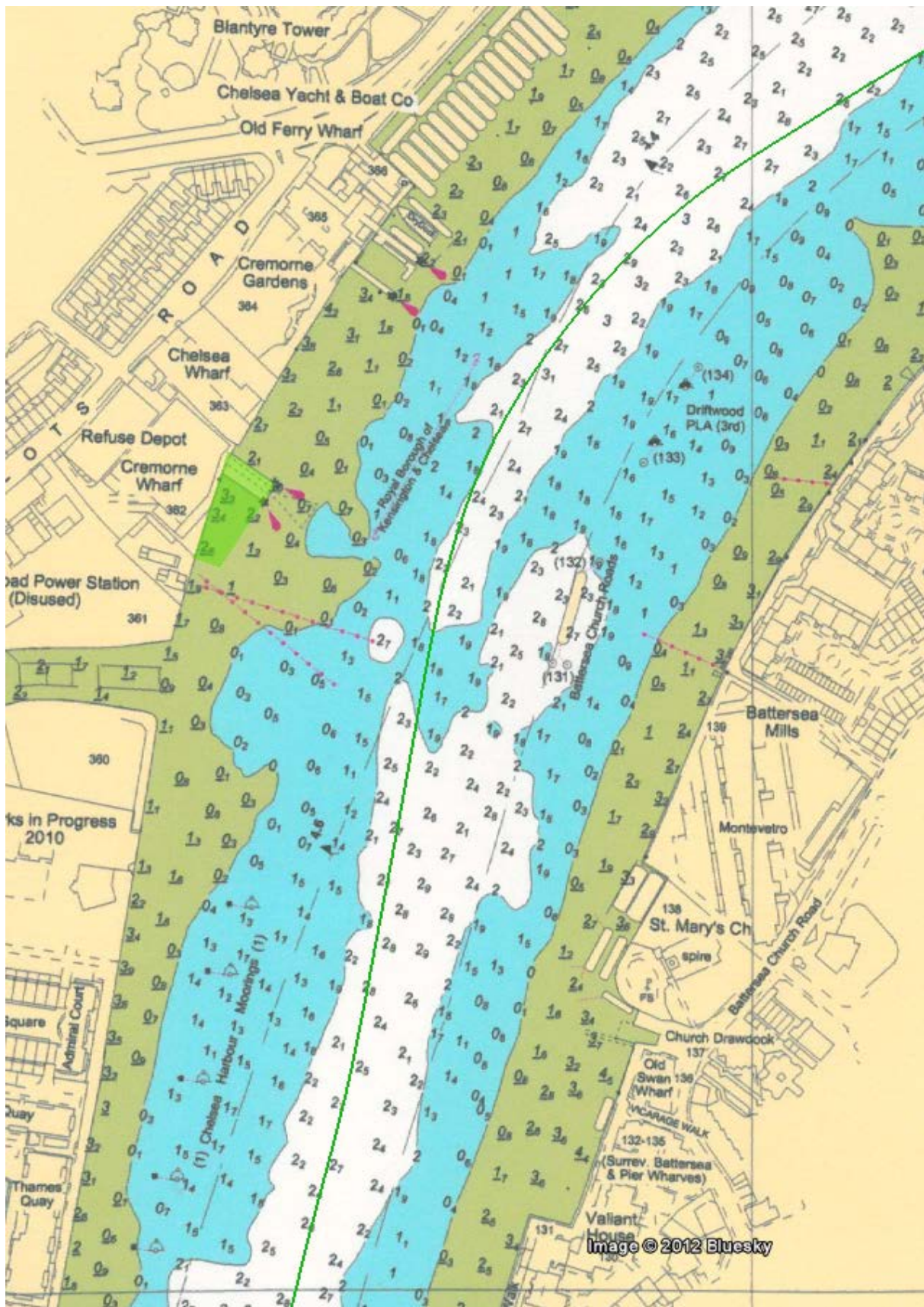


Figure B.8 23/11/2011 - Green Track image



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