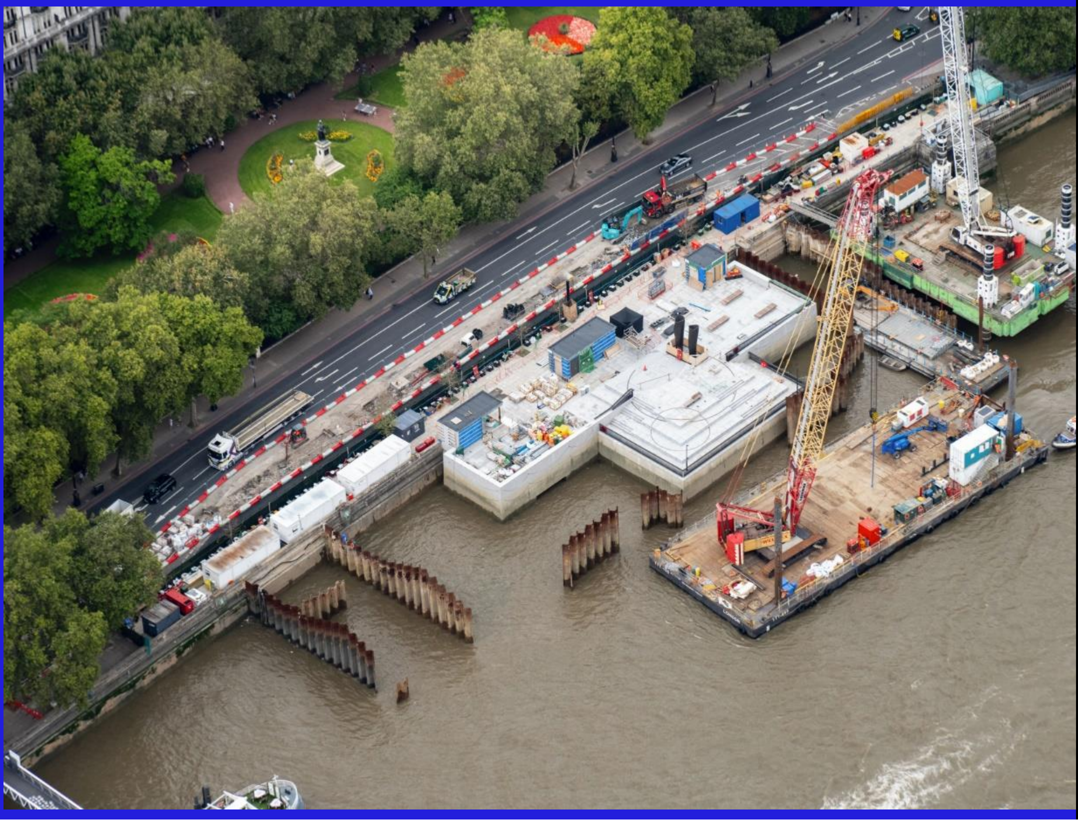
CSO Discharge Designers Risk Assessment Permanent Case – Victoria Embankment Foreshore

Document no: 665397CH-VCTEF-DRA-Permanent-Rev. 3
Version: 00

Bazalgette Tunnel Limited
Tideway
4 November 2024



CSO Discharge Designers Risk Assessment Permanent Case – Victoria Embankment Foreshore

Client name:	Bazalgette Tunnel Limited		
Project name:	Tideway		
Client reference:	Bazalgette Tunnel limited	**Project no:**	665397CH
Document no:	665397CH-VCTEF-DRA-Permanent-Rev. 3	**Project manager:**	James Smith
Version:	00	**Prepared by:**	James Spikesley, Paul Hallas, Phil Reed & Russell Guest
Date:	4 November 2024	**File name:**	VCTEF Permanent DRA
Document status:	Final		

Document history and status

Revision	Date	Description	Revised by
0	17/04/2024		JS/PH/PR/RG
1	19/06/2024	Minor revision to reflect change of contents of NRA/Ops Plan	JS/PR
2	22/10/2024	Updated to include the tidal consideration from the interim DRA for the purposes of the golden thread	PR/JS
3	04/11/2024	Updated section 4.3 Tidal Considerations	PR/JS

Required Approvals

	Name	Role	Signature	Date
Checked by	Phil Reed	Lead Marine Civil Engineer	PR	04/11/2024
Reviewed by	Ed Davies	CDM Advisor (Ports and Maritime)	ED	04/11/2024
Reviewed by	Simon Fricker	Head of Design Authority	SF	04/11/2024
Approved by	James Smith	Jacobs Project Manager	JS	04/11/2024

Jacobs U.K. Limited

2nd Floor, Cottons Centre
Cottons Lane
London SE1 2QG
United Kingdom

T +44 (0)203 980 2000
www.jacobs.com

Executive summary

1.1 This designers risk assessment has been produced to assess the hazards of swamping, capsizing, grounding and collision created by the VCTEF CSO discharge flows to vessels on the Thames at the Victoria Embankment Foreshore (VCTEF) site.

1.2 It has been undertaken for the permanent phase when the existing CSO is diverted into the new CSO that is situated further into the river Thames in the new VCTEF structure.

1.3 This designers risk assessment has assessed the risk of a CSO discharge to all types of vessels that passage past the location for the impact to the change the vessels drift angle and the consequential harm that could be caused.

1.4 A worst-case scenario discharge rate of a 1:15-year event at Mean Low Water Springs (MLWS) has been analysed to assess the impacts to vessels within zones of impact and vessel accessibility.

1.5 It has been concluded that the risk to powered vessels is very low, the risk to unpowered vessels is low when the mitigations of a warning system of lights and signs are adopted.

1.6 The DRA has been completed with a conservative approach, adopting reasonable worst cases.

1.7 The main works contractor FLO will undertake a navigational risk assessment to consider the residual risks and confirm their mitigations, in consultation with the Port of London Authority, required to be in place during the phase that is covered by this DRA.

1.8 The main works contractor FLO will need to consider the detailed design and the NRA to develop an operational plan, in consultation with the PLA, outlining how they will manage a CSO discharge event with the use of a warning system in line with Tideway's "Technical Memorandum on CSO warning performance specification and strategy".

1.9 To analyse the risk in greater detail for the permanent DRA the following study was undertaken:

a. Simulations of the discharge flows on vessels to assess the actual impact caused by the drift angle at HR Wallingford Ship Simulation Centre.

1.10 The permanent case has been risk assessed incorporating the findings of the ship simulations and will be subject to a navigational risk assessment by the Main Works Contractor to determine, in agreement with the Port of London Authority, any permanent mitigations that may be required. The Technical Memorandum on CSO warning performance specification and strategy should be considered to confirm the mitigations.

1.11 The permanent navigational risk assessment undertaken by the Main Works Contractor FLO will need to determine, in agreement with the Port of London Authority, that the permanent mitigations provide an acceptable warning system for the established risks.

Contents

Appendices

Tables

Figures

Acronyms and abbreviations

Abbreviation	Abbreviation Description
ALARP	As Low As is Reasonably Practicable
CCTV	Closed Circuit Television
CDM	Construction Design and Management Regulations 2015
CFD	Computational Fluid Dynamics
CSO	Combined Sewer Overflow
DRA	Designers Risk Assessment
EDM	Discharge Monitor
ERIC	Eliminate, Reduce, Inform and Control
FLO	Ferrovial Laing O'Rourke
GPS	Global Positioning System
ICM	Integrated Catchment Model
LTT	London Tideway Tunnel
NRA	Navigational Risk Assessment
PLA	Port of London Authority
SCADA	Supervisory Control and Data Acquisition
TWUL	Thames Water Utilities Limited
UWWTD	Urban Waste Water Treatment Directive
VCTEF	Victoria Embankment Foreshore
VTS	Vessel Traffic Service

2. Introduction

2.1 Introduction

2.1.1 As part of the Thames Tideway Tunnel project a new foreshore structure has been constructed at Victoria Embankment Foreshore (VCTEF) to connect to the Northern Low Level Sewer No.1.

2.1.2 A new CSO is being created and an existing CSO, from the adjacent Regent Street sewer, is being decommissioned.

2.1.3 Jacobs as the designer for the reference design has the duty under the CDM regulations to eliminate risks as far as reasonably practicable, where the risks cannot be eliminated the risks need to be reduced as far as reasonably practicable and information provided on residual risk.

2.1.4 Under the CDM regulations the Principal Designer “Jacobs” has a responsibility to plan, manage, monitor and coordinate the health and safety in the pre-construction phase of the project.

2.1.5 During the development of the design a designer’s risk assessment was undertaken to identify risks through design whilst also identifying any residual risks that would need to be considered.

2.1.6 There is part of Designers Risk Assessment PWR3X/TA where the impact of the Scour was considered under risk reference CDM-VCTEF-019, as presented below in Table 2-1.

Table 2-1 Extract from Designers Risk Assessment PWR3X/TA

Risk ref.	Title / description	Phase	Activity	Potential hazards	Effect summary inc person at risk.	Severity	Probability	First Risk Rating	Design measures to eliminate hazards	Design measures to reduce risk and/or design assumptions	Severity	Probability	Risk Rating after E & R	Residual risk (if significant, etc.)	How is it communicated and / or documented?
CDM-VCTEF-019	Scour – Permanent works	Operation and Maintenance	New permanent structure in the river	Scour damage following bed erosion triggered by increasing river velocity	Potential injury due to settlement or collapse of Chelsea Embankment and adjacent bridges affecting third parties and public	3	2	Medium	Unable to eliminate hazard.	Commissioned scour study analysis assess risk as minimal. Contractor is competent to reduce/manage risk further during construction. Fluvial modelling studies carried out as part of design and design modified to minimise increase in bed velocities Commissioned scour study analysis assess risk as minimal.	3	1	Low	Potential injury due to settlement or collapse of Victoria Embankment and adjacent bridges affecting third parties and public.	"Scour and fluvial modelling reports in SI of ITT. "

2.1.7 Whilst CDM-VCTEF-019 recognises that there is a risk produced by increases in river velocity it does not consider any direct risk to vessels in the river or that mitigations may be required.

2.1.8 To ensure that all the relevant risks and mitigations are covered through a Designers Risk Assessment this document is an addendum which will consider a detailed risk assessment of the new VCTEF CSO discharges impacting vessels on the river.

2.1.9 This designer's risk assessment (DRA) considers

(a) The permanent case with the new foreshore structure in place and the flows able to be intercepted and diverted to the main tunnel.

(b) When the tunnel is out of operation for maintenance and inspection works.

2.1.10 The DRA makes the assessment based on the information that has been produced by the contractor, HR Wallingford document 4410-FLOJV-VCTEF-520-VZ-RG-100001_P05 CSO Discharge modelling for permanent works Victoria Embankment Foreshore, the interim DRA 665397CH-VCTEF-DRA-Interim-REV.02 and the updated rainfall information produced by Tideway.

2.1.11 The DRA should be read in conjunction with HR Wallingford document 4410-FLOJV-VCTEF-520-VZ-RG-100001_P05 CSO Discharge modelling for permanent works Victoria Embankment Foreshore. Within the HR Wallingford report the discharges are modelled with a mean absolute error of 6% for neaps and 7% for springs when compared to the peak flow.

2.1.12 In addition, it includes information provided within document LL1658-R-01 Navigational Risk Assessment Review Port of London Authority, which was undertaken by Rendel Limited with Waves Group and the latest discharge modelling data and interim DRA 665397CH-VCTEF-DRA-Interim-Rev. 02

2.2 Report Structure

2.2.1 The Structure of this report is as follows:

a. Section 3 - Outline methodology for producing the risk assessment

b. Section 4 - Site discharge activity

c. Section 5 - Impact on vessels on the river

d. Section 6 - Ship simulation comparison

e. Section 7 - Risk assessment

f. Section 8 - Mitigations

g. Section 9 - Summary

2.3 The site and CSO discharge location

2.3.1 The VCTEF site is located on north bank of the river Thames, upstream of Hungerford Bridge and adjacent to Whitehall Gardens.

2.3.2 Prior to construction of the new foreshore structure an existing CSO, which takes flows from the Regent Street Sewer, discharged through the river wall into the Thames behind the vessel Tattershall Castle. Figure 2-1and Figure 2-2 show the pre-Tideway layout.

Figure 2-1 Aerial photograph of Victoria Embankment Foreshore Pre-Tideway

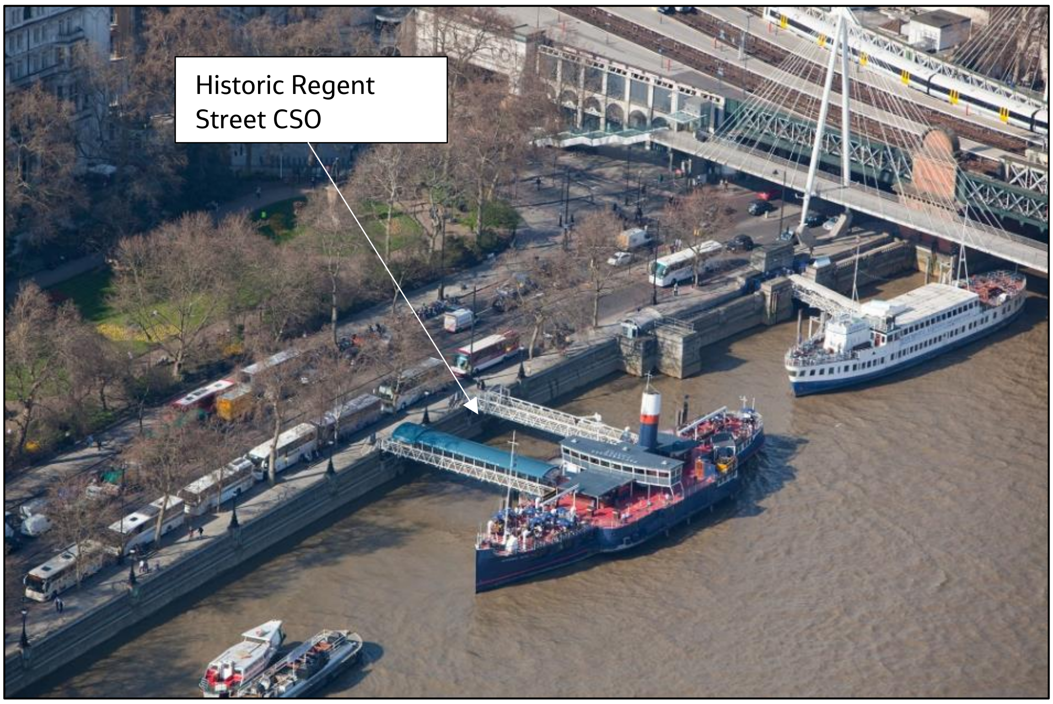
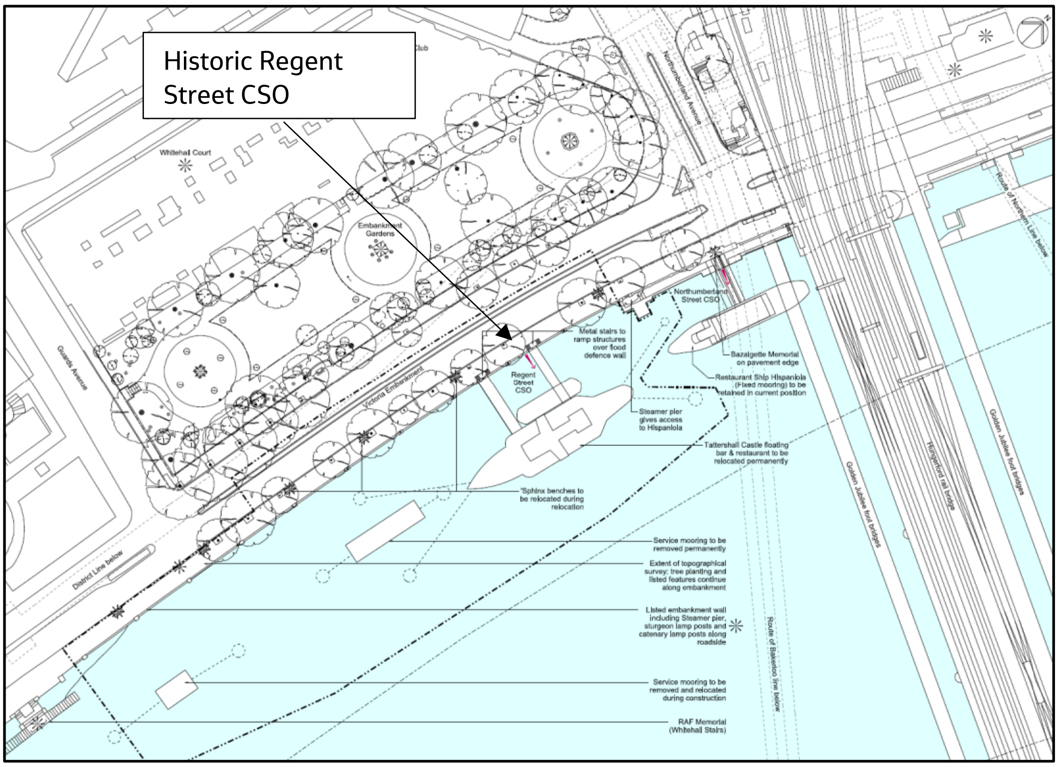


Figure 2-2 Extract of DCO-PP-16X-VCTEF-180002 showing the original layout.

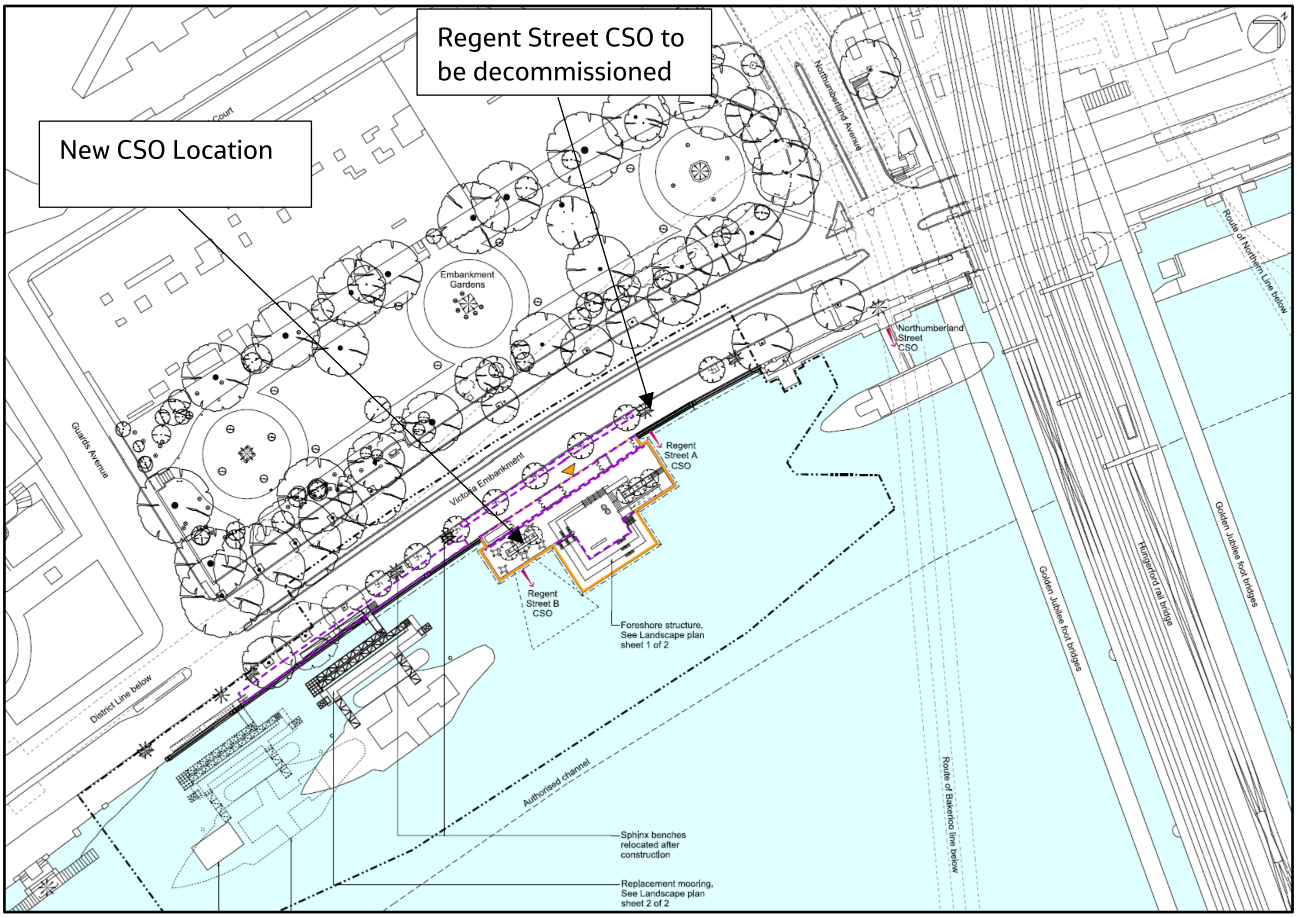


2.3.3 The Tattershall Castle has been moved upstream to enable the new foreshore structure to connect to the Northern Low Level Sewer No.1 at the location shown on Figure 2-3. High flows in the Northern Low Level Sewer No.1 will be diverted to the tunnel.

2.3.4 When the tunnel is not available, or at capacity, a new CSO will discharge flows to the Thames. The new CSO is approximately 45m further upstream of the Regent Street CSO and projects a further 12m into the river.

2.3.5 Once the new VCTEF CSO has been commissioned, the historic Regent Street CSO will be decommissioned.

Figure 2-3 Extract of DCO-PP-16X-VCTEF-180011 showing the permanent works arrangement.



2.3.6 In conjunction with the change of outfall location there is also a change in the size and layout of the new outfall.

2.3.7 The new VCTEF CSO outfall will discharge through three sets of flaps which discharge onto the new scour apron and are approximately 2.7 times larger than the original Regent sewer CSO outfall.

3. Outline Methodology

3.1 To analyse the impact of a CSO discharges from the site to the river, identify the risks to vessels on the river, identify the impacted vessels, propose mitigations and present the residual risks the following has been undertaken:

3.1.1 Confirm site discharge activity by:

i) Reviewing historical rain and discharge data

ii) Reviewing resilience to climate change

iii) Analyse tidal windows to confirm worst case

iv) Review and analyse the impact of discharges on the river from HR Wallingford document 4410-FLOJV-VCTEF-520-VZ-RG-100001_P05 CSO Discharge modelling for permanent works Victoria Embankment Foreshore.

3.1.2 Review impact of worst-case discharge on vessels on the river by:

i) Confirming areas of the river

ii) Confirming vessels that use the river in this area

iii) Confirming predicted drift angle of vessels caused by a VCTEF CSO discharge

iv) Summarise impacted vessels on the river

v) Incorporate ship simulation runs

3.1.3 Risk assessment

i) Hazards

ii) Receptors

iii) Severity of harm

iv) Likelihood of harm

3.1.4 ERIC approach to review mitigation

i) Eliminate

ii) Reduce

iii) Inform

iv) Control

3.1.5 Summary

4. Site discharge activity

4.1 Consideration of rainfall events

4.1.1 CSO discharges were produced for a range of return period storms using an InfoWorks network model of the upstream sewer catchment.

4.1.2 Synthetic storms were generated by the software based on the Flood Estimation Handbook (FEH).

4.1.3 The critical storm duration for the system (i.e., that which produces the highest flows at the outfall) was found to be 120 minutes.

4.1.4 Normally, when generating synthetic storm events, rainfall intensities are reduced as the footprint of a storm increases. However, in this instance, the storm event was applied over the entire catchment without applying an areal reduction factor.

4.1.5 With an approximate catchment area of 550km^2, the corresponding reduction factor for the Tideway catchment would have been 0.76 – the rainfall intensities are therefore overestimated by approximately 32%.

4.1.6 In addition, the model assumes that all rainfall landing on a catchment freely enters the sewer system. In practise, for higher rainfall intensities, this cannot happen as the gullies and upstream collection pipework act as a restriction, resulting in flooding and ponding on the surface. For this reason, the modelled 100-year storm flows are considered theoretical and unlikely to ever be realised. It is the upstream sewer system that limits the peak CSO discharge rate, not the size of the CSO opening itself.

4.1.7 The InfoWorks model of the sewer network, with the London Tideway Tunnel not available was run with free discharge as a worst-case scenario (i.e., low tide) and the peak flow rates included in the project's works information (WI 7706). These WI flows are shown in Table 4-1. The peak flow from the VCTEF CSO was found to be approximately 19m3/s for a 15-year storm.

4.1.8 Periodic updates are made to the model depending on the results of surveys/inspections. Discharge rates using the updated model are also given in Table 4-1. Peak flows are broadly similar to those given in the works information and have not significantly changed.

4.1.9 At higher tides the CSO becomes submerged and there is a corresponding decrease in discharge rates, also included in Table 4-1.

Table 4-1 Comparison of Instantaneous peak discharge rates from WI 7706 and the post 2016 model

Source		Typical Year Storm	LT 2-year storm	LT 5-year storm	LT 10-year storm	LT 15-year storm	LT 30-year storm	LT 50-year storm	LT 100-year storm
Latest DA Model	Instantaneous Peak Low water (m^3/Sec)	n/a	7.6	13.1	17.0	19.0	23.0	25.8	29.3
Latest DA Model	Rolling Hourly Average Low water (m^3/Sec)	n/a	5.6	10.6	14.4	16.6	20.2	22.9	26.0
Latest DA Model	Instantaneous Peak High water (m^3/Sec)	n/a	0.5	5.2	9.0	10.0	12.5	14.4	16.4
WI 7706	Instantaneous Peak Flow	7.8	9.4	13.1	16.1	18	21	n/a	n/a

4.1.10 It should be noted that occasionally TWUL can make minor diversions to the sewer network upstream to facilitate maintenance access. However, these are generally local in nature and don't have a significant impact on CSO discharges.

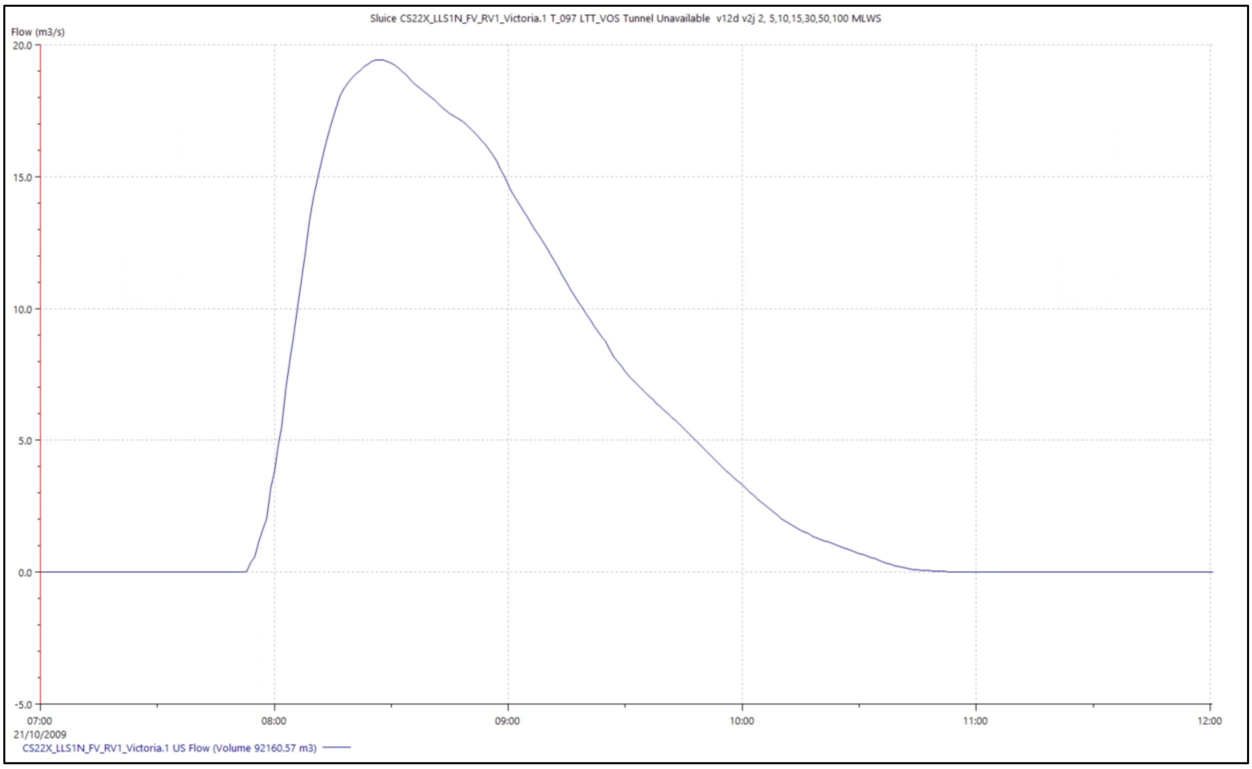
4.1.11 The developed nature of the upstream catchment means it is not possible to make substantial changes to the network connectivity that could significantly affect peak CSO discharges. Ultimately there is a fixed amount of rainfall falling on a fixed area, served by a sewer system of fixed and limited capacity.

4.1.12 Every 10 years it is planned to close the tunnel for inspections – under these conditions all flow is diverted to the CSO. Whilst the exact duration of the closure is yet to be finalised, it is expected to be of the order of two weeks.

4.1.13 Given the conservative nature of the rainfall generation, the theoretical nature of the network modelling, the limited scope to significantly alter the upstream sewer network and the range of possible tide levels, 19 m^3/s is considered a maximum realistic CSO discharge rate. It should be recognised that HR Wallingford undertook the discharge modelling using the works information discharge of 18 m^3/s, however this will make very little difference in the overall impact of the discharge.

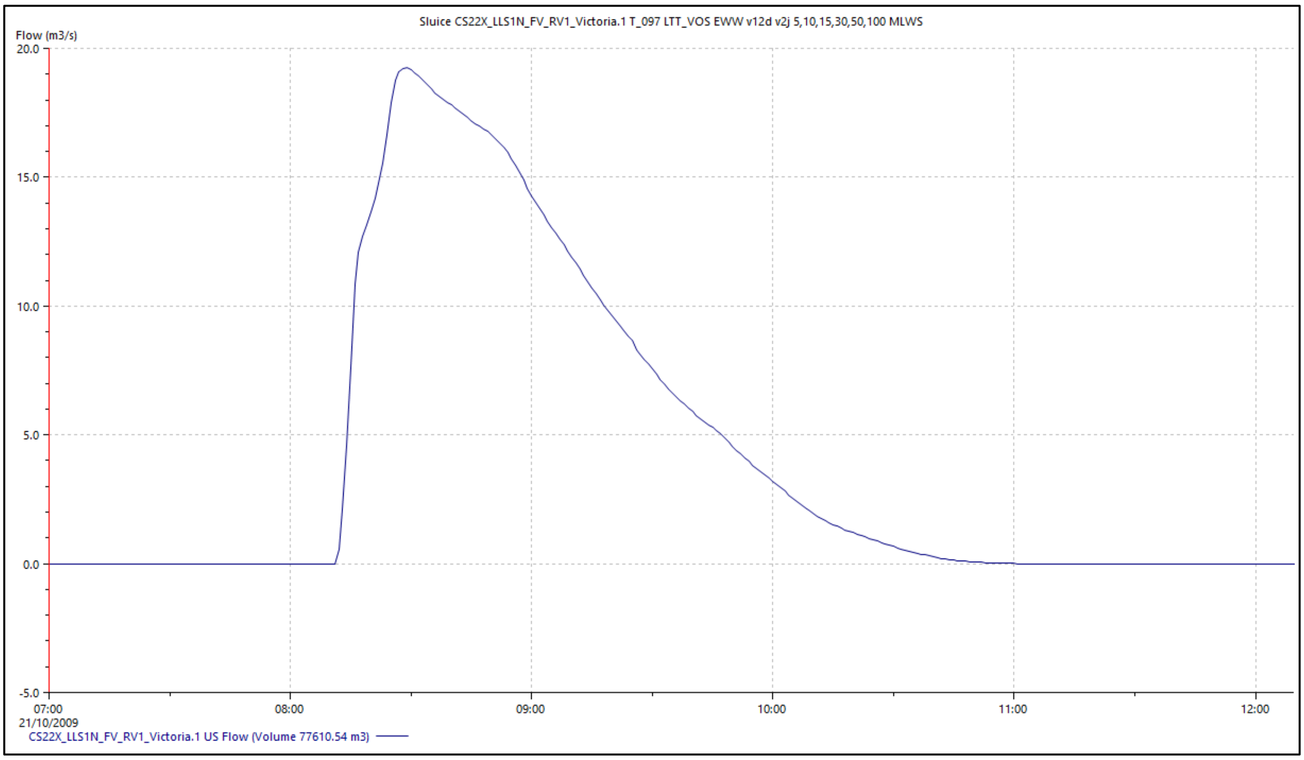
4.1.14 Figure 4-1 shows the discharge hydrograph for the 15-year storm at low tide, using the latest Design Authority model. The hydrograph represents the 'Tunnel Closed' scenario. In this instance the storm started at 07:00 - it took approximately 50 minutes for the CSO to start discharging and approximately another 35 minutes for the peak discharge to be realised.

Figure 4-1 CSO Discharge Hydrograph for the 15-year storm, tunnel closed



4.1.15 Figure 4-2 shows the 15-year discharge hydrograph representing the 'Tunnel Operational' scenario. The onset of the CSO discharge is delayed by approximately 25 minutes. Discharge occurs because, at VCTEF, flow to the tunnel is limited to approximately 13m^3/s. When this flow is achieved the tunnel penstocks are closed and all subsequent flow is diverted to the river. The peak discharge is not significantly affected.

Figure 4-2 CSO Discharge Hydrograph for the 15-year storm, Tunnel Operational



4.1.16 At the design phase of the project, 40 years of recorded rainfall data was available, spanning 1970–2010. Following inspection of this data set it was determined that the most representative (typical) year was October 1979 to September 1980. A further review of the data up to 2020 has confirmed that this remains the case.

4.1.17 Table 4-2 summarises the peak CSO discharges at VCTEF during the typical year (1979/80).

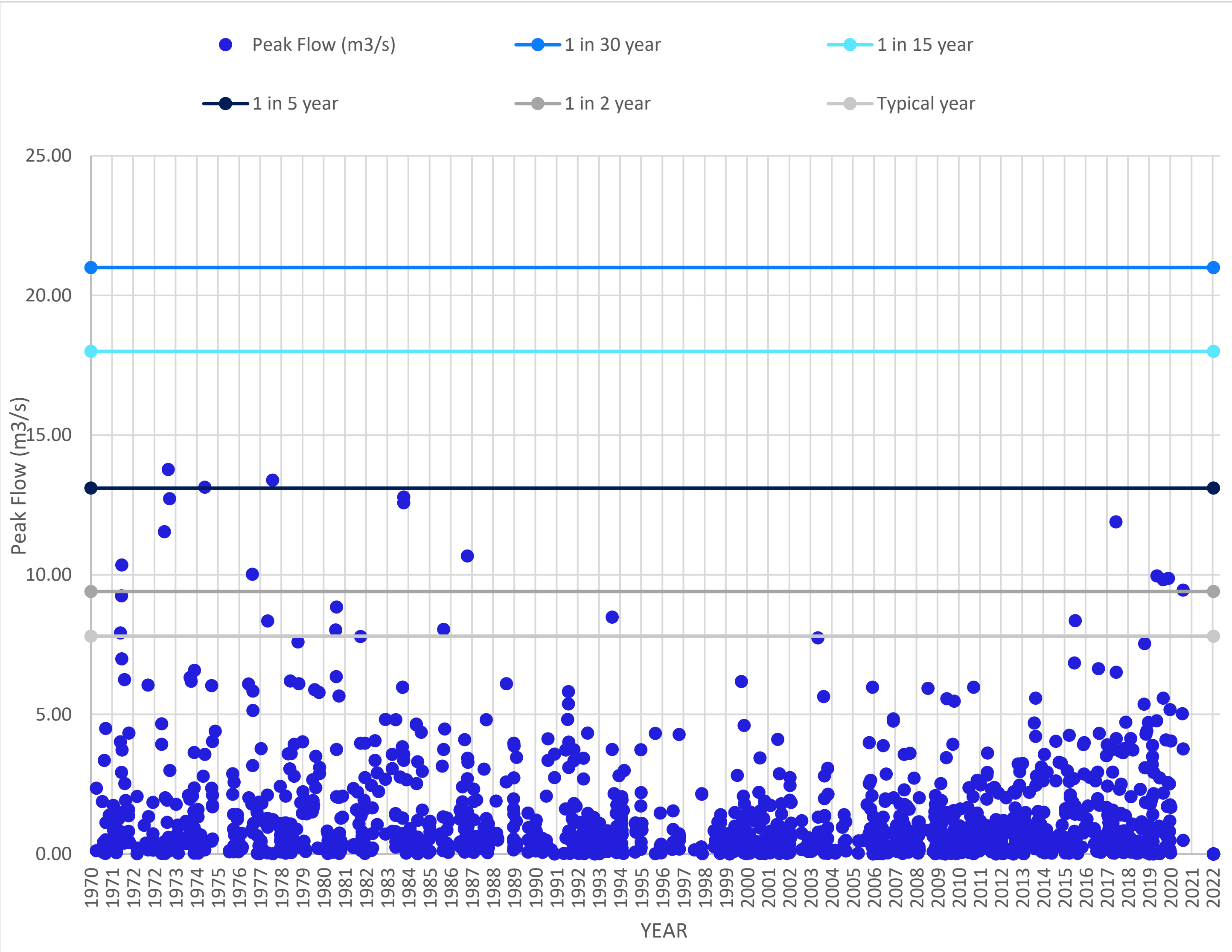
Table 4-2 Peak CSO discharges during typical year (1979/80)

Start of Spill	Spill Duration (mins)	Peak Flow (m3/s)	Spill Volume (m3)
09/10/1979 06:35	172.3	7.5893	258143
25/10/1979 13:50	227.6	6.09732	23870
26/11/1979 13:49	194.7	1.83778	5954
13/12/1979 05:10	49.4	0.21268	238
27/12/1979 01:46	314.9	1.45691	8382
28/12/1979 17:20	33.5	4.01219	1232
03/01/1980 22:35	114.8	2.22488	6142
20/01/1980 17:30	83.5	0.45626	1124
03/02/1980 15:15	57.5	0.20957	259
22/02/1980 10:45	43.6	0.09076	82
06/03/1980 09:55	119.3	1.43053	5362

17/03/1980 07:45	241.8	1.89229	13117
13/06/1980 02:40	89.1	1.50569	3415
22/06/1980 10:09	152.2	2.65827	8425
24/06/1980 09:45	110.5	1.91671	4861
30/06/1980 20:10	151.6	1.66065	7701
07/07/1980 13:50	113.8	1.7583	4314
25/07/1980 23:40	188.7	5.88255	28450
12/08/1980 21:45	98.9	2.37239	5461
14/08/1980 19:05	163	3.49338	15027
16/09/1980 08:19	43.9	0.20948	204

4.1.18 Figure 4-3 below shows the simulated peak flows from the new VCTEF CSO outfall, assuming the tunnel is not available, using the full set of actual rainfall data for 1970-2020.

Figure 4-3 Simulated peak flows from new VCTEF CSO outfall using actual weather data from 1970-2020 against the WI 7706 return periods (assuming tunnel unavailable).



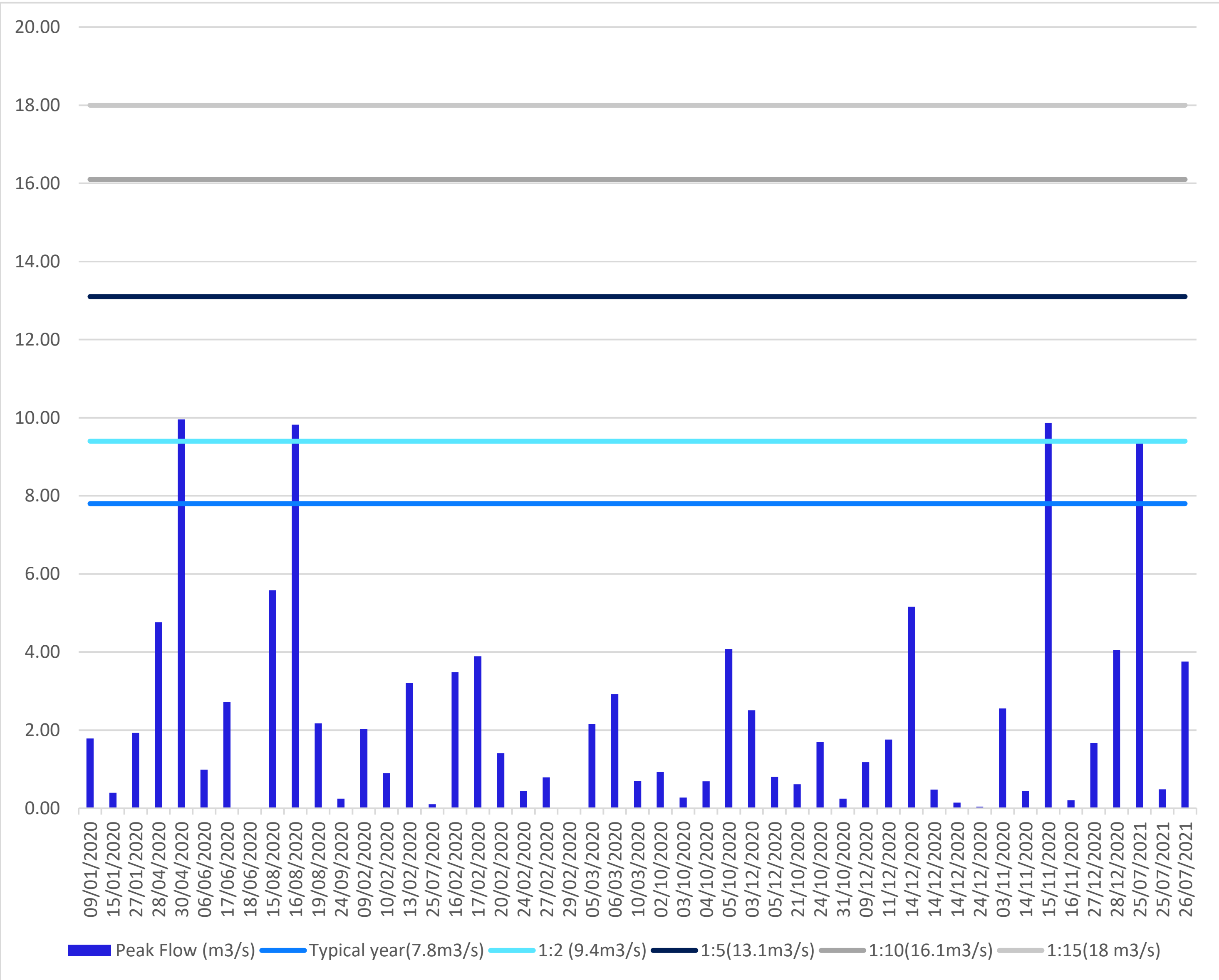
4.2 Discharge frequency and magnitude

4.2.1 The VCTEF structure will be intercepting the Regent CSO discharges to the main tunnel however there will be periods when the tunnel will be taken out of operation for inspection and maintenance. During these periods the tunnel will be isolated, and the intercepted flows will discharge through the new CSO. Whilst these works will be planned to be undertaken during periods of low flow there may be storms and there the magnitude of these discharges and the potential frequency needs to be understood.

Magnitude

4.2.2 The 2020 CSO peak discharge flows have been analysed and presented in Figure 4-4, this includes the two storms from July 2021 which were noted for their intensity.

Figure 4-4 Modelled VCTEF CSO discharge peak rates with actual rain data for 2020, including storms from July 2021



4.2.3 From the information presented in Figure 4-4 the average instantaneous peak discharge rate during 2020 was 2.36m^3/s with a maximum instantaneous peak of 9.96m^3/s. During the 25$^{th\ of}$ July 2021 summer storm the modelled VCTEF CSO peak discharge rate was 9.45m^3/s.

Frequency

4.2.4 The interception of the low level one at VCTEF will be a new connection that will absorb the discharges from the Regent Street CSO, as such there is no current EDM data that would have directly reported discharges from 2019. In place of this the discharge flow data from the model will be used for the period 2012 to 2020. From the modelled data over the 9-year period there would have been an average of 36.5 discharges per year, with a maximum of 47 discharges in a year and a minimum of 29 discharges in a year.

Climate change

4.2.5 During the development of the scheme and in support of the application for Development Consent, Tideway produced document 7.23 Resilience to Change. This document was developed to assess whether the scheme would continue to meet the Urban Waste Water Treatment Directive (UWWTD) requirements in the future whilst taking into consideration climate change and population increase.

4.2.6 The baseline data for the frequency and volume of CSO discharges was developed from the 1979/80 typical year of 588mm of rainfall depth which when modelled indicated a discharge of circa 39 million m^3 of sewage into the Thames.

4.2.7 Table 6.3 from document 7.23 presents the typical year CSO spill volumes and event count comparisons for the current climate and medium emission modelled scenarios from the UKCP09 government data on climate change. Table 4-3 below is the extract from that table for the modelled CSO discharges at VCTEF.

Table 4-3 Extract of table 6.3 from document 7.23 - typical year CSO spill volumes and event count comparisons for the current climate and medium emission modelled scenarios

LTT ID	EA Category	CSO Name	Typical Year - 2020 population and current climate			Typical year - 2080 population and medium emission scenario, 10 percentile			Typical year - 2080 population and medium emission scenario, 50 percentile			Typical year - 2080 population and medium emission scenario, 90 percentile		
			Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)	Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)	Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)	Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)
CS22X	Cat 1	Regent Street (new)	0	0	0	0	0	0	0	0	0	0	0	0

4.2.8 Table 4-3 demonstrates that, when the tunnel is operational, the new VCTEF CSO is not predicted to discharge in a typical year, even taking climate change into account.

4.2.9 The UK government updated the climate scenarios and presented them as UKCP18. Tideway reviewed the information to confirm that the scheme would still meet its UWWTD requirements in the future. The review confirmed there had not been significant change in the outcomes and the resilience of the scheme as described in document 7.23 still held true.

4.2.10 Table 4-4 summarises the peak rainfall climate change allowances in England up to 2125, extracted from the DEFRA website.

Table 4-4 Peak rainfall climate change allowances up to 2125

	Storm Return Period	
	30 year	100 year
Central Range (50th %ile)	20%	25%
Upper Range (95th %ile)	35%	40%

4.2.11 These allowances are of the same order of magnitude as the overestimation of the synthetic rainfall intensities explained in paragraph 4.1.5 (32%). It can therefore be considered that climate change has been adequately allowed for.

4.2.12 Notwithstanding the above, any future increase in rainfall intensities will not have a significant impact on the peak VCTEF CSO discharge rates for the reasons set out in paragraph 4.1.6.

4.3 Tidal Considerations

4.3.1 This section considers the HR Wallingford report titled "CSO discharge modelling for permanent works at the Victoria Embankment foreshore site" to establish the worst-case scenario and the impact of a CSO discharge across the full tidal range.

4.3.2 For the zone of impact of the lateral flow on the river, and associated tidal window, the HR Wallingford 1:15-year plumes are used to understand the most probable worst-case scenario that could occur without warning as established in Section 4 and paragraph 4.1.7 sets the discharge at 19m^{3}sec from WI 7710.

4.3.3 The HR Wallingford document 4410-FLOJV-HEAPS-520-VZ-RG-100001 REV: P02 was commissioned to provide 2-d depth averaged velocity discharge plumes using the instantaneous peak velocities for a typical year (1:1) and 1:15 events at the following tide states shown in Table 4-5. Depth average velocity is the average velocity at any location within the stream and typically occurs at 60% of the depth, measured from the top. Notably the results are only presented for 1:15 event due the negligible difference of 0.4m^3/s between events.

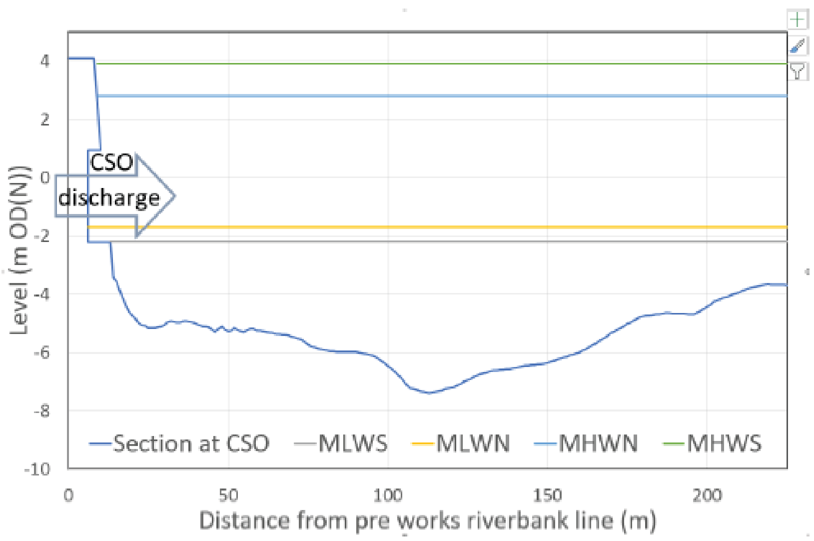
4.3.4 The report states that in considering the results it should be remembered that the model is 2D depth-averaged and hence will not model the detail of 3D aspects of the jet, especially within the distance taken for the expanding jet to mix fully with the receiving waters. Therefore, care should be taken in assessing the results close to the discharge point. Beyond 20 to 30 m of the discharge point the jet would be expected to be mixed with the receiving waters and the general modelled flow patterns are reliable. It has therefore been concluded that any effects within that zone are unpredictable and therefore the impacts within that zone cannot be established and will be considered as worst case.

Table 4-5 HR Wallingford modelling tidal discharge cases.

Tidal condition	Tidal States			
Spring tide	Low water slack	Mid-ebb flow	Mid-flood flow	High water slack
Neap tide	Low water slack	Mid-ebb flow	Mid-flood flow	High water slack

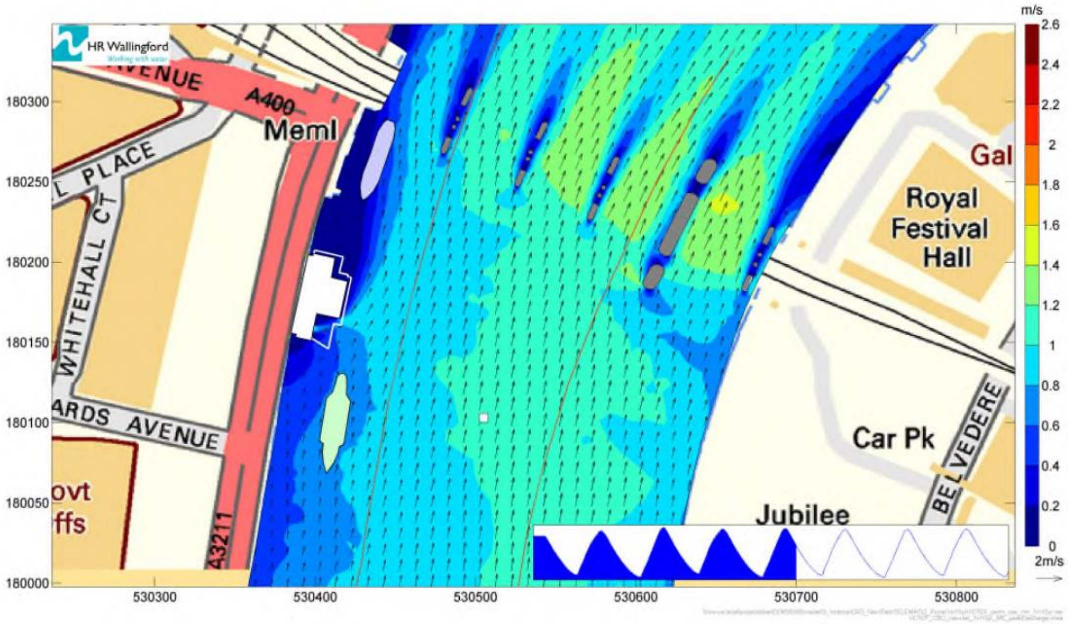
4.3.5 The height of the new CSO, relative to the riverbed and river level, is presented in Figure 4-5.

Figure 4-5 River section showing the new CSO outfall position relative to the riverbed.



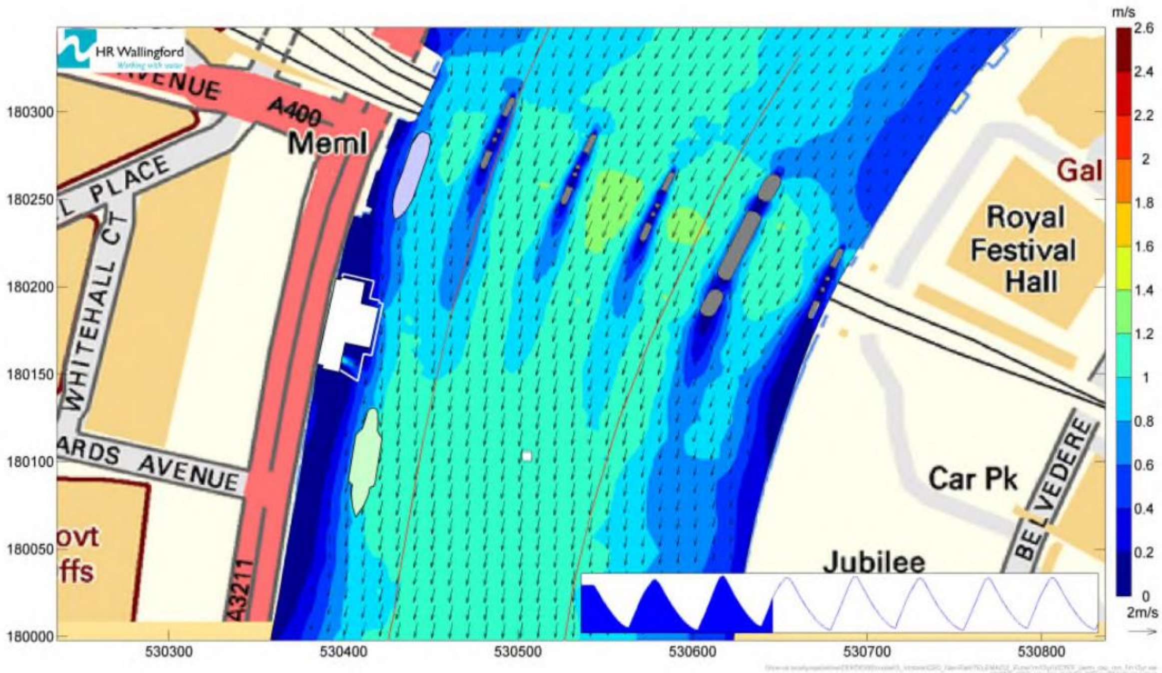
4.3.6 The analysis of the tidal cases undertaken by HR Wallingford identified that during the periods of rising or falling tide there was no lateral flow entering the navigational channel due to the dominance of the ambient river flow and rapid dispersion of momentum of the discharge. Likewise with the inshore zone the minimal impact of the flow is in the same direction as the dominant flow. Figure 4-6 presents an example of this for a mid-ebb tide.

Figure 4-6 Depth average currents at peak 1:15-year return period discharge at mid-ebb tide.



4.3.7 It can also be seen from Figure 4-7 that during mid-flood there is no impact to either the navigational channel or the inshore zone due to the dominance of the ambient river flow.

Figure 4-7 Depth average currents at peak 1:15-year return period discharge at mid-flood tide.



4.3.8 Further to 4.3.6 and 4.3.7 there was no discernible impact during the full period of modelling +50 minutes to -50 minutes either side of the mid-ebb and mid-flood tidal states.

4.3.9 Both the neap and flood tidal states were analysed for the period of low water where Figure 4-8 that represents HRW 2D modelling report, table 4.5 shows different periods of impact for the neap and flood at low water.

Figure 4-8 Neap and Spring low tide period of impacts

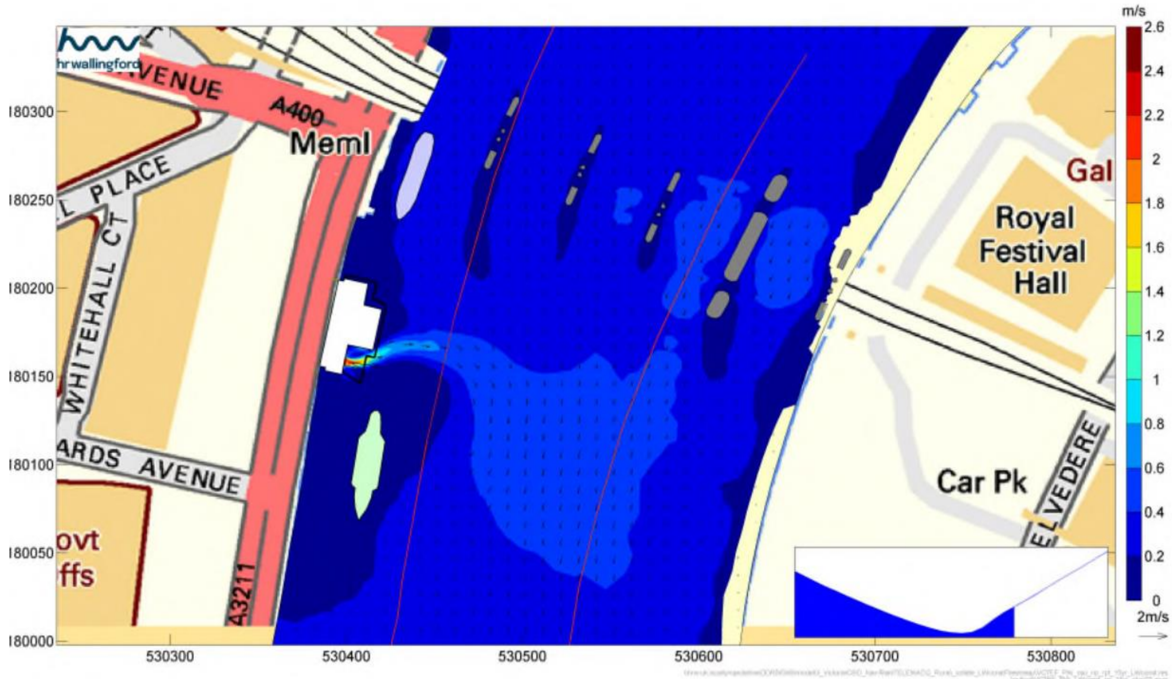
Table 4.2: Comparison of jet deflection for all cases modelled

	Spring LW Discharge Event				Spring Continuous Peak Discharge				Neap LW		Neap Continuous Peak Discharge			
Minutes to LW slack	Event Discharge	Jet not deflected 100yr	Jet not deflected 15yr	Jet not deflected 1yr	Peak Discharge	Jet not deflected 100yr	Jet not deflected 15yr	Jet not deflected 1yr	Event Discharge	Jet not deflected 100yr	Peak Discharge	Jet not deflected 100yr	Jet not deflected 15yr	Jet not deflected 1yr
-50	2.0	-	-	-	29.3	-	-	-	2.0	-	29.3	-	-	-
-40	7.3	-	-	-	29.3	-	-	-	7.3	-	29.3	-	-	-
-30	14.7	-	-	-	29.3	-	-	-	14.7	-	29.3	-	-	-
-20	22.0	-	-	-	29.3	-	-	-	22.0	-	29.3	-	-	-
-10	27.3	-	-	-	29.3	1	-	-	27.3	-	29.3	-	-	-
0	29.3	-	-	-	29.3	1	-	-	29.3	-	29.3	-	-	-
10	27.3	-	-	-	29.3	1	-	-	27.3	-	29.3	-	-	-
20	22.0	-	-	-	29.3	1	-	-	22.0	-	29.3	-	1	-
30	14.7	-	-	-	29.3	1	1	-	14.7	-	29.3	1	-	-
40	7.3	-	-	-	29.3	1	-	-	7.3	-	29.3	1	-	-
50	2.0	-	-	-	29.3	1	-	-	2.0	-	29.3	1	-	-

4.3.10 The total period from Figure 4-8 is 20 minutes where the impact starts on a neap tide at low water +15 minutes and finishes at +35 minutes after a spring low water.

4.3.11 It can be seen from Figure 4-9 that lateral flow from the CSO discharge in perpendicular to the background flow but it is only 0.2m3/sec in the navigational channel.

Figure 4-9 Depth average currents at peak 1:15-year return period discharge 20 minutes after neap low water slack.



4.3.12 Figure 4-10 shows the CSO discharge reaching the navigational channel and being influenced by the ambient river flow, the flow is 0.2m^{3}sec different to the background at this point. It is conservatively considered that there is still the possibility for some impact 40 minutes after neap low water slack and there is potential impact within the inshore zone.

4.3.13 Figure 4-11 shows that there is no impact to the navigational channel and the lateral flow from the CSO discharge does not affect the background flow in the inshore zone the 30m from the CSO discharge.

Figure 4-10 Depth average currents at peak 1:15-year return period discharge 40 minutes after neap low water slack.

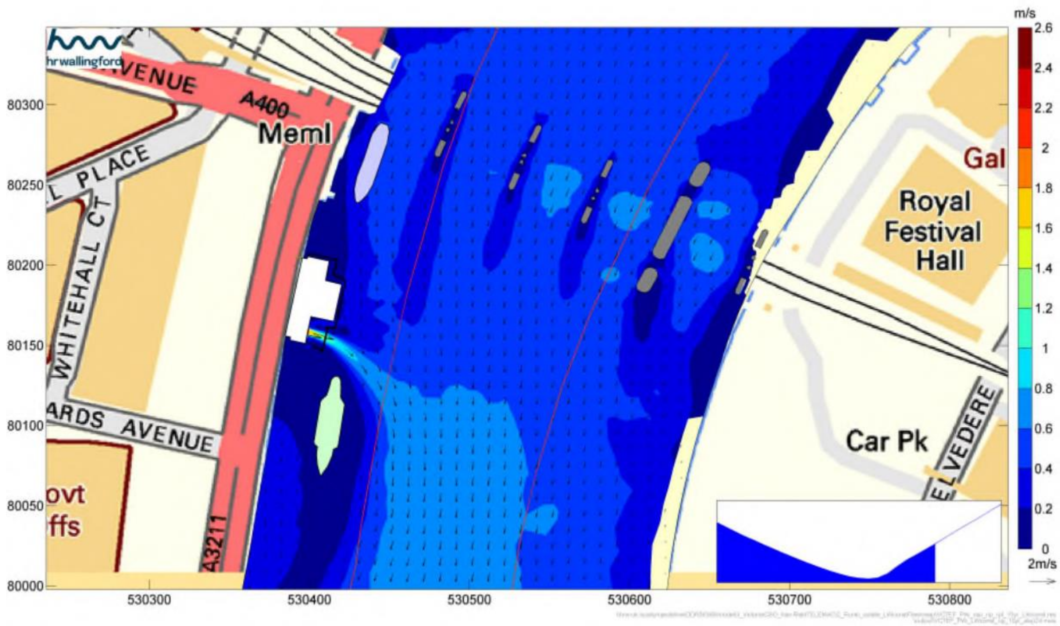
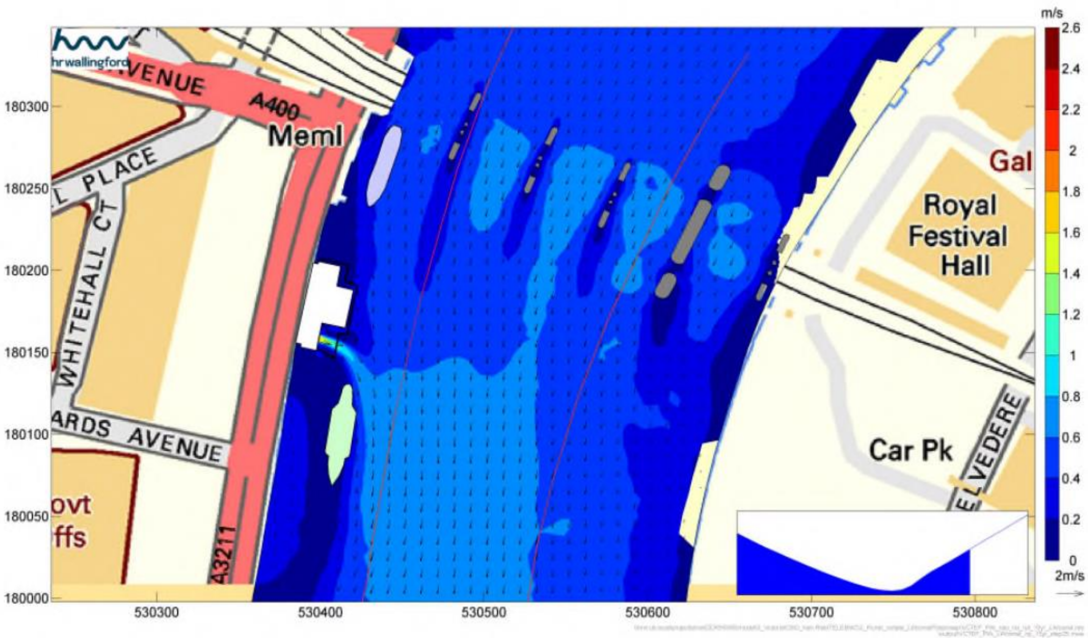
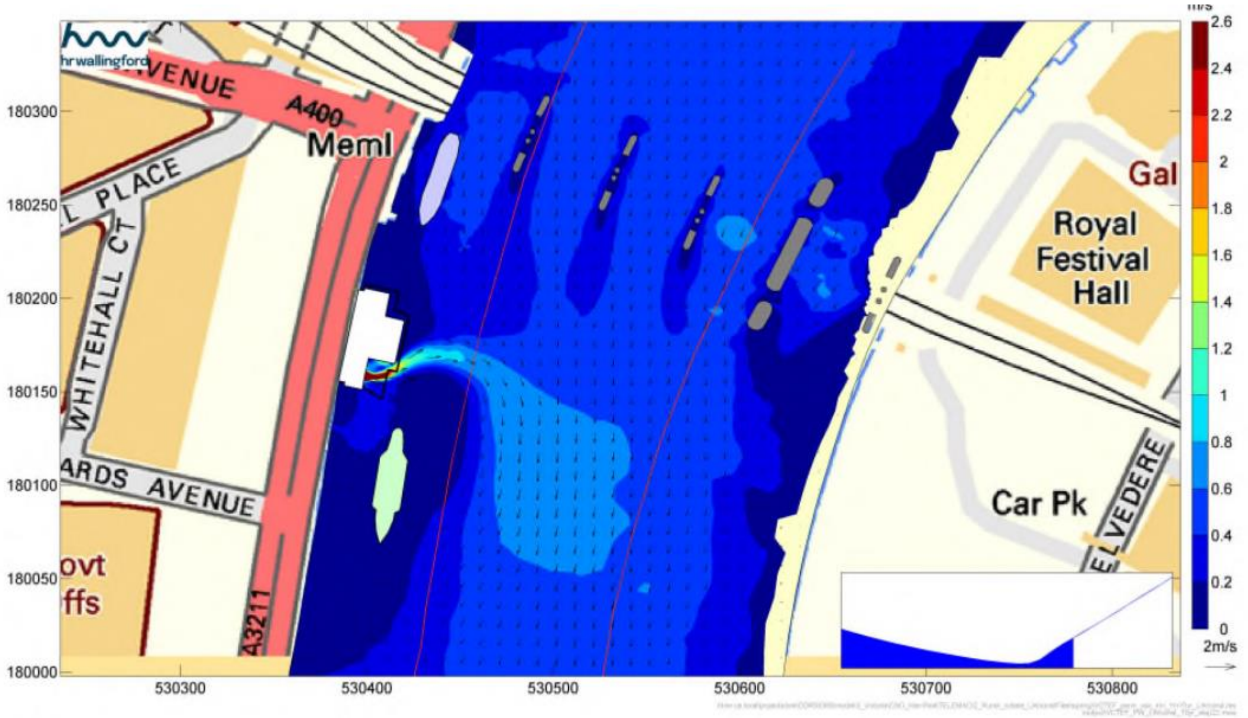


Figure 4-11 Depth average currents at peak 1:15-year return period discharge 50 minutes after neap low water slack.



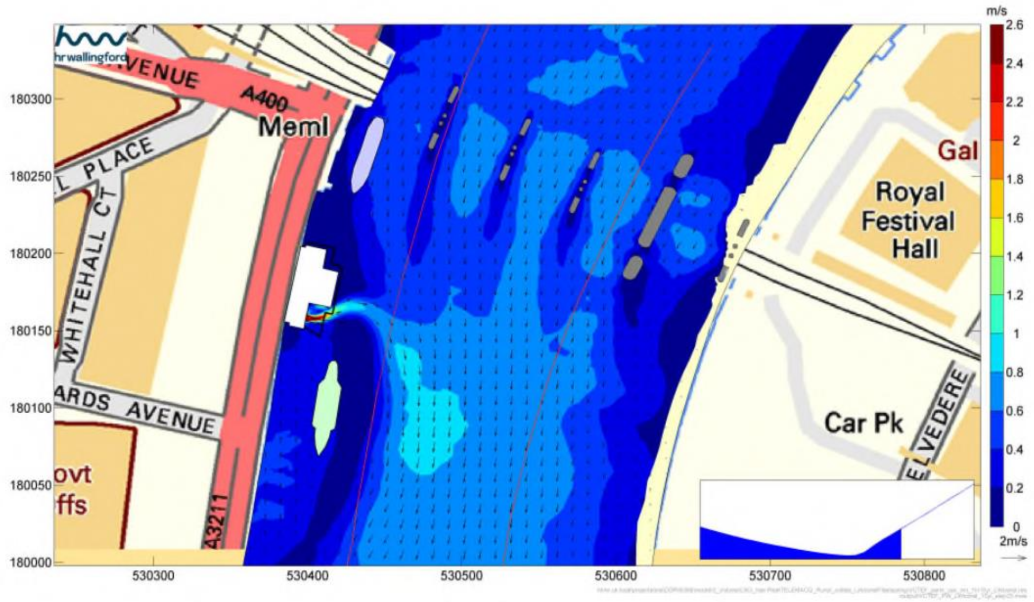
4.3.14 Figure 4-12 shows the lateral flow from the CSO discharge crossing the inshore zone and entering the navigational channel perpendicular to the CSO discharge 30 minute after spring low water slack. The lateral flow from the CSO discharge enters the navigational channel for a short distance before the background tidal currents become dominant.

Figure 4-12 Depth average currents at peak 1:15-year return period discharge 30 minutes after spring low water slack.



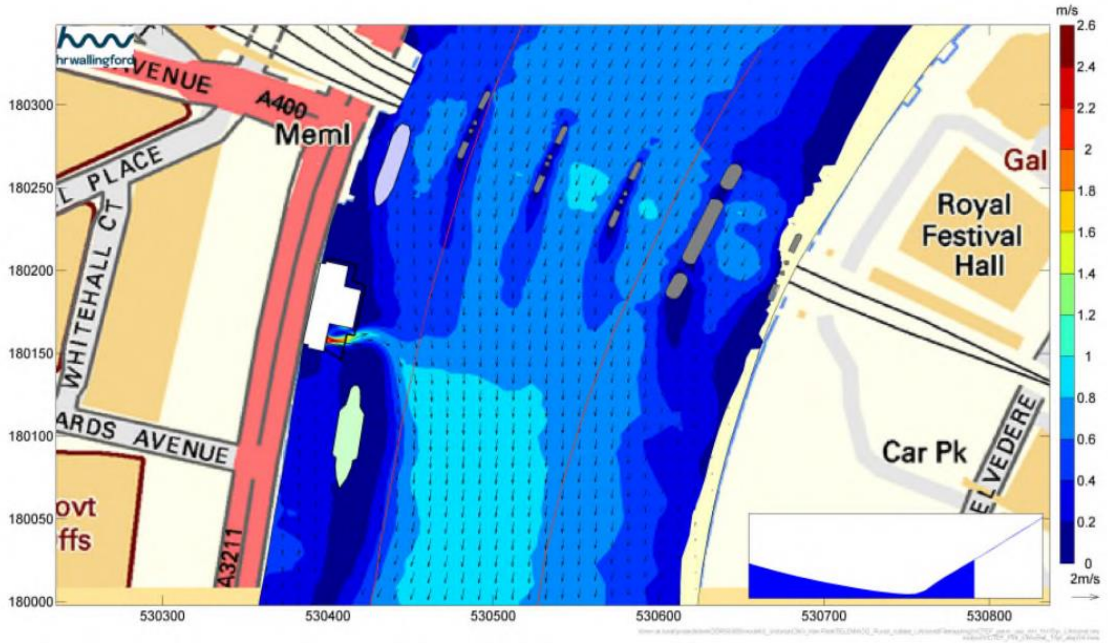
4.3.15 Figure 4-13 shows the lateral flow from the discharge entering the navigational channel for a very short distance before the ambient river flow becomes dominant, there is still a perpendicular flow from the CSO discharge in the inshore zone.

Figure 4-13 Depth average currents at peak 1:15-year return period discharge 40 minutes after spring low water slack.



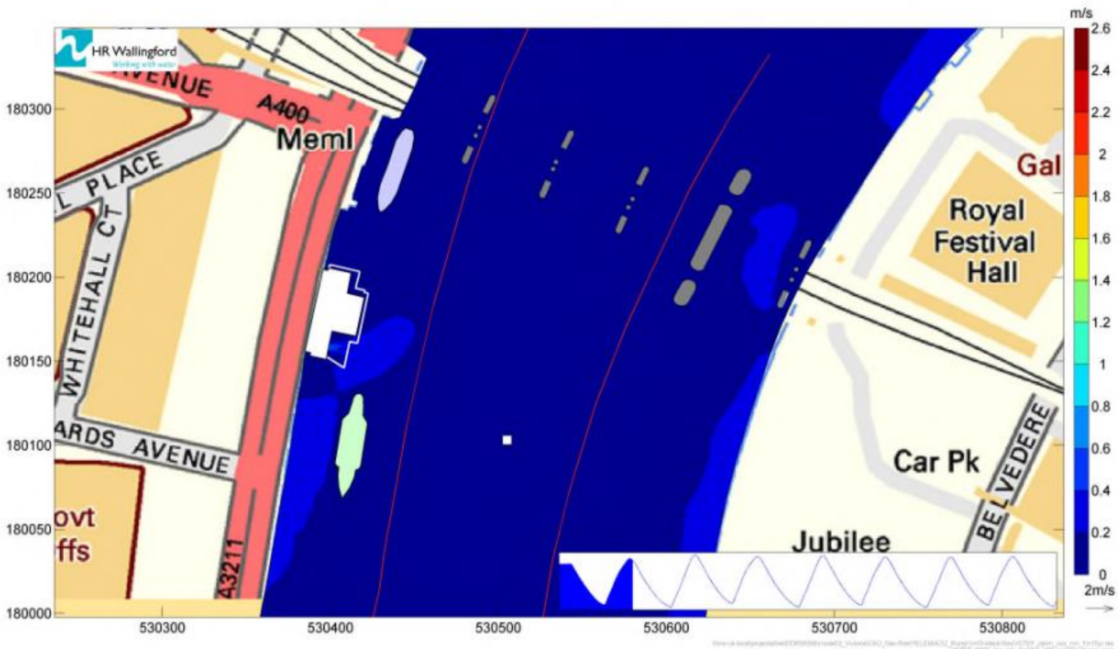
4.3.16 Figure 4-14 shows the lateral flow from the CSO discharge is dominated by the ambient river flow in the navigational channel, there is still a perpendicular flow from the CSO discharge in the inshore zone but appears to become dominated by the background tidal approximately 30m to 40 m from the CSO discharge.

Figure 4-14 Depth average currents at peak 1:15-year return period discharge 50 minutes after spring low water slack.



4.3.17 Figure 4-15 shows a lateral flow from the CSO discharge that does not reach the navigational channel and is below the threshold of navigational impact to vessels at 0.2m³/sec in the inshore zone.

Figure 4-15 Depth average currents at peak 1:15-year return period peak discharge high water slack.



4.3.18 From the analysis the worse case impact to vessels is at 30 minutes after low slack on a spring tide as presented in Figure 4-12.

4.3.19 From the analysis it can be concluded that the there is no discernible impact to vessels during a high-water discharge and during periods of low water the potential impact to vessels is seen to commence early on the neap and ends later during the spring tide. This summary and the details are presented in Table 9-1 Times of Impact. It should be noted that the periods of impact differ from the HRW Wallingford table 4.5, (Figure 4-8) where a more conservative approach has been adopted during the development of this DRA.

5. Impact on vessels on the river

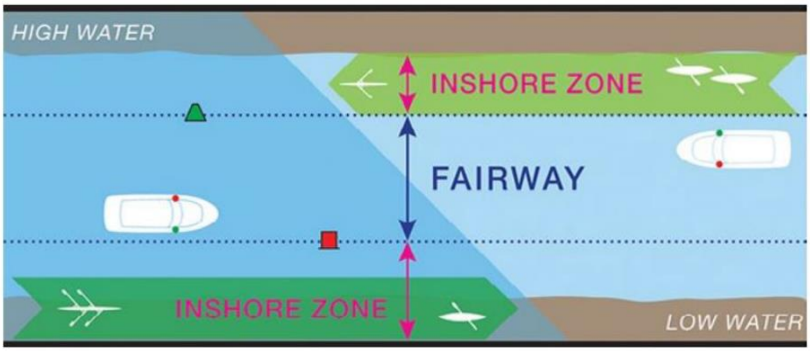
5.1 Assessment of the discharges

5.1.1 The 1:15 year event discharge plumes and sections are taken from document 4410-FLOJV-VCTEF-520-VZ-RG-100001_P05 CSO Discharge modelling for permanent works Victoria Embankment Foreshore and VCTEF Interim DRA 665397CH-VCTEF-DRA-Interim-Rev.02.

5.1.2 As stated in 4.4.2 the assessment for the impact on vessels on the river will be carried out using a 1:15 return period VCTEF CSO discharge of 18 m^3/s at 30 minutes after low water springs which produces the most probable worst case discharge plume for the site.

5.1.3 The assessment will consider the impact on vessels on the river in both the inshore zone, which is the area of the river between the main fairway edge and a point 30m from CSO outfall, and the main fairway, which is the area of the river between main fairway edges. As presented in Figure 5-1. The assessment will also consider collision with other vessels due to course change.

Figure 5-1 Diagram showing Fairway and Inshore Zones, (P58, The Tideway Code, PLA, 2019)



5.2 Outline which vessels have been assessed for and why.

5.2.1 Table 5-1 presents the vessels, and their characteristics, that have been chosen to represent the different types of vessels on the river that could be affected by a CSO discharge at VCTEF

Table 5-1 Vessels and their characteristics that could be affected by a CSO Discharge

	Vessel Classification	Vessel Type	Min Speed (knots)(SOG)	Max Speed (knots)(SOG)	Power	Manoeuvrability	VHF
1	Commercial Powered Vessels	Uber Boat	6	25	High	High	Yes
2		RIB/Emergency services	3	12 (40+ Emergency only)	High	High	Yes
3		Sightseeing/Pax	3	12	Medium	Medium	Yes
4		Restaurant/Pax	3	10	Medium	Medium	Yes
5		Tug vessel engaged in pushing	3	6	High	Low	Yes
6		Tug vessel engaged in towing	3	6	High	Low	Yes
7		Workboats	3	6	Low	Medium	Yes
8	Recreational Powered Vessels	Narrow Boat/cabin cruisers	3	4	Low	Low	No
9	Un-Powered Vessels	Dinghy	1	3	V. Low	Low	No
10		Kayak/Rowers/SUP	1	2	V. Low	Low	No

5.3 Impacts of discharge on the different classes of vessel.

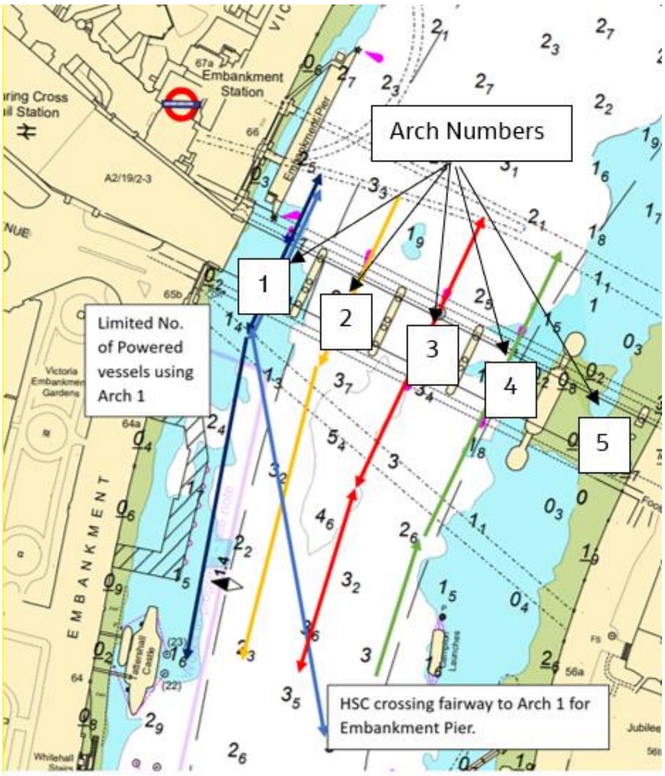
5.3.1 This section sets out the vessels that could be impacted by the CSO discharge, where the vessels are in relationship to the discharge and the corresponding drift angle that impact the vessels from the magnitude of the discharge flow.

5.3.2 VCTEF Interim DRA 665397CH-VCTEF-DRA-Interim-Rev.01 established the worst most likely case for a CSO impact and the duration of that impact. This information is presented in section 4.3.

5.3.3 The governing parameter of the draft of a vessel determines the minimum depth of water that the vessel needs to safely operate without grounding. This parameter is therefore listed in Table 5-1.

5.3.4 In this area at low tide vessels can operate in both the inshore zone and the main fairway.

Figure 5-2 Extract of PLA chart 316 Vessel Operating zones governed by draft



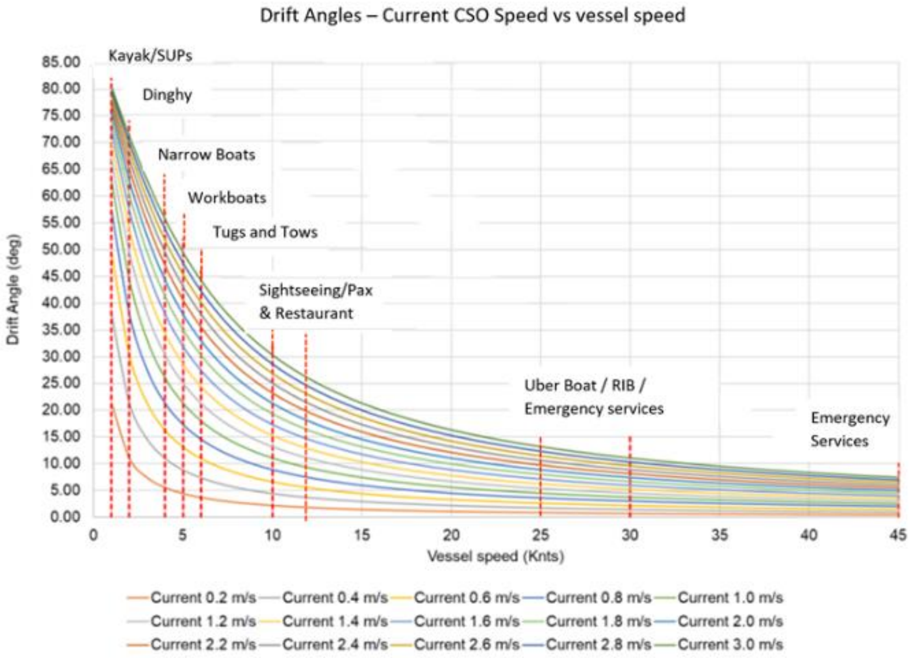
5.3.5 Figure 5-2 is an extract of PLA chart 316 Lambeth reach and highlights the passage of vessels transiting through the area. The dark blue arrowed line shows the closest running position for vessels transiting upstream and downstream through Arch 1 at low water. The light blue arrowed line shows a running line for some High-Speed Craft to pass through Arch 1 following a departure from the London Eye. The orange arrowed line presents the normal running position for reporting vessels transiting through Arch 2 of Charing Cross rail bridge. The Red arrowed line is the normal running position for a reporting vessel transiting either upstream or downstream.

5.3.6 Whilst considering the passage of a vessel past the CSO the hydrograph in figure 4-1, without the tunnel in operation, indicates that there are 35 minutes from the start of discharge before it reaches its 1:15 year peak discharge of 18m^3/s, whilst the hydrograph in figure 4-2, with the tunnel in operation, indicates that whilst there is a delay in the start of the discharge the duration to reach its peak discharge peak discharge is reduced to fifteen minutes.

5.3.7 The drift angle will be determined in relation to the lowest operating speed at the relevant distance from the CSO (Table 5-1) where the lowest speed will incur the highest magnitude impact.

5.3.8 The drift angles of the vessels are a function of the vessel speed while impacted by the VCTEF CSO discharge current speed without any course correction, this will be taken as the worst-case scenario. The results are presented below in Figure 5-2 noting that drift angles are related to the speed of vessel and not category of vessel.

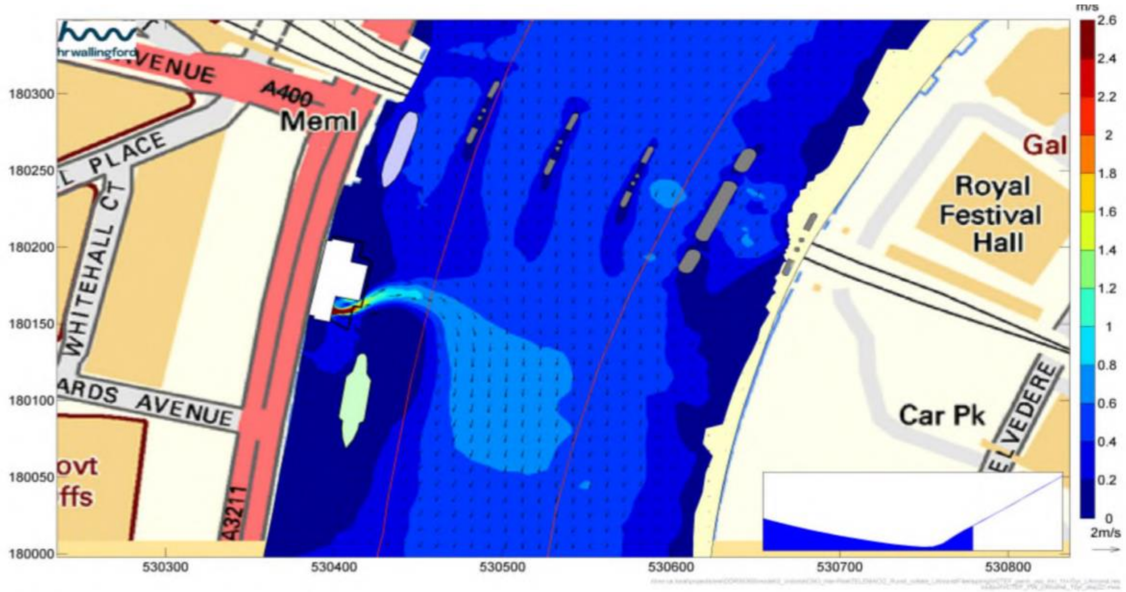
Figure 5-3 Drift angle – Current CSO vs vessel speed



5.3.9 This approach allows a direct evaluation of the CSO discharge as a potential hazard to the vessels passing the area.

5.3.10 Modelled flow velocities from VCTEF CSO outfall discharge during a 1:15-year event at 30 minutes after spring low water is shown in Figure 5-3.

Figure 5-4 Modelled flow velocities for a 1:15 year discharge at 30 minutes after low water springs.

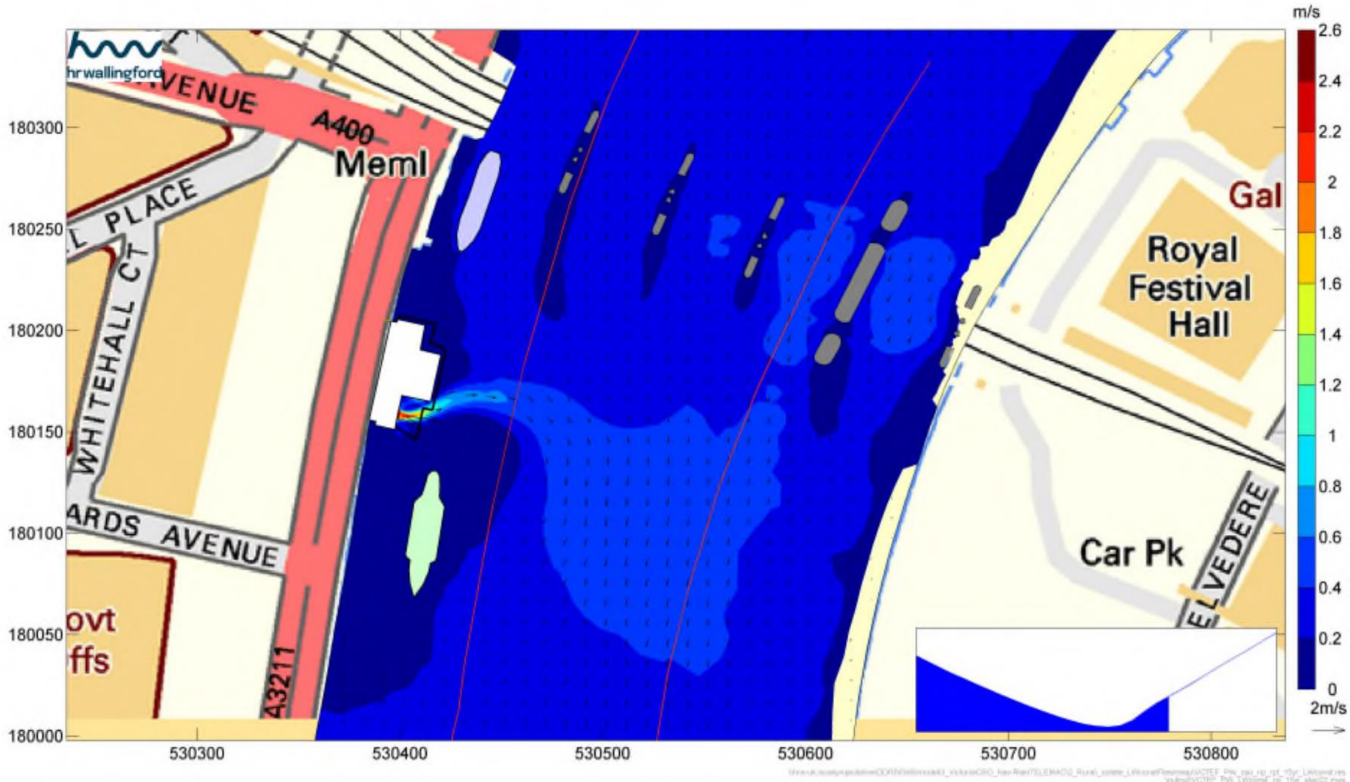


5.3.11 Figure 5-3 shows the CSO discharge velocity starting at approximately 2.6m/s from the outfall passing into the river over the scour apron. As it continues into the river its velocity reduces to approximately 2 m/s as it passes the end of the new structure and interfaces with the main river flow, which is starting to flood. The velocity deteriorates across the inshore zone at between 0.8 and 1.2m/s. This decreases to approximately 0.6-0.8m/s as it reaches the edge of the channel. The lateral flow enters the channel veers to align with the main flow, at approximately 30m into the main channel, with an average of 0.2 m/s increase over the background current.

5.3.12 For vessels transiting upstream or downstream through Arch-1 in the inshore zone the past the CSO outfall the discharge impact could be 0.8 to 1m/s. High-Speed Craft transiting downstream from the London Eye will be unaffected. Vessels transiting upstream and downstream in the normal running position through Arch-2 and 3 will be unaffected by a CSO discharge. Vessels transiting in the normal running position through Arch-4 will be unaffected by a CSO discharge.

5.3.13 Modelled flow velocities for a 1:15 year return period event discharge 20 minutes after low water neaps is shown in Figure 5-5. There is a significant reduction in the impact of lateral flow velocity on the main channel within this case.

Figure 5-5 Modelled flow velocities for a 1:15 return period event discharge twenty minutes after low water neaps.



5.3.14 Table 5-2 presents the assessed impact of a 1:15-year VCTEF CSO discharge on the different vessel types, using the drift angle curves when the vessels are operating within the inshore Zone using Arch 1 and reporting vessels in normal running position transiting upstream through Arch 2 past the CSO discharge.

5.3.15 The estimated speed over ground for vessels passing the CSO, as stated in the Table 5-2, is recorded as an estimate of the slowest probable speed whilst still maintaining steerage.

Table 5-2 Approximated drift angle when passing the CSO in the inshore zone and/or Main Fairway, during a 1:15-year CSO discharge at 30 minutes after MLWS and 20 minutes after MLWN

				30 minutes after MLWS		20 minutes after MLWN	
Vessel Type	Vessels Speed passing CSO. (SOG)	Minimum Vessels Draft (metres)	Water depth allowing for Under Keel Clearance (Add 0.5m)	Approximation of drift angle when passing the CSO - Inshore Zone	Approximation of drift angle when passing the CSO - Fairway (Arch 2)	Approximation of drift angle when passing the CSO - Inshore Zone	Approximation of drift angle when passing the CSO - Fairway (Arch 2)
Uber Boat (i.e., Hunt Class)	6 knots	1.2	1.7	17°	14°	14°	11°
RIB/Emergency Services	3 knots	0.5	1.0	32°	27°	27°	20°
Sightseeing/Pax	3 knots	1.5	2.0	32°	27°	27°	20°
Restaurant/Pax (i.e., Symphony)	3 knots	1.8	2.3	32°	27°	27°	20°
Tug vessel pushing	3 knots	3	3.5	32°	27°	27°	20°
Tug vessel towing	3 knots	3	3.5	32°	27°	27°	20°
Workboats	3 knots	0.5	1.0	32°	27°	27°	20°
Narrowboats/Motor cruisers	3 knots	1.0	1.5	32°	27°	27°	20°
Dinghy	1 knot	0.8	1.3	61°	56°	56°	48°
Kayak/Rower	1 knot	0.2	0.2	61°	56°	56°	48°

5.3.16 Table 5-2 has determined that there are impacts on all vessels transiting upstream and downstream in the inshore zone past the VCTEF CSO. Vessels would be similarly impacted by speed group although the non-powered vessels are the most significantly impacted.

5.4 Summary of impacted vessels and outcomes.

5.4.1 The summary of the 1:15-year CSO discharge impacts on the different vessel types for any state of tide is presented in Table 5-3 below.

Table 5-3 Impact of 1:15-year CSO discharge on vessels at different states of tide.

Vessel Type	Fairway / Inshore	Impact on vessel	
		Minimum achievable distance from CSO at MLWS	Minimum achievable distance from CSO at MLWN
Uber Boat	Fairway	Minimal impact	Minimal impact
	Inshore	Minimal impact	Minimal impact
RIB/Emergency services	Fairway	Min/Moderate impact Course and/or speed adjustment required	Minimal impact
	Inshore	Min/Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
Sightseeing/Pax	Fairway	Min/Moderate impact Course and/or speed adjustment required	Minimal impact
	Inshore	Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
Restaurant/Pax	Fairway	Min/Moderate impact Course and/or speed adjustment required	Minimal impact
	Inshore	Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
Tug vessel engaged in pushing/Towing	Fairway	Min/Moderate impact Course and/or speed adjustment required	Minimal impact
	Inshore	Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
Workboats	Fairway	Min/Moderate impact Course and/or speed adjustment required	Minimal impact
	Inshore	Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
Narrow boat/Motor cruisers	Fairway	Min/Moderate impact Course and/or speed adjustment required	Minimal impact
	Inshore	Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
Dinghy/Kayak/SUP//Rower	Fairway	High impact Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course.	High impact Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course.
	Inshore	High impact Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course.	High impact Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course.

5.4.2 The assessment of 1:15 year return period event impact indicates: -

- There is no impact on vessels transiting downstream towards Arch 3 and 4 in the fairway past the CSO when it is discharging at low water springs.
- There is moderate impact on most vessels transiting upstream/downstream in the inshore zone through Arch 1 past the CSO when it is discharging at low water springs except for the Uber boat which receives a minimal impact and a Kayak/Dinghy/SUP/Rower which will be highly impacted.
- There is minimal/moderate impact on most vessels transiting upstream through Arch 2 in the fairway past the CSO when it is discharging at low water springs except for the Uber boat which receives a minimal impact and a Kayak/Dinghy/SUP/Rower which will be highly impacted.

- There is minimal/moderate impact on most vessels transiting upstream/downstream in the inshore zone through Arch 1 past the discharging CSO at low water except for the Uber boat which receives a minimal impact and a Kayak/Dinghy/SUP/Rower which will be highly impacted.
- There is minimal impact on all vessels transiting upstream through Arch 2 in the fairway past the CSO at low water neaps when it is discharging except for a Kayak/Dinghy/SUP/Rower which will be highly impacted, but this is reduced when compared to low water springs.

6. Ship simulation comparison

6.1.1 As part of the works to identify the impact of a CSO discharge on the safe navigation of vessels passing the area Tideway engaged HR Wallingford to undertake a real time navigation simulation to assist in the assessment of this impacts.

6.1.2 The outputs of the simulations would be used to corroborate the desktop analysis undertaken in sections 4.3 and 4.4, which identify the period and zones of impact, and section 5 which used predicted drift angles as a function of the lateral flow velocities and the vessel velocities to determine the level of impact on passing vessels or indicate if additional considerations needed to be made.

6.1.3 The HR Wallingford ship simulation centre did not have a suitable model that would represent Class V vessels. It was proposed, and agreed by the mariners at both simulation sessions, that the impact of the CSO and the response of Narrowboats, Tug Pushing and clippers would be representative of the response of a Class V vessel.

6.1.4 Simulations for Victoria Embankment Foreshore were undertaken at the HR Wallingford Ship Simulation Centre on the 8th, 9th and 10th of November 2023 of November with representatives from HR Wallingford, Tideway, Waves, Port of London Authority and several river operators.

6.1.5 The full table of simulations are presented in Table 6-1 which include the comments on the run, which were agreed by the attendees following each simulation.

Table 6-1 Simulated cases for VCTEF

Run ID	CSO	Ship	Manoeuvre	Bridge arch	Tidal condition	Comments
19	VTCEF	28m tug pulling unladen 50m barge	Inbound at 6 knots	No. 2	Low water slack	Vessel appeared unaffected by flow.
20	VTCEF	Clipper	Inbound at 6 knots	No. 1	20 minutes after low water slack	Vessel appeared unaffected by flow.
21	VTCEF	kayak	Along outfall face at 3 knots	None	20 minutes after low water slack	No impact at 50m from outflow. Vessel reacted to outflow but was similarly influenced by the eddy that is also present at this stage of the tide.
22	VTCEF	Clipper	Outbound at 6 knots	No. 1	20 minutes after low water slack	Vessel appeared unaffected by flow. No action taken to correct course.
23	VTCEF	kayak	At outfall face	None	40 minutes after low water slack	Noticeable effect from the outflow on the kayak.
24	VTCEF	Clipper	Outbound at 3 knots	No. 1	40 minutes after low water slack	Noticeable effect from the outflow on the kayak.
25	VTCEF	Clipper	Outbound at 6 knots	No. 1	40 minutes after low water slack	Moderate effect from current. Less time to react going the no.1 arch. Corrections were to maintain a track were successful.

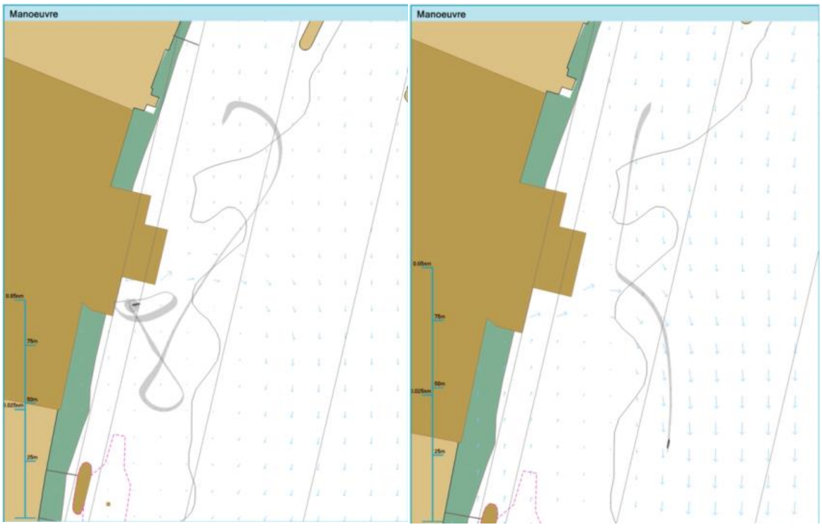
6.1.6 During the simulations the vessels were operated by a master who established the course and speed of the vessel to align with the case. Once the simulation started the master made the necessary corrections to allow the vessel to maintain course and then feedback to the group

6.1.7 The track of each simulated run was recorded so that it could be reviewed. Run 19 is of a tug towing a barge upstream at 6 knots using arch 2 at low water slacks. The tug passed the site approximately 30m from the outfall and was unaffected.

Figure 6-1 Record of run 19

6.1.8 Figure 6-2 shows the recorded track for runs 21 and 23. Run 21 is of a Kayak transiting upstream at 20 minutes after low water. The kayak passes the face of the new structure at approximately 25 metres from the CSO and there was minimal impact. The kayak then transited closer to the outfall to investigate the impact, which was also minimal, but this can't be considered fully conclusive due to the lack of certainty of the flows within 20-30m of the discharge. Run 23 is of a Kayak transiting upstream at 40 minutes after low water and there was a noticeable deviation of the course by approximately 30m which would put the kayak at the edge of the main fairway.

Figure 6-2 Record of runs 21 and 23

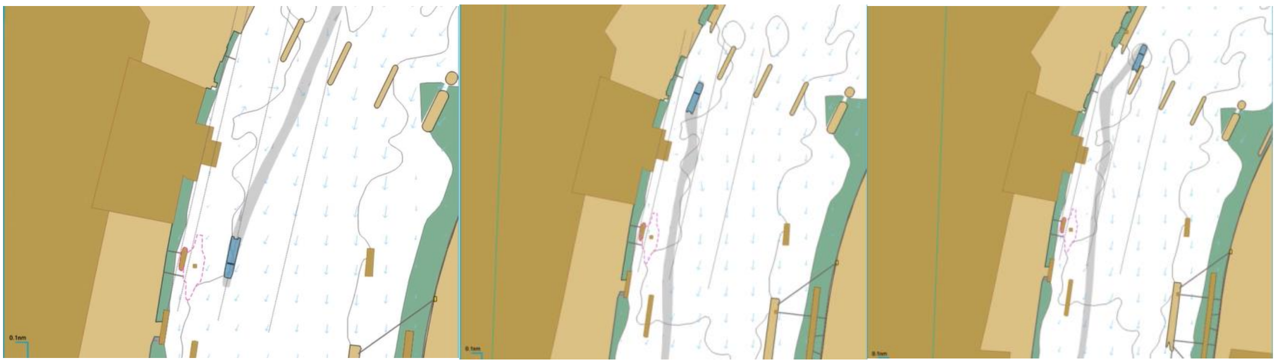


6.1.9 Figure 6-3 shows the recorded track for runs 20, 24 and 25 Run 20 is a clipper transiting upstream through Arch 2 at low water slack and passing approximately 25 metres from the outfall, the clipper was unaffected by the discharge.

6.1.10 Run 24 is a clipper transiting downstream at 3 knots passing within 25 metres of the outfall towards Arch 1 at 40 minutes after low water slacks. Whilst there is a slight impact on the vessel the corrections could be made to allow the vessel to complete its transit.

6.1.11 Run 25 is a clipper transiting downstream at 6 knots passing within 25 metres of the outfall towards Arch 1 at 40 minutes after low water slacks. Whilst there is a slight impact on the vessel and corrections could be made to allow the vessel to complete its transit there was less time to respond.

Figure 6-3 Record of runs 20, 24 and 25



6.1.12 Following the completion of the ship simulations past the VCTEF CSO outfall the impacts on the vessels was considered against the desk top assessment presented in Table 5.3. The summary of these changes are presented in Table 6-2. The key changes are related to reductions in impacts on vessels within the main fairway where all vessels, except for the unpowered vessels, are reduced to minimal impact, whereas the unpowered vessels are reduced from high impact to minimal/moderate impacts.

Table 6-2 Record of changes of impact on vessels

Vessel Type	Fairway / Inshore	Impact on vessel	
		Minimum achievable distance from CSO at MLWS	Minimum achievable distance from CSO at MLWN
Uber Boat	Fairway	No change	
	Inshore		
RIB/Emergency services	Fairway	Minimal impact	No change
	Inshore	No change	
Sightseeing/Pax	Fairway	Minimal impact	No change
	Inshore	No change	
Restaurant/Pax	Fairway	Minimal impact	No change
	Inshore	No change	
Tug vessel engaged in pushing/Towing	Fairway	Minimal impact	No change
	Inshore	No change	
Workboats	Fairway	Minimal impact	No change
	Inshore	No change	
Narrow boat/Motor cruisers	Fairway	Minimal impact	No change
	Inshore	No change	
Dinghy/Kayak/SUP//Rower	Fairway	Min/Moderate impact Course and/or speed adjustment required	Min/Moderate impact Course and/or speed adjustment required
	Inshore	No change	

7. Risk Assessment

7.1 Risk Assessment

7.1.1 The Risk Assessment is undertaken using the Jacobs design hazard elimination and risk reduction register and can be found in Appendix A.

7.1.2 The following sections of this document present the risk associated with the hazard linked to a VCTEF CSO discharge impacting on vessels operating on the Thames.

7.1.3 The risk assessment has been undertaken to eliminate or reduce risk to vessels on the Thames and provide mitigations for the risk so far as reasonably practicable by assessing the design and operation risks for the permanent state of the VCTEF CSO discharge.

7.1.4 The residual design / operational risks identified in this will be used to inform an NRA. The NRA will be produced by navigational experts for consideration by the PLA and any further mitigations established if required.

7.2 Hazards

7.2.1 The Risk Assessment considers the impact of the flows from the VCTEF CSO discharge to Vessels on the river with consideration to the change in drift angle incurred by contact with the flow. The hazards associated with the impact are:

i) Capsizing

ii) Collision with vessels.

iii) Contact with new realm

7.3 Receptors

7.3.1 Table 5.4 lists the vessels that could be subject to potential impacts of a VCTEF CSO discharge flow.

7.3.2 Figure 5-2 presents the normal passage through Arches 1, 2, 3 and 4 for reporting vessels at low water. It also includes the agreed passage for High-Speed Craft crossing from London Eye to Arch 1.

7.3.3 All vessels able to navigate in the inshore zone past the CSO outfall have been assessed to be operating through Arch 1.

7.4 Severity of Harm

7.4.1 Jacobs rate the hazard on worst potential severity:

i) 1: Nil or slight injury / illness, property damage or environmental issue.

ii) 2: Minor injury / illness, property damage or environmental issue.

iii) 3: Moderate injury or illness, property damage or environmental issue.

iv) 4: Major injury or illness, property damage or environmental issue.

v) 5: Fatal or long-term disabling injury or illness. Significant property damage or environmental issue.

vi) 10. Multiple fatalities and catastrophic event

7.4.2 The hazard identified above has potential to cause harm to the vessel users:

i) Capsizing leading to a major injury or drowning.

ii) Collision with another vessel due to a CSO discharge event forcing non-powered vessel to drift from previous course leading to major injury or drowning.

iii) Collision between third party vessels caused by one of the vessels changing course to avoid collision with a non-powered vessel leading to major injury or drowning.

iv) Contact with the public realm causing capsize.

7.5 Likelihood of Harm

7.5.1 Jacobs risk assessment rates the likelihood of harm with the following probabilities:

1: Highly Unlikely
2: Unlikely
3: Possible
4: Likely
5: Highly Likely

7.5.2 The assessment has been undertaken by analysing the data presented in documents HR Wallingford document 4410-FLOJV-VCTEF-520-VZ-RG-100001_P05 CSO Discharge modelling for permanent works Victoria Embankment Foreshore, the interim DRA 665397CH-VCTEF-DRA-Interim-REV.02 and the updated rainfall information produced by Tideway. The Interim risk assessment established the 18m^3/sec to be the most probable worst-case scenario.

7.5.3 From analysis of the peak flow velocity plumes, it has been determined that the tidal window of impacts is 30 minutes, approximately 25 minutes after low water to 55 minutes after low water.

7.5.4 The tidal window is considered conservative because of the very brief period of approximately 30 minutes of instantaneous peak flow that is shown in the hydrograph for a 1:15-year event in Figure 4-1. The coincidence of the instantaneous peak flow and the minimal 10-minute period of still water, or indeed a period without dominant tidal flow from the VCTEF CSO discharge are extremely low for the worst-case scenario.

7.5.5 Modelled annual frequency of discharge has been established as an average of 36.5 discharges per year, with a maximum of 47 discharges in a year which could impact river users. However, when the tunnel is operational it is predicted that all discharges will be intercepted.

7.5.6 From Figure 4-3 Simulated peak flows from new VCTEF CSO outfall using actual weather data from 1970-2020 against the WI 7706 return periods (assuming tunnel unavailable)**.**, there are only approximately 23 instances in a 50 year period that are greater than a typical year the 1:5 year only being exceeded 3 times.

7.5.7 The analysis was undertaken for spring periods of low water but due to the variability of tides from residual effects the risk assessment will consider impacts to vessels at all states of low water.

7.5.8 Taking all the above-mentioned factors into consideration then the likelihood of harm is considered unlikely for vessels using the main fairway and the inshore channel at low water springs and neaps during a 1:15 year return period CSO discharge.

8. Mitigation

8.1.1 The ERIC, the hierarchy of risk management, approach will be adopted to review mitigation for this DRA.

- ERIC stands for Eliminate, Reduce, Inform and Control.
- This is a four -level hierarchy that outlines the steps it should take to mitigate risk.

8.2 Eliminate

8.2.1 The VCTEF CSO outfall is needed to allow sewers to discharge when they reach capacity and prevent the risk of flooding upstream in the catchment area. To eliminate the flows entirely would require the closing of the CSO outfall and would flood the upstream catchment area during storm events and is therefore not feasible.

8.2.2 Consideration was made to eliminate the risk to non-powered vessels by diverting them to the south bank to pass the CSO area and recross to the north bank once past the CSO area. This was discounted due to the level of congestion in the area which would likely increase the risk significantly to the unpowered vessels.

8.3 Reduce

8.3.1 The number of discharges will be reduced by bringing the main tideway tunnel into operation which will reduce the number of discharges from the average of 36.5 down to 0 discharges anticipated in a typical year.

8.3.2 To reduce the risk of impact to vessels a warning system could be adopted for the permanent works in line with the proof of concept which is being developed in consultation with the PLA and main works contractors.

8.3.3 The vessels could be warned of a pending discharge or a current discharge with the use of lights and signs. The lights and signs would need to be strategically placed to ensure the optimum sight by the river vessel users.

8.4 Inform

8.4.1 PLA to issue new notice to mariners identifying VCTEF CSO operation and associated warning system.

8.4.2 PLA to update navigational support documents such as the Tideway Code, Port information guide and any other pertinent documents.

8.4.3 PLA to consider the use of a VTS broadcast when a CSO starts discharging.

8.4.4 Warning lights and signs could be used to inform river users when the CSO is discharging.

8.5 Control

8.5.1 All agreed CSO signage and warning lights to be installed and commissioned in agreement with the PLA.

8.5.2 An operation plan for the of the warning system will need to be considered and agreed with the PLA.

9. Summary

9.1 Summary

9.1.1 Jacobs as Designer for the reference design have a duty to eliminate and reduce risks so far as reasonably practicable (SFARP) and to identify residual risks. Jacobs have undertaken this risk assessment to assess the magnitude of this risk for each vessel type and to consider whether mitigation measures can be adopted that can reduce the risks to an acceptable low level.

9.1.2 Overall, the residual risk has been determined as low due to: -

(a) Minimum impact of CSO discharges on powered vessels in the main fairway,

(b) Limited number of vessels that transit in the inshore zone past the CSO,

(c) Zero predicted discharges

(d) Very short tidal window that could impact vessels

(e) The introduction of a warning light and sign to advise powered vessels that the CSO is discharging and to proceed with caution.

(f) The introduction of a warning light and sign to advise non powered vessels that the CSO is discharging and to proceed with caution.

Powered Vessels

9.1.3 Jacobs has assessed it sufficient to provide signage and lighting to warn river users that the CSO is a discharging.

9.1.4 In the case of powered vessels, the risk is considered negligible (very low) as all powered vessels can pass within the main fairway during a discharge, provided that they proceed with caution.

Unpowered Vessels

9.1.5 Jacobs has assessed it sufficient to provide signage and lighting to warn river users that the CSO is a discharging.

9.1.6 In the case of manually operated or unpowered vessels the risk is considered low.

Operational Plan

9.1.7 The operational plan will be developed by Tideway and the Main Works Contractor, FLO, in consultation with the Port of London Authority, to define the communication and warning systems that will be in place to for a CSO discharge.

9.1.8 The plan will clarify what the warning system consists of, how the warning of a discharge will be raised and verified, how the warning system will be activated and how the end of a discharge will be verified and communicated.

Navigational Risk Assessment

9.1.9 A Navigational Risk Assessment (NRA) is to be undertaken by navigational specialists with expert knowledge of waterway traffic and the conditions in the area of the VCTEF CSO outfall.

9.1.10 This designers risk assessment will be considered by the MWC in addition to the navigation risk assessment as part of the iterative process to develop the detailed design and Operational Plan. The navigational risk specialists will need to consider both the DRA and the Operational Plan to produce the Navigational Risk Assessment.

9.1.11 The MWC should consider the following in the development of the detailed design and the operational plan.

- The recommendation of the NRA,
- the optimal "on" time for the live warning signal(s), taking account of the discharge hydrograph and the actions to be taken by powered vessels and unpowered vessels or a member of the public on the foreshore nearby,
- Consideration of operational mitigations (e.g. lights and signs) in consultation with the PLA.
- Consider the operational plan that will include the manner of promulgation of information and communication with the river community, including what is required of Tideway, the PLA and the river users,

9.1.12 The NRA will consider the residual risks from the DRA, the detailed design and the Operational Plan to determine the most appropriate mitigation in consultation with the PLA and other river users. In particular the NRA should consider:-

- the necessary responses of powered vessels to a discharge (e.g., adjust course as require, proceed with caution and look out for unpowered vessels affected by a discharge) and the time needed to action the responses,
- the necessary responses of unpowered vessels to a discharge (e.g. exit the river at a fixed egress point, etc.) and the time needed to action the responses,
- the assessment of any increased risk to normal river operations arising from the implementation of mitigations.

9.1.13 In the development of the NRA the timings of the mitigation implementation should also be considered and detailed for agreement with the PLA.

9.1.14 The updated NRA with its proposed mitigations will be reviewed by the MWC to confirm that the design risks have been mitigated insofar as is reasonably practicable for the permanent works.

9.1.15 It should be noted that during the interim phase the NRA adopted the warning system of a light that was proposed by the interim DRA.

9.2 Key information

9.2.1 The most credible worst case CSO discharge is for a 1:15 year return period storm without the tunnel in operation with a discharge of 18m^3/s. The frequency of discharges once the tunnel in in operation is expected to be 0 in a typical year when the tunnel is in operation. When the tunnel is to be taken out of operation additional information will need to be made available to stakeholders outlining the potential for increased frequency of discharges.

9.2.2 The assessment considers the river in three zones as defined in figure 7-1, and the critical discharge occurring at low water springs. The discharges are considered to impact within the following tidal windows and are presented in Table 9-1.

Table 9-1 Times of Impact

Inshore Zone (beyond 30m)		Main Fairway	
Start	Finish	Start	Finish
LW + 15 minutes	LW +55 minutes	LW + 15 minutes	LW +45 minutes

9.2.3 It is noted that it was not possible model the discharge within 30m of the CSO and possible impacts should be considered at any state of the tide within that zone.

9.2.4 It is noted that during any slack periods such as the closure of the Thames barrier that the same consideration should be given to the discharge as if it were at LW slack.

9.2.5 This document provides information on the timing and intensity of the discharges and the hydrographs are presented in Figures 4.1 and 4.2. The proof of concept document (LONDON TIDEWAY TUNNELS PROOF OF CONCEPT - CSO DISCHARGE WARNING DRAFT 27/02/24) provides further detailed discharge hydrographs that should be utilised in the development of suitable warning times in the development of the detailed design undertaken by the MWC.

9.2.6 Any unmitigated risks arising from the detail design development, such as insufficient warning time, should be identified in the MWCs design documentation and potential mitigation measures identified for consideration by the PLA.

9.2.7 A warning a system, such as lights and signs has been established as a mitigation measure suitable to reduce the risk to vessels during the development of the NRA and the operational plan the MWC should assess the suitability of the mitigation measures and substantiate their proposals within the detailed design documentation.

Appendix A. Designers Risk Assessment

Jacobs

DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

Latest Meeting Date	
Phase	
C	Construction
M	Maintain/Clean
U	Use as a Workplace
D	Demolish
Project Name:	Tideway
Project Number:	665397CH
Client:	Bazalgette Tunnel Limited

Update Critical Risk Summary Tab

Probability

1: Highly Unlikely
2: Unlikely
3: Possible
4: Likely
5: Highly Likely

Worst Potential Severity (WPS) of Impact

1: Nil or slight injury / illness, property damage or environmental issue.
2: Minor injury / illness, property damage or environmental issue.
3: Moderate injury or illness, property damage or environmental issue.
4: Major injury or illness, property damage or environmental issue.
5: Fatal or long term disabling injury or illness. Significant property damage or environmental issue.

Risk Rating

NOTE: The purpose of Risk Rating is to determine which risks are significant. It is a subjective assessment and not an absolute or precise determination

High	HSEID risk resulting from design is unacceptably high. Revise design to reduce
Medium	HSEID risk resulting from design is permitted with appropriate design controls and management oversight in
Low	HSEID risk resulting from design is permitted.

LIKELIHOOD	RISK				
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
	1	2	3	4	5
	SEVERITY				

1 Risk ID.	2 Formal Review Description	3 Phase	4 Activity	5 Potential Hazard	6 Person(s) Most at Risk	7 Prob	8 WPS	9 Initial Risk Rating	10 Discipline	11 Design Measures to Eliminate Hazards	12 Design Measures to Reduce Risk	13 Residual Prob	14 Residual WPS	15 Residual Risk Rating	16 Residual Risk Description	17 Included on Drawing No(s) or other doc. (give ref.)
CDM-VCTEF-024-A	Non-powered craft underway - Low tide	Permanent	Kayak/Rower/Dinghy/SUP navigating in the inshore zone in the vicinity of a CSO discharge	Capsizing due to CSO discharge event	Public: Major injury and/or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Major injury and/or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-B	Non-powered craft underway - Low tide	Permanent	Kayak/Rower/Dinghy/SUP navigating in the inshore zone in the vicinity of a CSO discharge	Contact with new realm due to a CSO discharge event	Public:Major Injury and/or drowning	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	4	4	Public:Major Injury and/or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-C	Non-powered and Rec. powered vessel underway - Low Tide	Permanent	Kayak/Rower/Dinghy/SUP and recreational powered vessel navigating in the inshore zone in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-D	Non-powered and Commercial powered vessel underway - Low tide	Permanent	Kayak/Rower/Dinghy/SUP navigating in the inshore zone and a commercial powered vessel navigating in the main fairway in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-E	Rec. Powered Vessel underway - Low tide	Permanent	Rec. Powered Vessel navigating in the inshore zone in the vicinity of a CSO discharge	Capsizing due to CSO discharge event	Public: Major injury and or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Major injury and/or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-F	Rec. Powered Vessel underway - Low tide	Permanent	Rec. Powered Vessel navigating in the inshore zone in the vicinity of a CSO discharge	Contact with new realm due to a CSO discharge event	Public: Injury	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	3	3	Public: Injury	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-G	Rec. Powered Vessel and Commercial Powered Vessel underway - Low tide	Permanent	Rec. Powered Vessel navigating in the inshore zone and a commercial powered vessel navigating in main fairway in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing Rec.Powered vessel to drift from its previous course	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	4	4	Public: Major injury	MWC's WPP, Notice to Mariners

Jacobs

DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

Latest Meeting Date

Update Critical Risk Summary Tab

Phase	
C	Construction
M	Maintain/Clean
U	Use as a Workplace
D	Demolish

Project Name:	Tideway
Project Number:	665397CH
Client:	Bazalgette Tunnel Limited

Probability

1: Highly Unlikely
2: Unlikely
3: Possible
4: Likely
5: Highly Likely

Worst Potential Severity (WPS) of Impact

1: Nil or slight injury / illness, property damage or environmental issue.
2: Minor injury / illness, property damage or environmental issue.
3: Moderate injury or illness, property damage or environmental issue.
4: Major injury or illness, property damage or environmental issue.
5: Fatal or long term disabling injury or illness. Significant property damage or environmental issue.

Risk Rating

NOTE: The purpose of Risk Rating is to determine which risks are significant. It is a subjective assessment and not an absolute or precise determination

High	HSEID risk resulting from design is unacceptably high. Revise design to reduce
Medium	HSEID risk resulting from design is permitted with appropriate design controls and management oversight in
Low	HSEID risk resulting from design is permitted.

LIKELIHOOD	RISK				
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
	1	2	3	4	5
	SEVERITY				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Risk ID.	**Formal Review Description**	**Phase**	**Activity**	**Potential Hazard**	**Person(s) Most at Risk**	**Prob**	**WPS**	**Initial Risk Rating**	**Discipline**	**Design Measures to Eliminate Hazards**	**Design Measures to Reduce Risk**	**Residual Prob**	**Residual WPS**	**Residual Risk Rating**	**Residual Risk Description**	**Included on Drawing No(s) or other doc. (give ref.)**
CDM-VCTEF-024-H	Commercial Powered Vessel underway - Low tide	Permanent	Commercial powered vessel navigating in the inshore zone inbound in the vicinity of a CSO discharge	Contact with new realm due to a CSO discharge event	Public: Injury Property damage, Disruption	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	3	3	Public: Injury Property damage, Disruption	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-I	Non-powered craft underway - All other states of tide	Permanent	Kayak/Rower/Dinghy/SUP navigating in the inshore zone in the vicinity of a CSO discharge	Capsizing due to CSO discharge event	Public: Illness due to exposure to sewage or Drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Illness due to exposure to sewage or Drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-J	Non-powered craft underway - All other states of tide	Permanent	Kayak/Rower/Dinghy/SUP navigating in the inshore zone in the vicinity of a CSO discharge	Contact with new realm due to a CSO discharge event	Public: Illness due to exposure to sewage or Drowning	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	3	3	Public: Illness due to exposure to sewage or Drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-K	Non-powered and Rec. powered vessel underway - All other states of tide	Permanent	Kayak/Rower/Dinghy/SUP and recreational powered vessel navigating in the inshore zone in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-L	Non-powered and Commercial powered vessel underway - All other states of tide	Permanent	Kayak/Rower/Dinghy/sup navigating in the inshore zone and commercial powered vessel navigating in the main fairway in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners
CDM-VCTEF-024-M	Rec. Powered Vessel and Commercial Powered Vessel underway - All other states of tide	Permanent	Rec. Powered Vessel navigating in the inshore zone in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing Rec.Powered vessel to drift from its previous course	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	4	4	Public: Major injury	MWC's WPP, Notice to Mariners

Jacobs

DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

Latest Meeting Date	
Phase	
C	Construction
M	Maintain/Clean
U	Use as a Workplace
D	Demolish
Project Name:	Tideway
Project Number:	665397CH
Client:	Bazalgette Tunnel Limited

Update Critical Risk Summary Tab

Probability	Worst Potential Severity (WPS) of Impact
1: Highly Unlikely	1: Nil or slight injury / illness, property damage or environmental issue.
2: Unlikely	2: Minor injury / illness, property damage or environmental issue.
3: Possible	3: Moderate injury or illness, property damage or environmental issue.
4: Likely	4: Major injury or illness, property damage or environmental issue.
5: Highly Likely	5: Fatal or long term disabling injury or illness. Significant property damage or environmental issue.

Risk Rating

NOTE: The purpose of Risk Rating is to determine which risks are significant. It is a subjective assessment and not an absolute or precise determination

High	HSEID risk resulting from design is unacceptably high. Revise design to reduce
Medium	HSEID risk resulting from design is permitted with appropriate design controls and management oversight in
Low	HSEID risk resulting from design is permitted.

LIKELIHOOD	RISK				
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
	1	2	3	4	5
	SEVERITY				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Risk ID.	Formal Review Description	Phase	Activity	Potential Hazard	Person(s) Most at Risk	Prob	WPS	Initial Risk Rating	Discipline	Design Measures to Eliminate Hazards	Design Measures to Reduce Risk	Residual Prob	Residual WPS	Residual Risk Rating	Residual Risk Description	Included on Drawing No(s) or other doc. (give ref.)
CDM-VCTEF-024-N	Powered Emergency Vessels underway - All other states of tide	Permanent	Powered Emergency Vessels responding to an emergency in close proximity of a CSO discharge	Contact with new realm due to CSO discharge event	Public: Injury Property damage, Disruption	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light	1	3	3	Public: Injury Property damage, Disruption	MWC's WPP, Notice to Mariners