CSO Discharge Designers Risk Assessment Permanent Case - King Edward Memorial Park Foreshore

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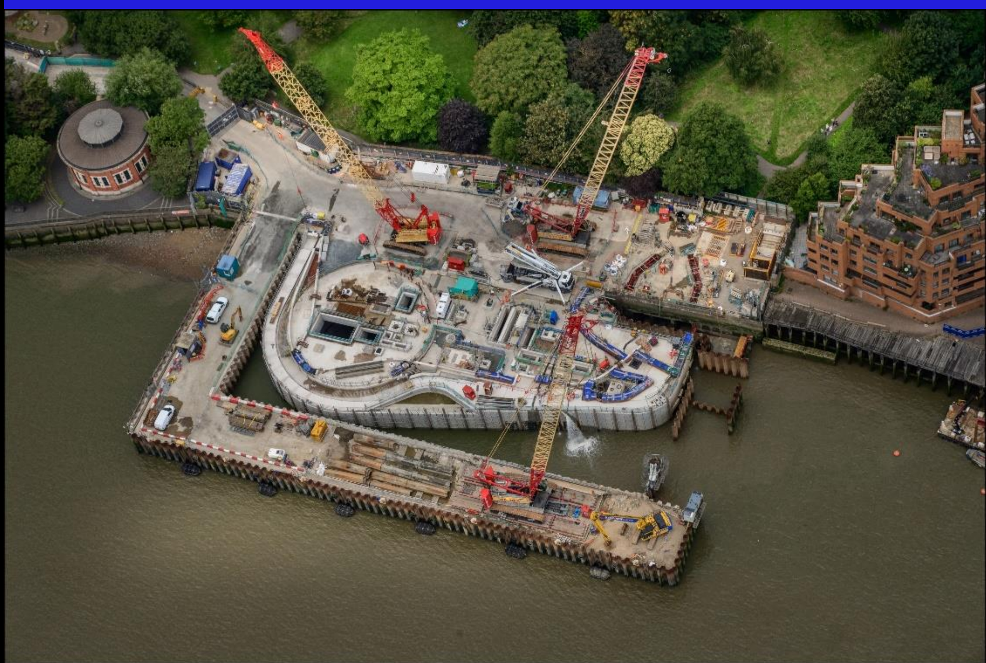
Bazalgette Tunnel Limited

Tideway
9 October 2024



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Document history and status

Revision	Date	Description	Revised by
0	22/03/24	Draft issue to PLA and Waves	JS/PH/PR/RG
1	19/06/2024	Minor revision to reflect change of contents of NRA/Ops Plan	JS/PR
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Required Approvals

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Reviewed by	Ed Davies	CDM Advisor (Ports and Maritime)	ED	30/09/2024
Reviewed by	Simon Fricker	Head of Design Authority	SF	30/09/2024
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Executive summary

1.1 This designers risk assessment has been produced to assess the hazards of swamping, capsizing, grounding and collision created by the NESR CSO discharge flows to vessels on the Thames at the King Edward Memorial Park Foreshore (KEMPF) site.

1.2 It has been undertaken for a permanent case when the new CSO is in operation and the flows can be intercepted by the tunnel.

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 of changing the vessels course and the consequential harm that could be caused with a further check to vessel simulations.

1.4 A worst-case scenario discharge rate of a 1 in 15-year event at 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 overall risk is low. The residual risk to powered vessels is considered to be very low should the mitigations of a warning system of lights and signage be adopted and, where necessary, avoid the limits of the discharge, approximately130m south of the CSO, in the navigation channel. The residual risk to un-powered vessels is considered to be very low if the mitigation of a warning system is adopted.

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

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

1.8 The main works contractor CVB 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.

1.9 To analyse the risk in greater detail for the permanent DRA, the following studies have been undertaken:

a. Simulations of the discharge flows on vessels to assess the actual impact caused by the drift angle have been completed.

b. Closed circuit television (CCTV) recording of actual vessel traffic have been completed and the report is currently being drafted.

1.10 The permanent mitigations are currently being planned and produced by Tideway in conjunction the Main Works Contractor CVB and will be issued for agreement to the PLA and the operational suitability confirmed in line with Tideway's "Technical Memorandum on CSO warning performance specification and strategy".

1.11 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.

1.12 The permanent navigational risk assessment undertaken by the Main Works Contractor CVB 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.

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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
CVB	Costain Vinci Bachy-Soletanche
DRA	Designers Risk Assessment
EDM	Discharge Monitor
ERIC	Eliminate, Reduce, Inform and Control
GPS	Global Positioning System
HAT	Highest Astronomical tide
ICM	Integrated Catchment Model
KEMPF	King Edward Memorial Park Foreshore
LAT	Lowest Astronomical Tide
LRT	Lowest Recorded Tide
LTT	London Tideway Tunnel
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
NESRS	North East Storm Relief Sewer
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
VTS	Vessel Traffic Service

2. Introduction

2.1 Introduction

2.1.1 As part of the Thames Tideway Tunnel project a new foreshore structure to intercept the North East Storm Relief Sewer (NESR) has been constructed at King Edward Memorial Park (KEMPF).

2.1.2 At the KEMPF site the new combined sewer overflow (CSO) outfall has been relocated from its original location, at the river wall, to discharge from the new permanent structure.

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 As part of Designers Risk Assessment PTH1X/KEMPF/KEM the impact of the CSO outfall was considered under risk reference CDM-KEMPF-020, as presented below in Table 2-1.

Table 2-1 Extract from Designers Risk Assessment PTH1X/KEMPF/KEM

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-KEMPF-020	CSO Discharge	Operation and Maintenance	Discharge from overflow.	Public on the foreshore/ vessels on the river.	Public: falls, contact with sewage.	4	2	Medium	Unable to eliminate hazard.	Unable to reduce by design of permanent works. Warning signs to inform the public of the hazard. Standard/ specification to be agreed with PLA and included within navigational risk assessment.	4	1	Medium	Public: falls, contact with sewage, drowning.	The need for continued maintenance of the sign should be added to the Health and Safety File.

2.1.7 Whilst CDM-KEMPF-20 recognises that there is a risk to vessels in the river it doesn't identify that the impact on vessels vary or that mitigations are required.

2.1.8 To ensure that all the relevant risks and mitigations are covered through a Designers Risk Assessment this document will be an addendum which will consider a detailed risk assessment of the NESR CSO discharges impacting the 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 This DRA makes the assessment based on the information that has been produced by the contractor:-

- King Edward Memorial Park Foreshore CSO discharge assessment,
- CCTV river traffic survey:
- and the updated rainfall information produced by Tideway.

2.1.11 In addition, it will include 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.

2.1.12 To support the development of this DRA vessel passages past the new KEMPF CSO outfall were simulated at the HR Wallingford Ship simulator.

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

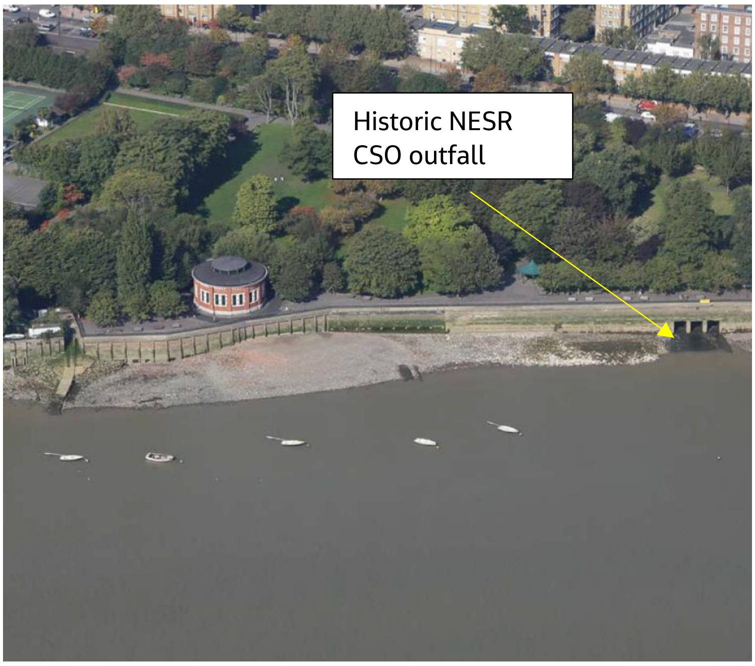
g. Section 9 – Summary

2.3 The site and CSO discharge location

2.3.1 The KEMPF site is located on the eastern edge of King Edward Memorial Park to allow for the construction of the new foreshore realm which will house the new infrastructure that will enable the interception of the CSO flows from the NESR sewer down into the main tunnel.

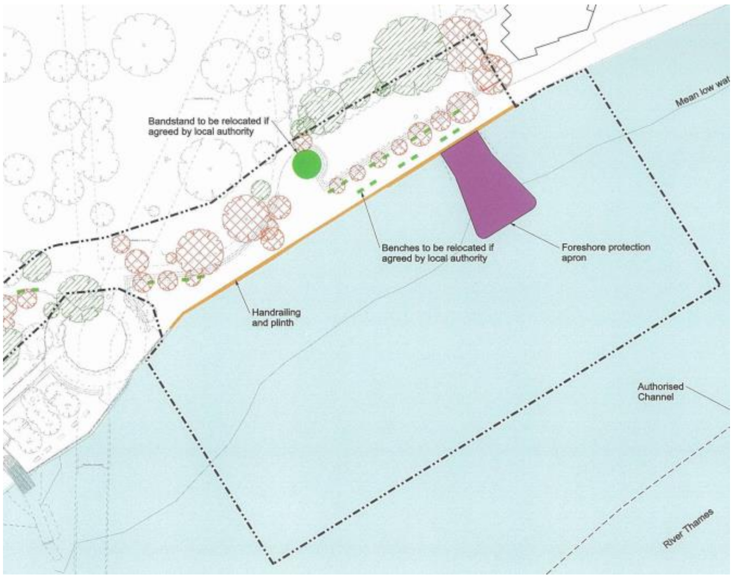
2.3.2 Prior to the construction of the site the NESR CSO outfall was at the eastern end of the park to discharge the flow into the river. Figure 2-2 presents the image of King Edward Memorial Park with the NESR CSO outfall visible on the right-hand side and the SHAD basin moorings located slightly upstream.

Figure 2-1 King Edward Memorial Park Pre-Tideway.



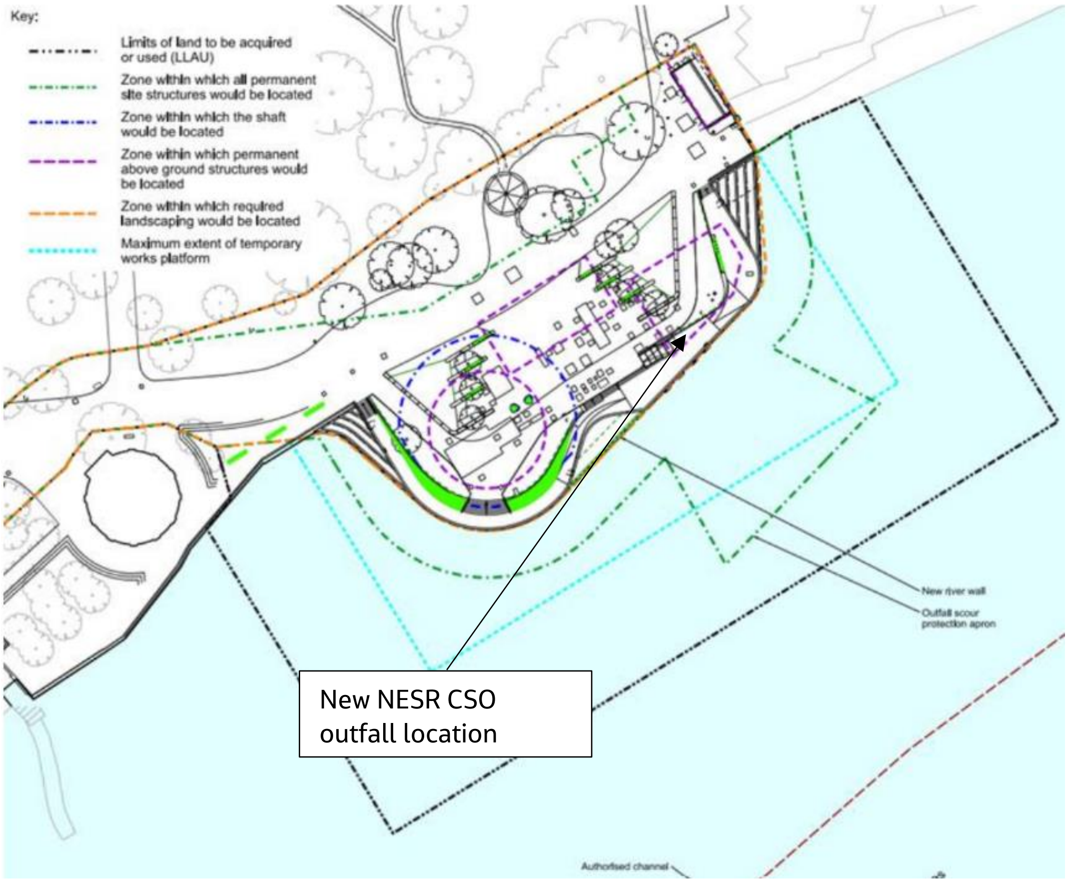
2.3.3 Figure 2-3 presents the historical outfall point with its scour apron. In the figure the historic scour apron is shaded in purple.

Figure 2-2 Extract of DCO-PP-2AX-KEMPF-250004 showing the NESR discharge point.



2.3.4 The new foreshore structure projects into the river and moves the NESR CSO outfall approximately 16m upstream and 28m further into the river. Figure 2-4 presents the permanent works arrangement with the new outfall location and scour apron.

Figure 2-3 Permanent works arrangement.



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

2.3.6 The original NESR CSO outfall discharged through two flap valves before passing through the river wall via three openings whereas the new NESR CSO outfall will discharge through 2 rows of 4 flap valves directly onto the scour apron and are approximately 1.8 times larger than the original NESR 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 "King Edward Memorial Park Foreshore CSO discharge assessment"

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

i) Confirm areas of the river

ii) Confirming vessels that use the river in this area

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

iv) Summarise impacted vessels on the river

v) Analyse vessel tracks from the ship simulation runs past NESR CSO discharges

3.1.3 Risk assessment

i) Hazards

ii) Receptors – incorporating the CCTV river traffic survey data outputs.

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 was run with free discharge (i.e., low tide) as a worst-case scenario and the discharge rates included in the projects works information (WI 7706). These WI flows are shown in Table 4-1.

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

4.1.9 In 2016 it was established that a weir board was present in the NESR Sewer (NESRS) which had not been included in the InfoWorks network model. This had the effect of diverting some flows into the Northern Low-Level Sewer No 2 and away from the NESR CSO. The result was a reduction in predicted peak CSO discharge rates, also shown in Table 4-1.

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

Source		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)	9.2	17.6	19.5	25.3	26.7	27.9	29.3
Latest DA Model	Rolling Hourly Average Low water (m^3/Sec)	4.7	14.5	16.5	21.9	24.8	25.6	26.9
Latest DA Model	Instantaneous Peak High water (m^3/Sec)	5.5	15.3	20.4	21.5	22.8	24.0	25.5
WI 7706	Instantaneous Peak Flow	19.3	25.2	29.1	30.0	33.0	-	-

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.

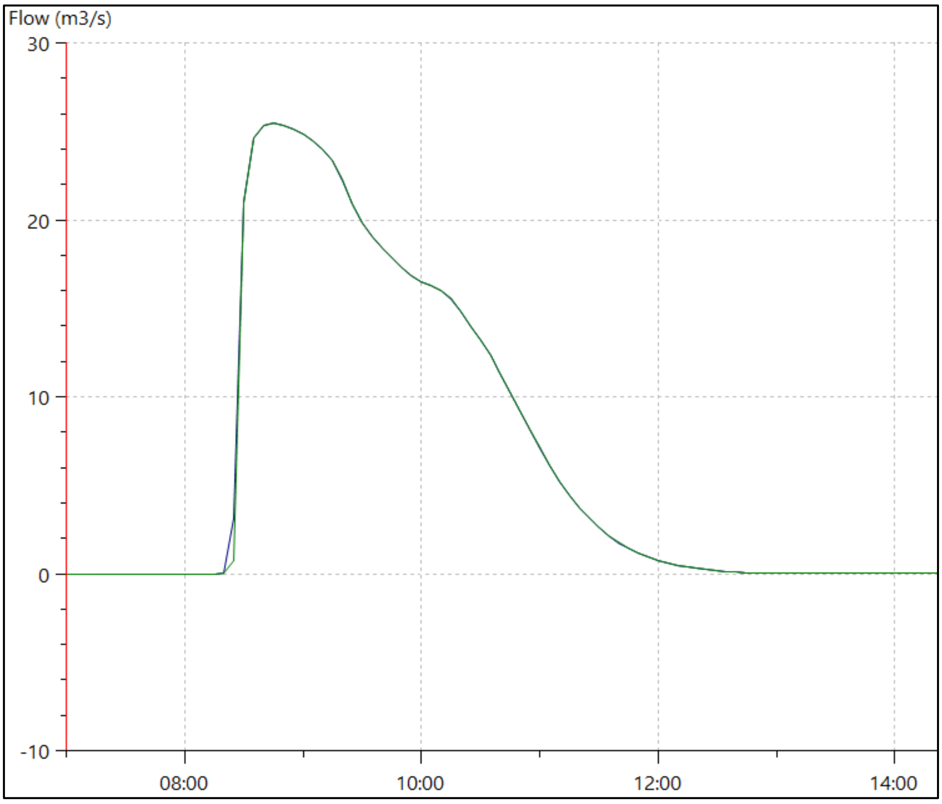
4.1.11 The developed nature of the upstream catchment means it is not possible to make substantial changes to the network connectivity that could significantly affect peak CSO discharges. Ultimately there is a fixed amount of rainfall falling on a fixed area, served by a sewer system of fixed and limited 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, 30 m^3/s is considered a maximum realistic CSO discharge rate.

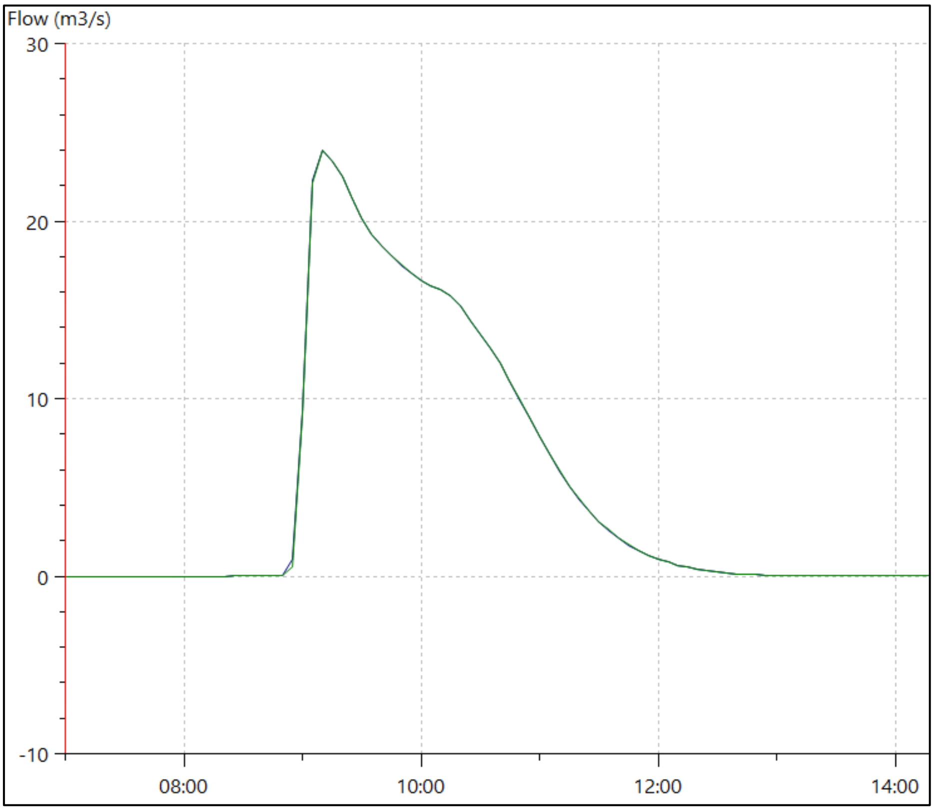
4.1.14 Figure 4-1 shows the discharge hydrograph for the 15-year storm at low tide, using the latest Design Authority model. The hydrograph represents the 'Tunnel Closed' scenario. In this instance the storm started at 07:00 - it took approximately 75 minutes for the CSO to start discharging and approximately another 25 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 discharge hydrograph for the 15-year storm at low tide, using the latest Design Authority model. The hydrograph represents the 'Tunnel Operational' scenario. It can be seen that the tunnel storage delays the onset of the CSO discharge by approximately 35 minutes. The peak discharge is unaffected.

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.

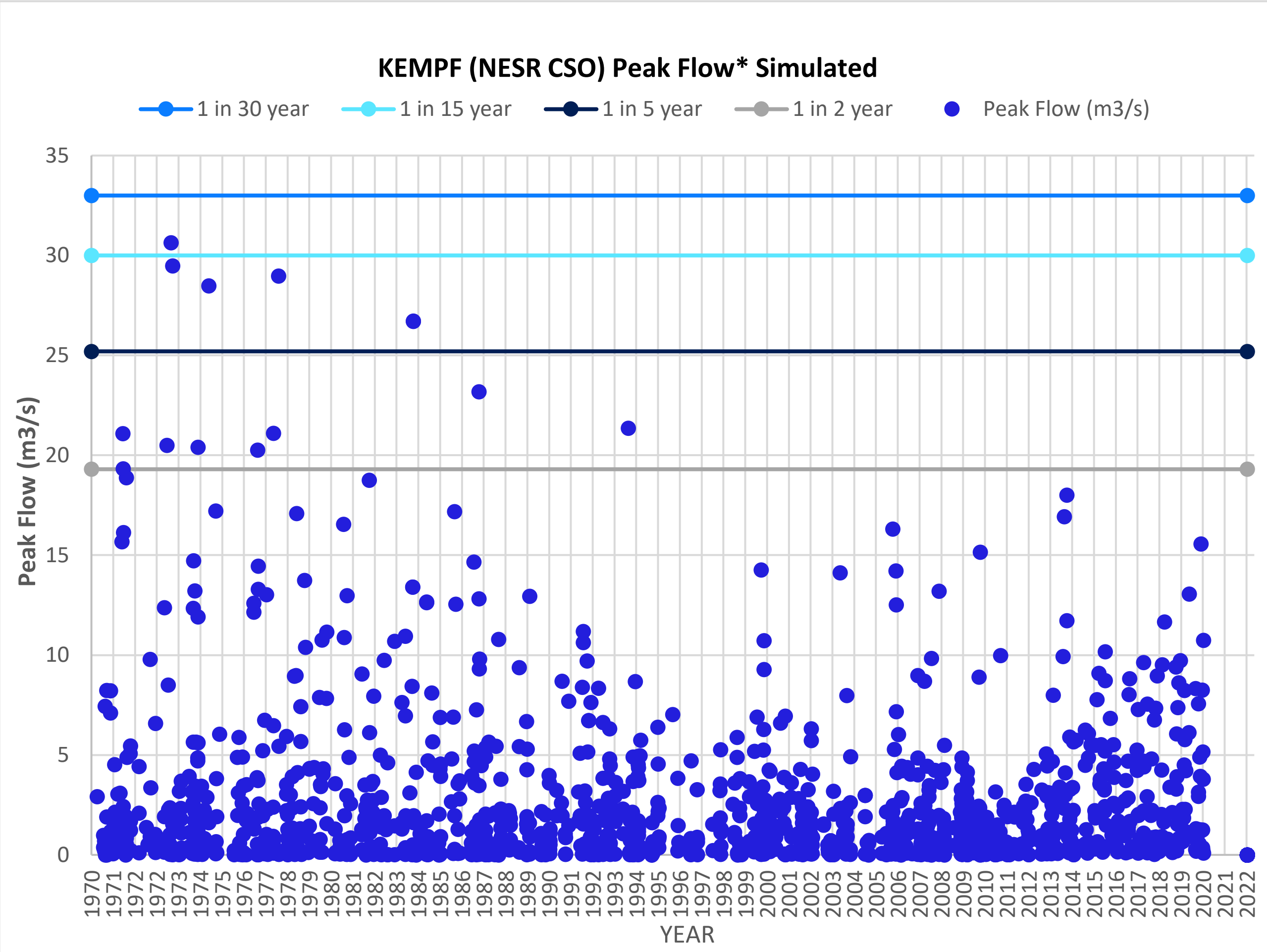
4.1.17 Table 4-2 summarises the peak CSO discharges at KEMPF during the typical year (1979/80).

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 07:15	294	13.6	65,027
25/10/1979 14:55	306	10.4	51,877
26/11/1979 15:35	237	1.3	6,605
27/12/1979 02:48	630	2.5	36,962
03/01/1980 23:30	220	4.3	16,170
03/02/1980 16:10	161	0.6	1,661
06/03/1980 10:35	234	2.5	10,663
17/03/1980 08:35	330	4.4	29,349
13/06/1980 03:05	247	7.8	32,775
22/06/1980 11:05	173	0.6	2,144
24/06/1980 10:40	205	2.3	8,996
30/06/1980 20:35	256	3.5	18,076
07/07/1980 15:05	207	3.4	11,825
26/07/1980 00:20	309	10.7	78,112
12/08/1980 22:25	208	4	13,750
14/08/1980 19:50	259	4.3	23,290

4.1.18 Figure 4-3 below shows the simulated peak flows from the NESR CSO outfall using the full set of actual rainfall data for 1970-2020. The simulated flows prior to 2016 do not include the weir in the NESRS. The simulated flows post 2016 include the weir. Simulated flows for 2021 and 2022 should be available by the end of October (2023) and consideration will be made to them in the permanent DRA.

Figure 4-3 Simulated peak flows from NESR CSO outfall using actual weather data from 1970-2020 against the WI 7706 return periods.



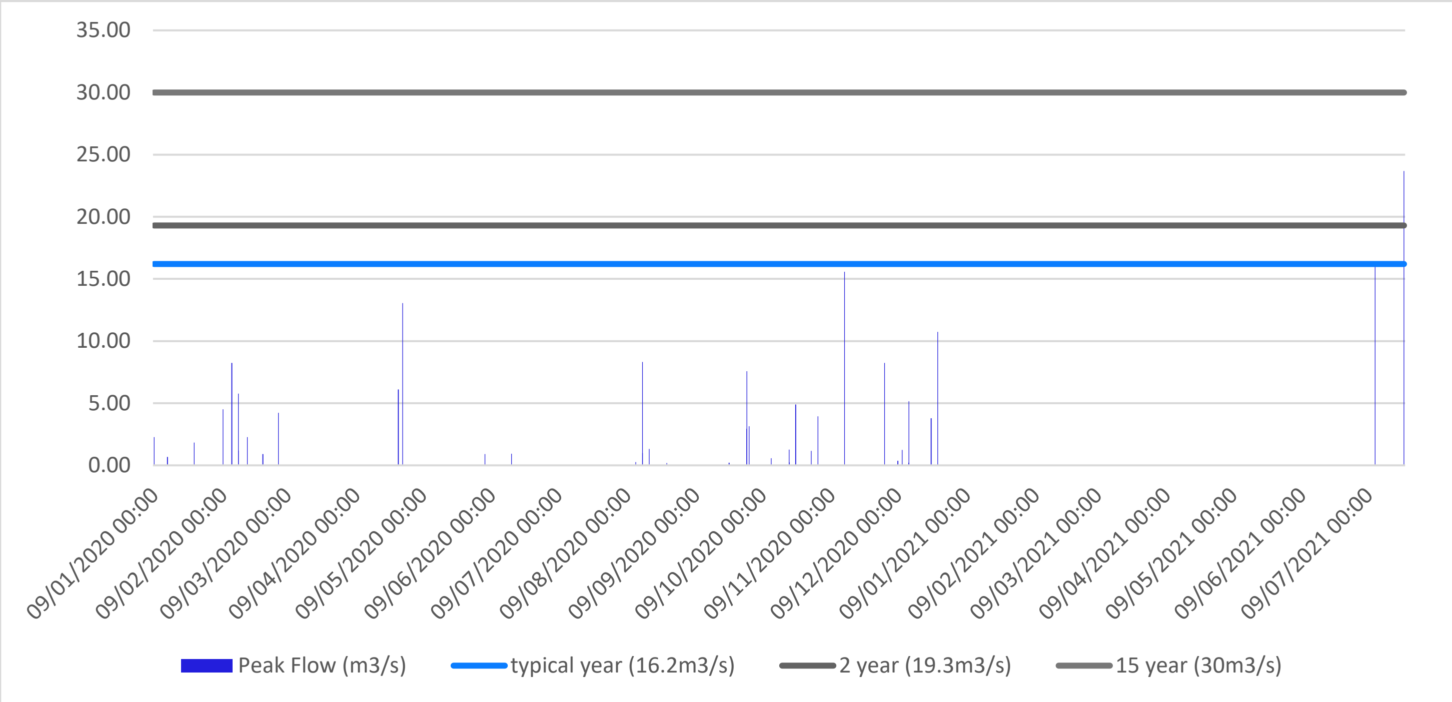
4.2 Discharge frequency and magnitude

4.2.1 The KEMPF structure will be intercepting the North East Storm Relief 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 the magnitude of these discharges and the potential frequency needs to be understood.

Magnitude

4.2.2 The 2020 average 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 NESR 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 4.5m^3/s with a maximum instantaneous peak of 15.5m^3/s. During the 25th July 2021 summer storm the modelled NESR CSO peak discharge rate was 22.7m^3/s.

Frequency

4.2.4 In 2019 an event duration monitor (EDM) was installed in the North East Storm Relief Sewer to enable TWUL to deliver against the regulatory requirement to report CSO discharges capturing the number of discharges and their duration. The records from the NESRS EDM started being reported from 2020 and since installation the EDM has recorded between 13 and 31 discharges per year with an average of 19.7 discharges per 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 is the extract from that table for the modelled CSO discharges from the NESRS at KEMPF.

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)
C529X	Cat 1	North East Storm Relief	85,300	4	32	90,100	3	29	133,100	5	44	237,200	6	55

4.2.8 Table 4-3 demonstrates that the predicted CSO discharge frequency at from the NESR at KEMPF is not expected to increase significantly due to any anticipated change in climate.

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 100-year NESR CSO discharge rates for the reasons set out in paragraph 4.1.6.

4.3 Tidal Considerations

4.3.1 This section is to consider the HR Wallingford report titled "King Edward Memorial Park Foreshore CSO discharge assessment" to confirm the impact of the most likely worst-case scenario and the impact of a CSO discharge across the tidal range. The HR Wallingford report has considered the 1:2 year, 1:5 year and 1:15 year return period discharge rates.

4.3.2 The HR Wallingford document "King Edward Memorial Park Foreshore CSO discharge assessment was commissioned to provide 2-d depth averaged velocity discharge plumes using the instantaneous peak velocities at the following tide states shown in Table 4-5 HR Wallingford modelling tidal discharge cases. 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.

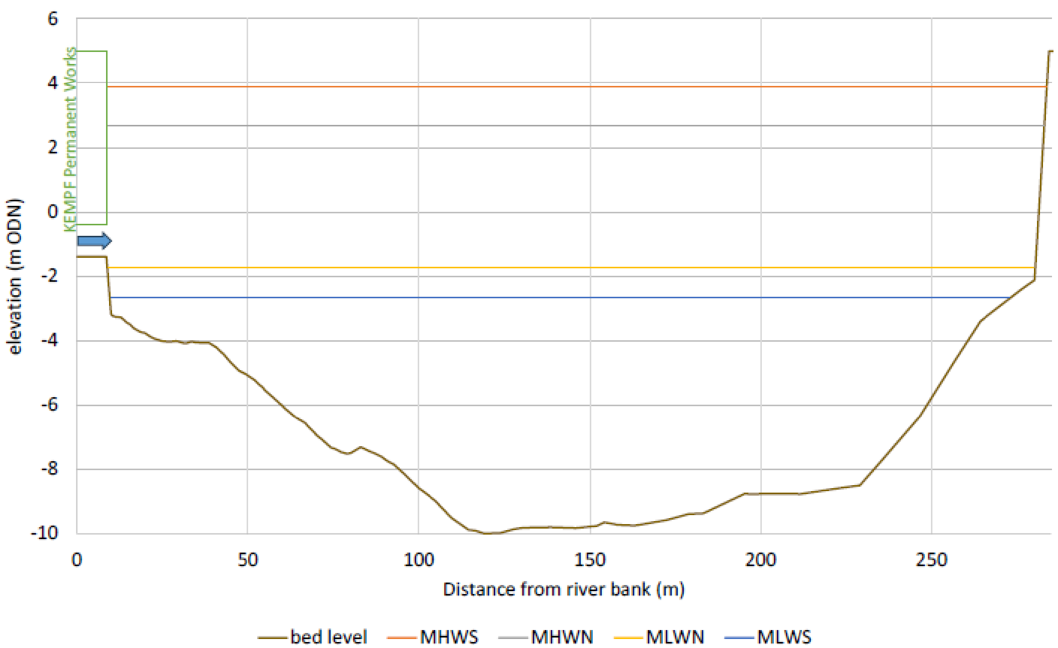
4.3.3 The report states that in considering the results it should be remembered that the model is 2D depth-averaged and hence will not model the detail of 3D aspects of the jet, especially within the distance taken for the expanding jet to mix fully with the receiving waters. Therefore, care should be 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

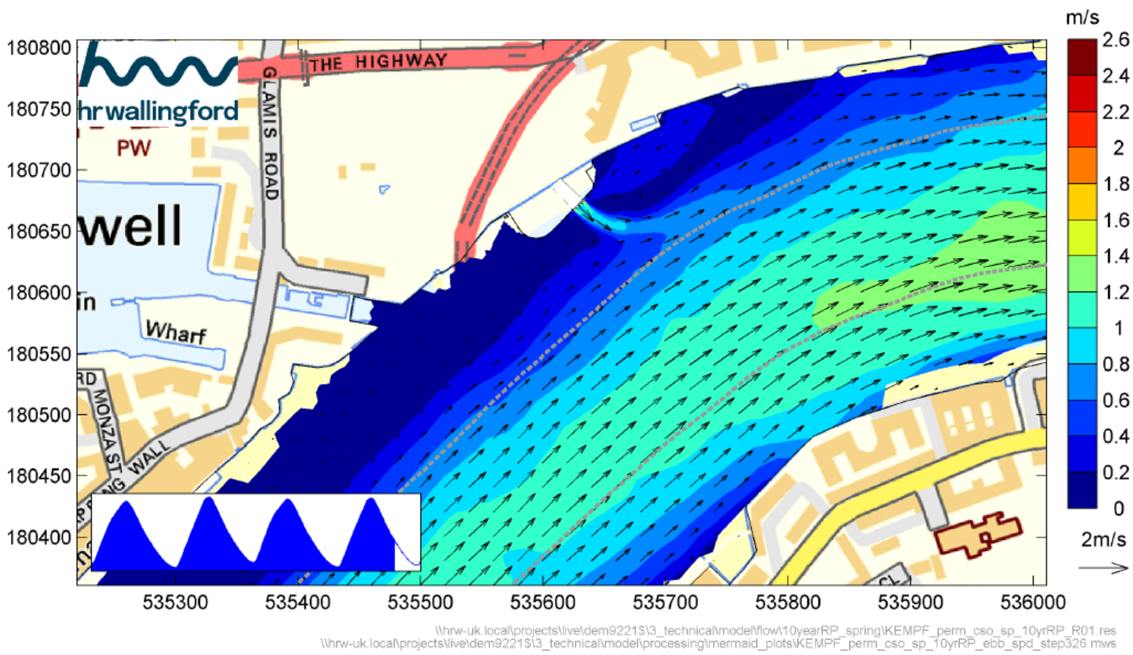
4.3.4 The height of the new CSO above the riverbed is presented in Figure 4-5. The bathymetry used for the modelling was taken from the quarterly surveys undertaken by Tideway juts prior to the start of the temporary works with the assumption that the riverbed will return to previous levels upon completion of the works.

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



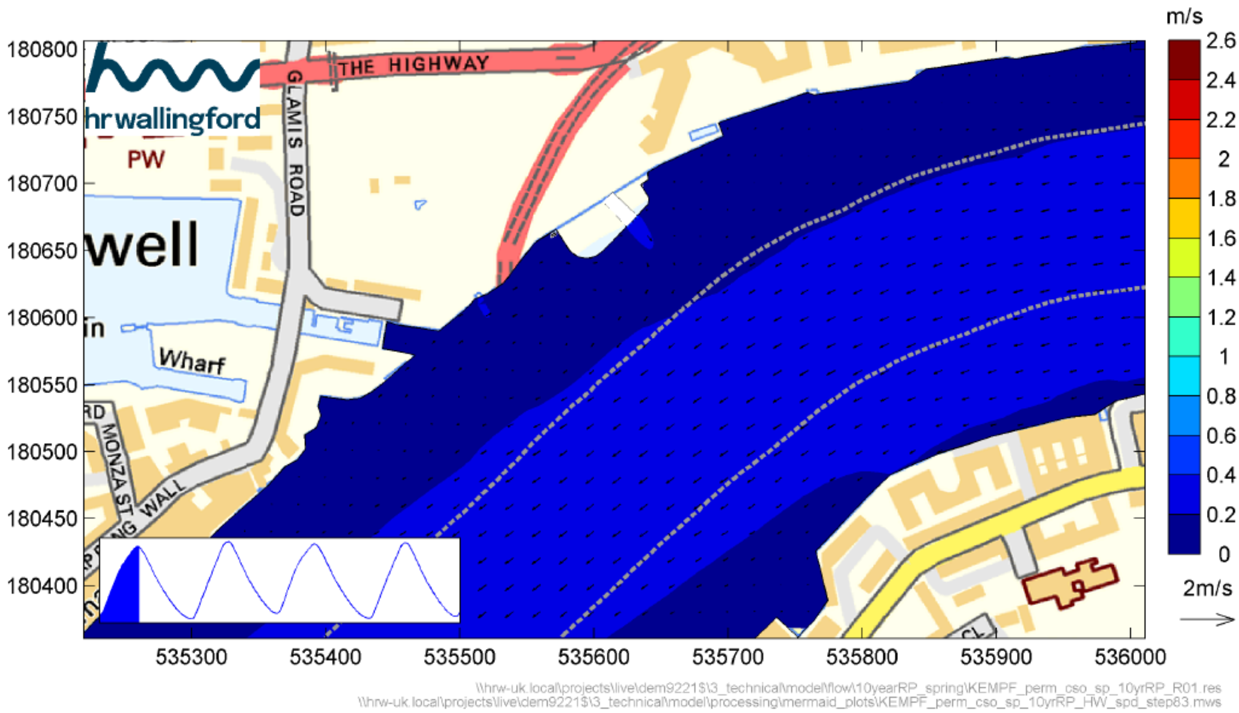
4.3.5 The analysis of the tidal cases undertaken by HR Wallingford identified that during the periods of rising or falling tide there was no lateral flow entering the main fairway due to the dominance of the main river flow and rapid dispersion of momentum of the discharge. Although there is a small impact on the inshore zone. Figure 4-6 presents an example of this for a mid-ebb tide. The resulting impact of the lateral flow on the main fairway is similar for the mid-flood tide.

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



4.3.6 During spring high water slacks for the 1:15 return period discharges the lateral flow at around 0.25m/s more than the main river and projects approximately 20m from the structure into the inshore zone. This is presented in Figure 4-7

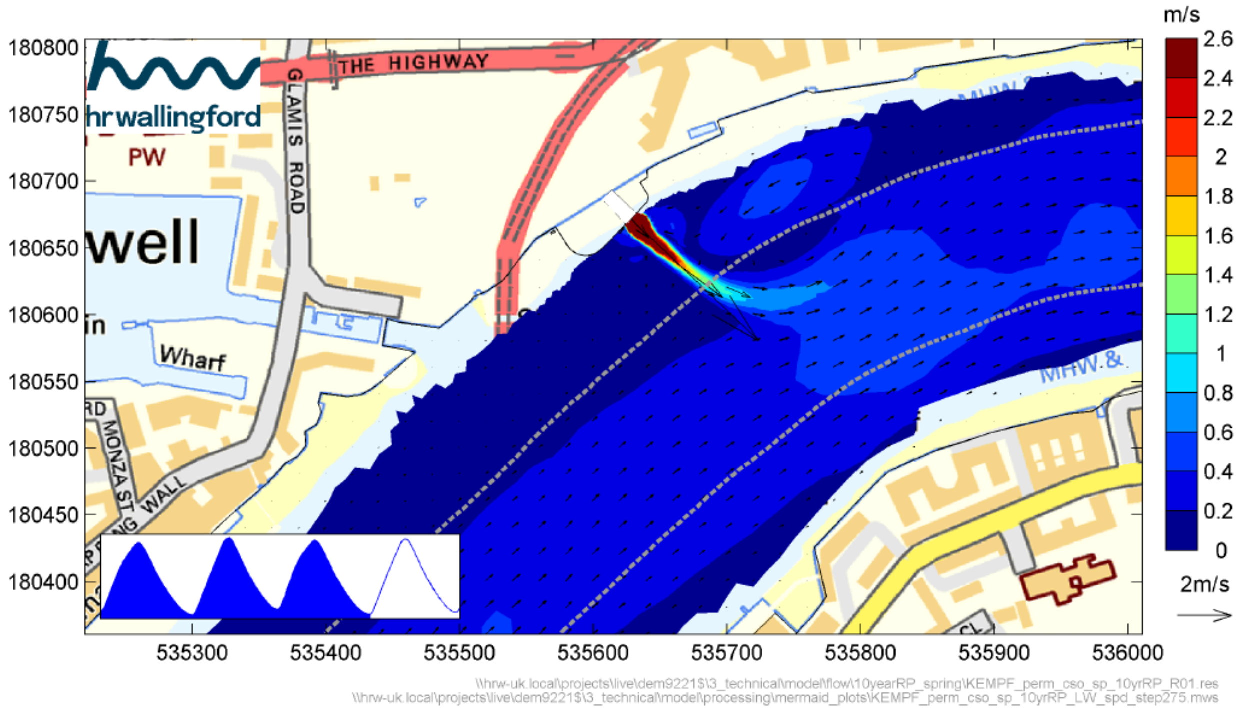
Figure 4-7 Depth average currents associated with a 1:15 return period discharge at spring high water slacks.



4.3.7 From analysing the above information, it can be determined that for any discharge event from mid-flood across high water to mid ebb there is no lateral flow that would make it to the main fairway. However, there is a small impact on the inshore zone.

4.3.8 The report states that the worst case for KEMPF CSO is at low water springs, with the lateral flow of 1m/s extending up to 150 from the outfall into the fairway. There is also a lateral flow impact at neap low water slacks although it doesn't extend as far. The model of the 1:15 return period discharge at spring low water slacks is presented in Figure 4-8.

Figure 4-8 Depth average currents associated with a 1:15 year return period discharge at spring low water slacks.

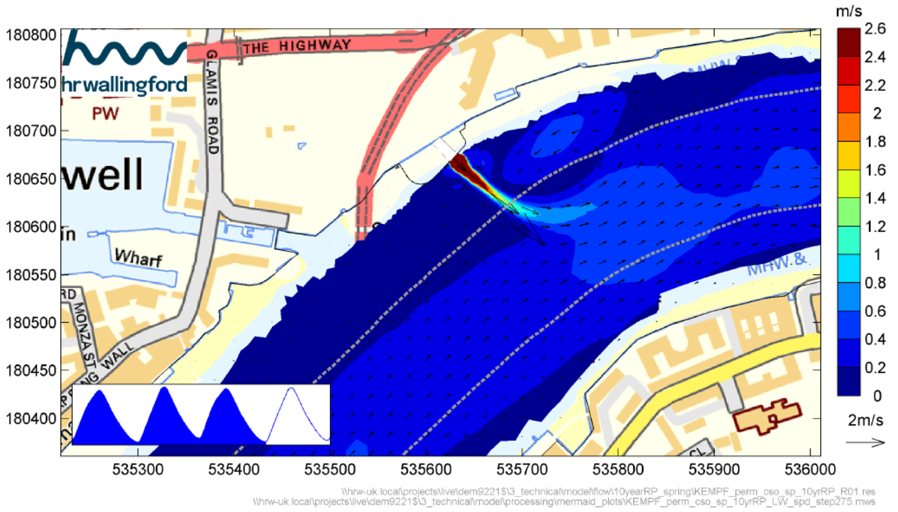


4.4 Zone of KEMPF CSO discharge impact

4.4.1 For consistency with the information available, and for the reasons described in section 4.3.3, to determine the zone of discharge impact the 1:15-year return period will be used as the most probable worst-case with a discharge rate of 30 m^3/s. In addition the zone of impact for a typical year will also be analysed using the typical year return period discharge rate of 16.3m3/s.

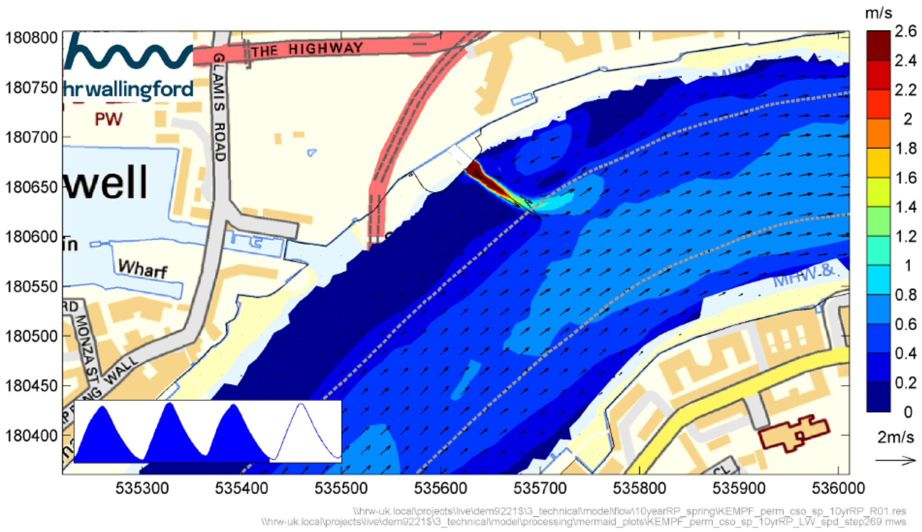
4.4.2 Figure 4-9 presents the 1:15 year return period depth average currents at spring low water slacks. The CSO discharge velocity starts at over 4.0m/s from the outfall and is retained across the inshore zone but dropping to 2m/s by approximately 50m and deteriorating to 1.4m/s by the edge of the main fairway. The lateral flow reduces from 1.4m/s down to the background flow by halfway across the main fairway.

Figure 4-9 Depth average currents associated with a 1:15 year return period discharge at spring low water slacks.



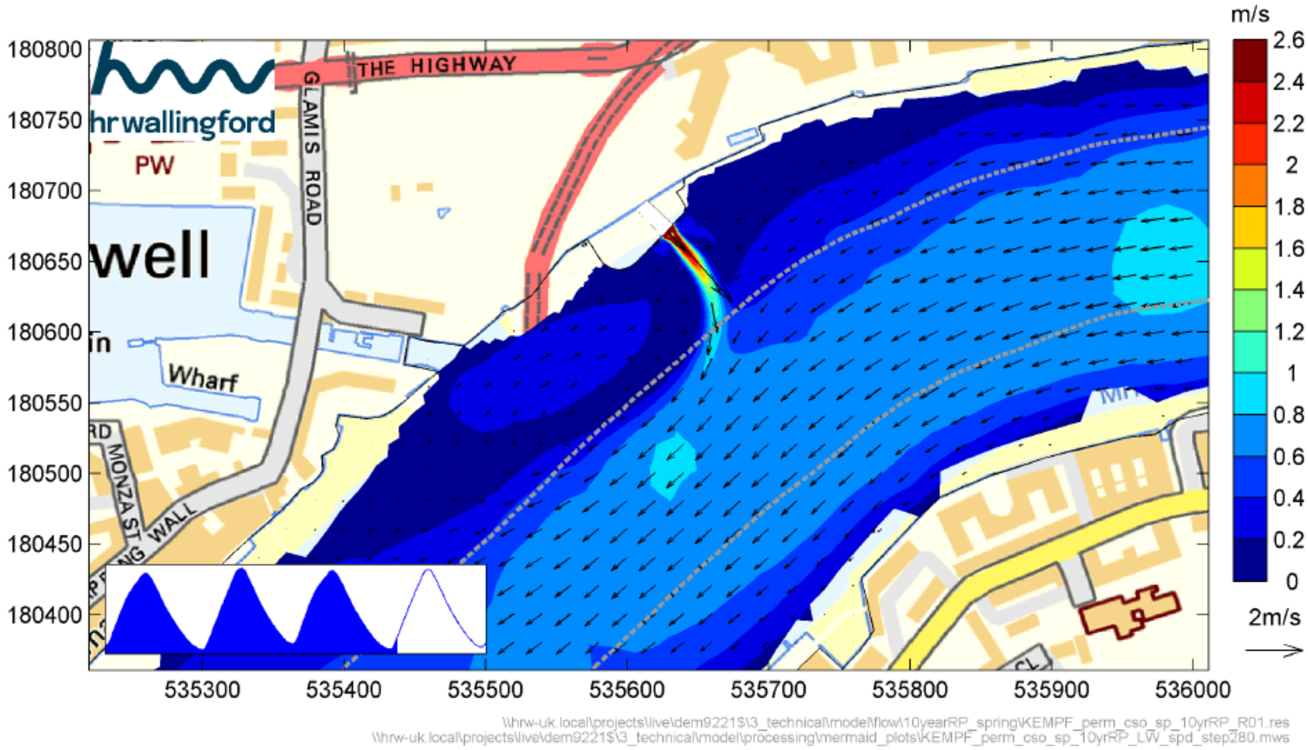
4.4.3 Figure 4-9 presents the worst-case scenario for the main fairway from a 1:15-year event at the point of still water and spring low water. Figure 4-10 shows the depth average currents for a 1:15 year return period event 60 minutes before spring low water and can be seen to be impacting the inshore zone and starting to impact the edge of main fairway.

Figure 4-10 Depth average currents associated with a 1:15 year return period discharge at 60 minutes before spring low water slacks.



4.4.4 Figure 4-11 Shows the 1:15 year return depth average at 50 minutes after spring low water and shows that whilst the velocity of the lateral flow still impacts on the inshore zone, there is minimal flow entering the main fairway.

Figure 4-11 Depth average currents associated with a 1:15 year return period discharge at 50 minutes after spring low water slacks



4.4.5 From the analysis of the 1:15 year return period events it can be determined that the only area that receives significant lateral flow is the inshore zone edge and just into the edge of the main fairway.

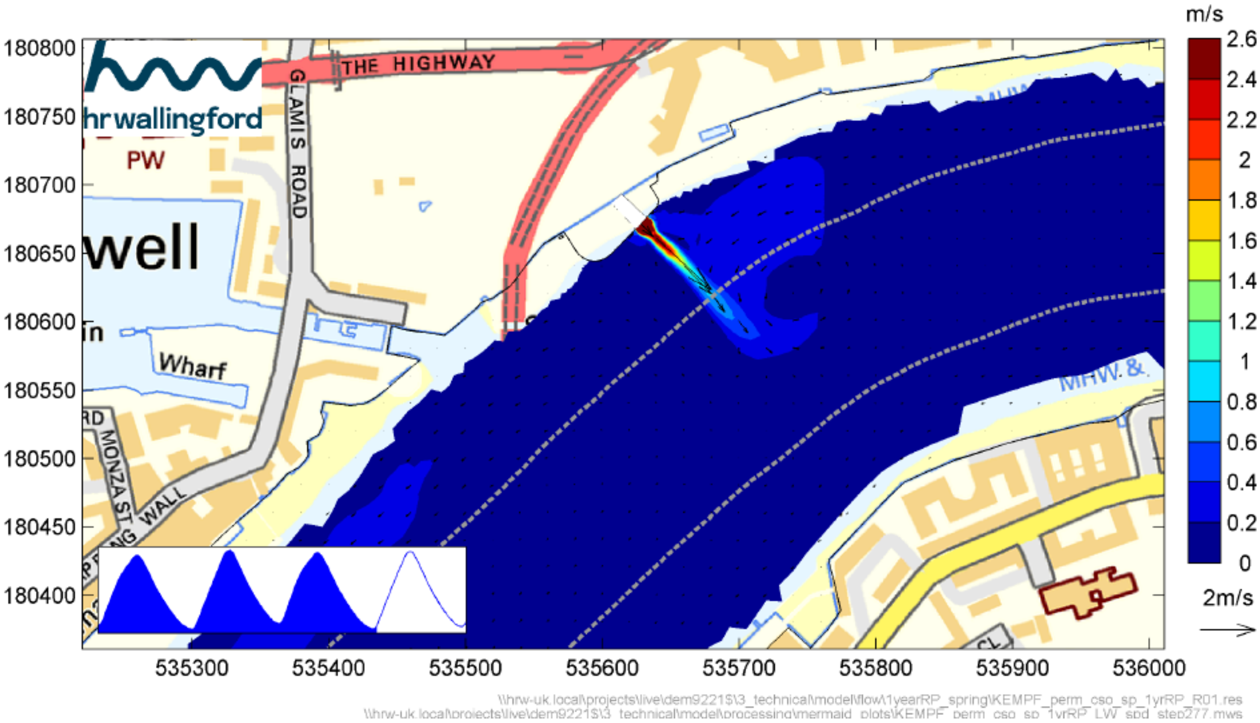
4.4.6 HR Wallingford analyses the scenarios including 5 minutes either side of the time stamp e.g. 60 minutes before low water is defined as the period 65 to 55 minutes before low water. Therefore, the overall tidal window will be 120 minutes, from 65 minutes before low water to 55 minutes after low water.

4.4.7 The 120 minutes is the period where the flows could impact on the main fairway. Outside of the 120 minutes the main river flow is dominant, and the navigation of the main fairway is largely unaffected.

4.4.8 Having determined the zone of impact in the 1:15 year probable worst case. the zone of impact for a typical year, using the typical year discharge plumes will be assessed.

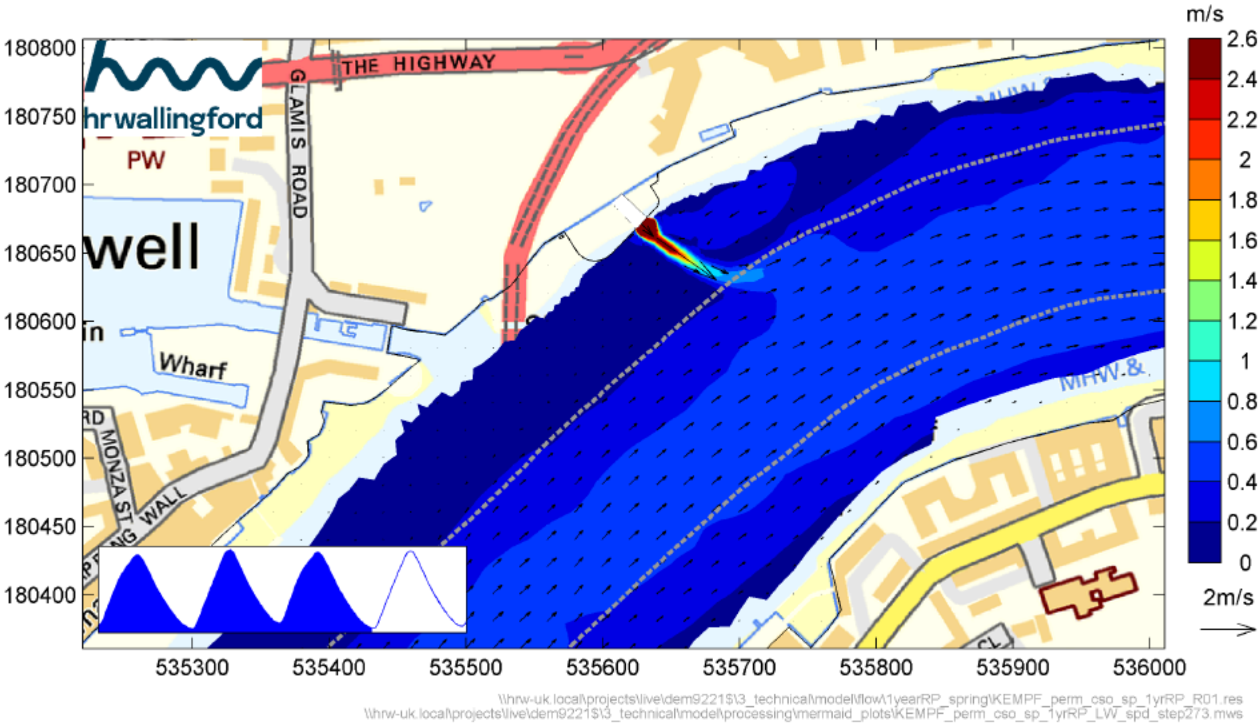
4.4.9 Figure 4-12 shows the typical year return period CSO discharge 20 minutes after at spring low water slacks. The lateral flow discharges through the flaps in excess of 2.6 m/s and starts to slow down to 1.4 to1.6m/s by 30m from the outfall. The lateral flow continues across the river and reduces to down 0.6 to 0.8m/s by the edge of the main fairway. The lateral flow deteriorates within 30m of entering the main fairway.

Figure 4-12 Depth average currents associated with a typical year return period discharge at 20 minutes after spring low water slacks



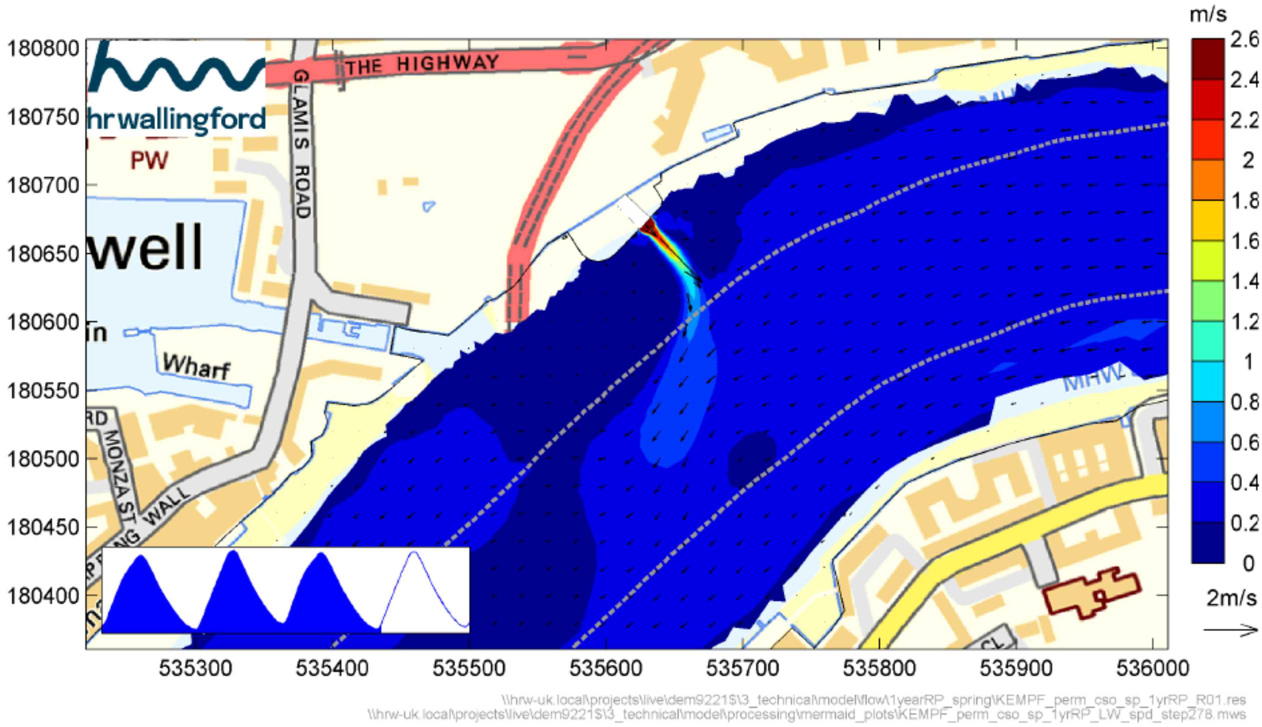
4.4.10 Figure 4-13 Shows the typical year return period discharge 20 minutes before spring low water slacks. Whilst the initial lateral flow is similar to Figure 4-10 the plume from the lateral flow barely makes it into the main fairway.

Figure 4-13 Depth average currents associated with a typical year return period discharge at 20 minutes before spring low water slacks



4.4.11 Figure 4-14 Shows the typical year return period discharge at 30 minutes after spring low water slack. At this point there is minimal impact of the lateral flow into the main channel, but there is still an impact within the inshore zone.

Figure 4-14 Depth average currents associated with a typical year return period discharge at 30 minutes after spring low water slacks



5. Impact on vessels on the river

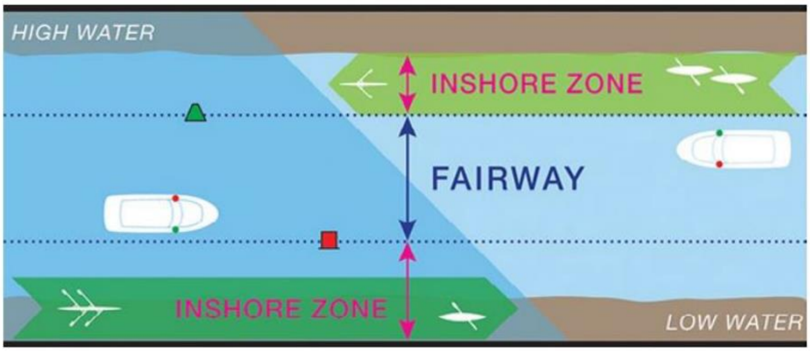
5.1 Assessment of the discharges

5.1.1 The 1:15 year event discharge plumes are taken from" King Edward Memorial Park Foreshore CSO discharge assessment".

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 NESR CSO discharge of 30 m^3/s at low water springs which produces the most severe hydraulic condition for the scour protection.

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 riverbank, and the main fairway, which is the area of the river between main fairway edges. 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 NESR CSO discharge at King Edward Memorial Park Foreshore.

Table 5-1 Vessels and their characteristics that could be affected by a NESR 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	40+	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	Unpowered Vessels	Dinghy	1	3	V. Low	Low	No
10		Kayak/Rowers/SUP's	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 NESR 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.

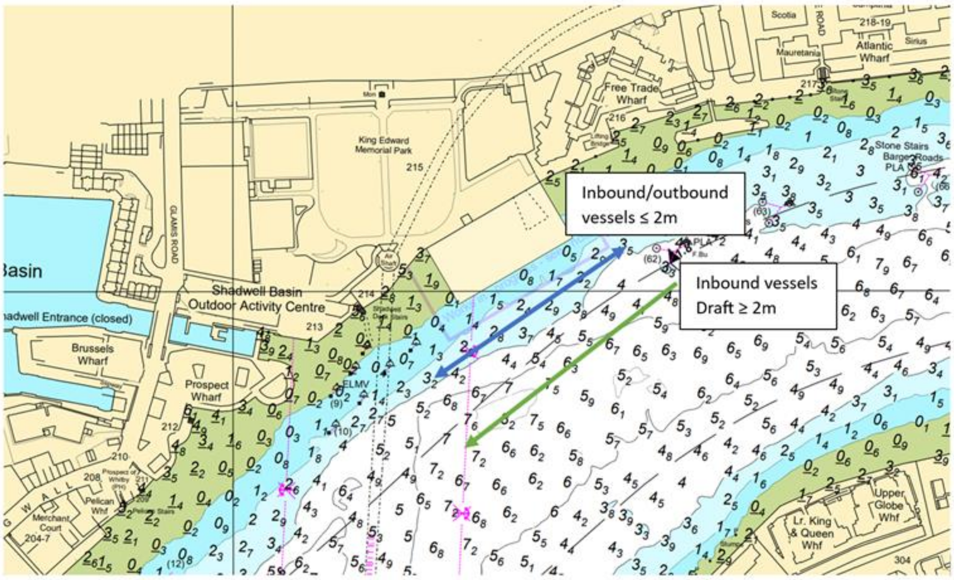
5.3.2 KEMPF Interim DRA 665397CH-KEPMF-DRA-Interim-Rev 6 established the worst most likely case for a CSO impact and the duration of the impact. This information is presented in section 4.3.

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 listed in Table 5-1.

5.3.4 In this area at low tide vessels will operate in the fairway due to the drying heights and the lack of traffic. The closest a vessel can transit past the CSO outfall at neap low water would be approximately 50m from CSO outfall, approximately at the channel edge, therefore the vessels have been assessed passing at this distance.

5.3.5 Figure 5-2 presents the extract of PLA chart 319, which covers the Lower Pool to Limehouse Reach and highlights the passage of vessels transiting the area . The Blue arrowed line shows the passage of shallower draft vessels such as Kayaks and rowing boats, as well as some powered vessels such as a narrow boat. The arrowed Green line shows the closest running position for reporting vessels transiting upstream past the site over the low water period.

Figure 5-2 Extract of PLA Chart 319 marked with vessel operating zones governed by draft.

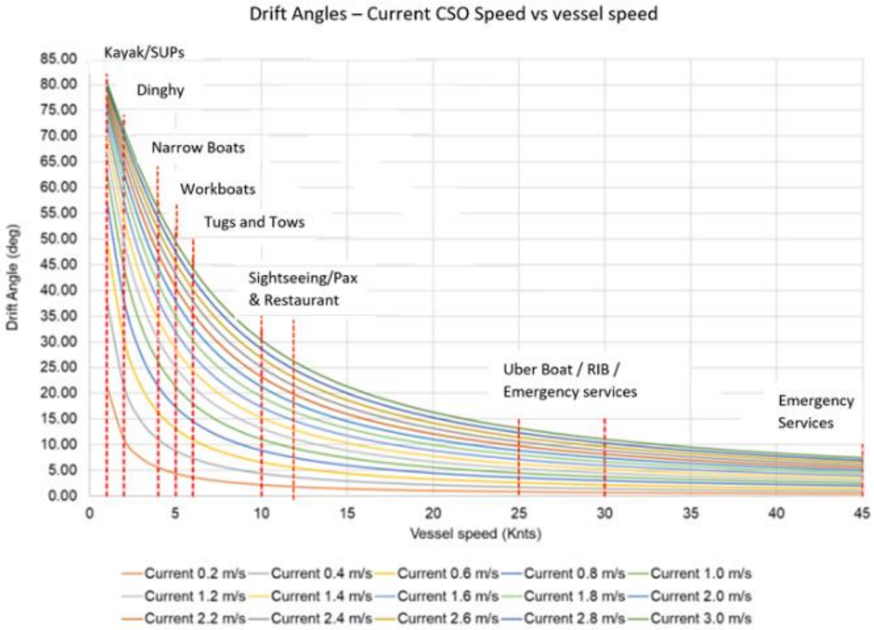


5.3.6 Whilst considering the passage of a vessel past the CSO the hydrograph in figure 4-1, without the tunnel in operation, indicates that there are approximately 25 minutes from the start of discharge before it reaches its 1:15 year peak discharge of 30 m^3/s, whilst the hydrograph in figure 4-2, with the tunnel in operation, indicates that whilst there is a delay in the start of the discharge the duration to reach its peak discharge is the same at approximately 25 minutes.

5.3.7 The drift angle will be determined in relation to the lowest operating speed within the inshore zone (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 NESR CSO discharge current speed without any course correction, this will be taken as the worst-case scenario. The results are presented in Figure 5-3 noting that drift angles are related to the speed of vessel and not category of vessel.

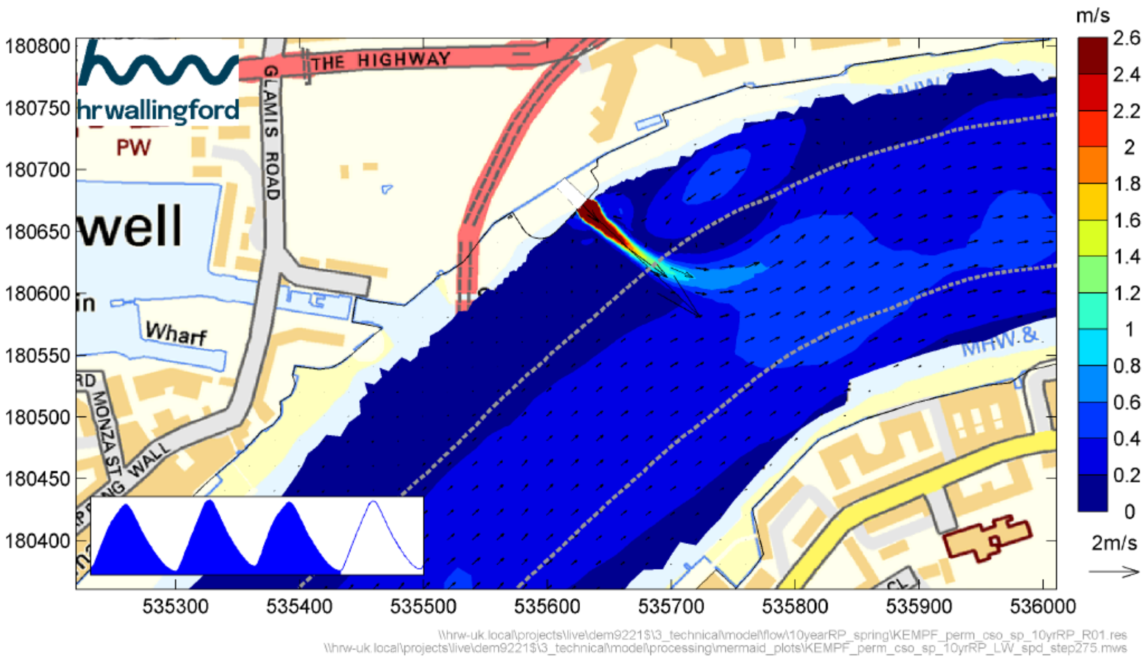
Figure 5-3 Drift angle – Current CSO vs vessel speed



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 KEMPF CSO outfall during a 1:15 year evet at low water slacks is presented in Figure 5-4

Figure 5-4 Depth average currents associated with a 1:15 year return period discharge at spring low water slacks



5.3.11 Figure 5-4 shows that the lateral flow is high, between 4m/s and 1.4m/s in the inshore zone and decreases from 1.4m/s to the background velocity within the first third of the main fairway. It can therefore be established that powered vessels operating near the edge of the main fairway could be impacted by a discharge, whereas vessels operating in the centre of the channel are unlikely to be impacted.

5.3.12 Table 5-2 presents the assessed impact of a 1 in15-year NESR CSO discharge on the different vessel types, using the drift angle curves when the vessels are operating in the inshore zone.

5.3.13 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, during a 1 in10-year NESR CSO discharge at MLWS.

Vessel Type	Vessels Speed passing CSO. (SOG)	Minimum Vessels Draft (metres)	Water depth allowing for Under Keel Clearance (Add 0.5m)	Approximate Distance from CSO to allow safe draft clearance at chart datum	Approximation of drift angle when passing the CSO
Uber Boat (i.e., Hunt Class)	6 knots	1.2	1.7	75m	22°
RIB/Emergency Services	3 knots	0.5	1.0	75m	42°
Sightseeing/Pax	3 knots	1.5	2.0	75m	42°
Restaurant/Pax (i.e., Symphony)	3 knots	1.8	2.3	75m	42°
Tug vessel pushing	3 knots	3	3.5	75m	42°
Tug vessel towing	3 knots	3	3.5	75m	42°
Workboats	3 knots	0.5	1.0	35m	60°
Narrowboats/Motor cruisers	3 knots	1.0	1.5	35m	60°
Dinghy	1 knot	0.8	1.3	35m	78°
Kayak/Rower	1 knot	0.2	0.2m	35m	78°

5.4 Summary of impacted vessels and outcomes.

5.4.1 The summary of the 1in15-year NESR CSO discharge impacts on the different vessel types at low water is presented in table 5-3 below.

Table 5-3 Impact of 1in15-year CSO discharge on vessels at different states of tide.

Vessel Type	Fairway or inshore zone	Impact on vessel Normal Running Position
Uber Boat	Fairway	Minimal impact - Transits are ≥ 75m from CSO
	Inshore Zone	Moderate impact - Course and/or speed adjustment required
RIB/Emergency services	Fairway	Moderate impact - Course and/or speed adjustment required
	Inshore Zone	High impact - Unable to maintain course Risk of collision with other vessels due to inability to maintain course. Risk of swamping if too close.
Sightseeing/Pax	Fairway	Moderate impact- Course and/or speed adjustment required
	Inshore Zone	High impact - Unable to maintain course Risk of collision with other vessels due to inability to maintain course.
Restaurant/Pax	Fairway	Moderate impact - Course and/or speed adjustment required
	Inshore zone	High impact - Unable to maintain course Risk of collision with other vessels due to inability to maintain course.
Tug vessel engaged in pushing/Towing	Fairway	Moderate impact - Course and/or speed adjustment required
	Inshore Zone	High impact - Unable to maintain course Risk of collision with other vessels or own barge, due to inability to maintain course.
Workboats	Fairway	Moderate/High Impact Course and/or speed adjustment required
	Inshore Zone	High impact- Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course. Risk of swamping or capsizing if too close.
Narrow boat/Motor cruisers	Fairway	Moderate/High Impact - Course and/or speed adjustment required
	Inshore Zone	High impact - Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course. Risk of swamping if too close.
Dinghy/Kayak/Rower	Fairway	High impact - Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course. Risk of swamping or capsizing if too close.
	Inshore Zone	High impact - Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course. Risk of swamping or capsizing if too close.

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

- There is moderate impact on all vessels, except clippers, transiting upstream in the fairway past the CSO when it is discharging at low water springs.
- There is a high impact on the vessels when passing the CSO in the inshore zone.
- and the northern part of the main fairway.
- There is a high impact on Dingy/Kayak/Rowers, Narrow boats and workboats transiting upstream in the main fairway.

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 The simulations for King Edward Memorial Park Foreshore were undertaken at the HR Wallingford Ship Simulation Centre during the 8^{th}, 9^{th} and 10^{th} of November 2023 with representatives from HR Wallingford, Tideway, Waves, the Port of London Authority and several river operators and the 5^{th} March 2024 with Tideway, Waves and the Port of London Authority.

6.1.5 It was agreed that the focus at KEMPF should be on vessels that could be in and around the area at low tide, except for the passages with a tug and tow.

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

Figure 6-1 Extract of simulated cases for KEMPF

26	KEMPF	28m tug pulling unladen 50m barge	Outbound at 3 knots along 50m line	None	Low water slack	The barge overran the 28m tug when the 28m tug changed course due to the outflow. 28m tug lost control.
27	KEMPF	28m tug pulling unladen 50m barge	Inbound at 3 knots along 100m line	None	Low water slack	The barge overran the 28m tug when the 28m tug changed course due to the outflow. 28m tug lost control.
28	KEMPF	28m tug pulling unladen 50m barge	Inbound at 6 knots along 100m line	None	Low water slack	The barge overran the 28m tug when the 28m tug changed course due to the outflow. 28m tug lost control.
29	KEMPF	28m tug pushing unladen 50m barge	Inbound at 3 knots along 100m line	None	Low water slack	Vessel maintained desired track after course corrections were applied.
30	KEMPF	21m Narrowboat	Inbound at 3 knots along 50m line	None	Low water slack	Vessel track deflected by the discharge. However, this did not pose a significant risk in the inbound direction in the absence of conflicting traffic.
31	KEMPF	21m Narrowboat	Inbound at 3 knots along 100m line	None	Low water slack	Vessel track deflected by the discharge. However, this did not pose a significant risk in the inbound direction in the absence of conflicting traffic.
32	KEMPF	Kayak	Inbound at 1 knot constant speed. Close to outfall	None	Low water slack	Vessel track deflected significantly by the discharge.
33	KEMPF	Kayak	Inbound at 1 knot speed into flow then drifting when flow impact felt. Close to outfall	None	Low water slack	Vessel track deflected significantly by the discharge.
34	KEMPF	Kayak	Inbound at 1 knot speed with intervention by person. Close to outfall	None	Low water slack	An attempt was made to regain desired track. Significant effect from the outflow on the kayak. Multiple attempts to manoeuvre through the flow were unsuccessful.
35	KEMPF	Kayak	Inbound at 1 knot speed into flow then drifting when flow impact felt. 100m from outfall.	None	Low water slack	Vessel track deflected significantly by the discharge. Wider jet caused a bodily drift sideways with less rate of turn when compared to passing close to the outfall.
36	KEMPF	Kayak	Inbound at 1 knot speed with intervention by person. 100m from the outfall	None	Low water slack	Vessel track deflected significantly by the discharge. Vessel passed through the flow and, after corrective action was taken, it was possible to proceed on the desired track when the effect from the flow subsided.
37	KEMPF	Clipper	Inbound at 7 knots at 100m from the outfall	None	Low water slack	Manageable with some additional control input required to maintain the desired track.
38	KEMPF	28m tug pulling unladen 50m barge	Inbound at 3 knots and 100m from the outfall	None	20 minutes after low water slack	No noticeable effect from the outflow.
39	KEMPF	28m tug pulling unladen 50m barge	Inbound at 3 knots and 100m from the outfall	None	20 minutes before low water slack	Some effect felt from the outflow and corrections made. It was possible to recover desired track after the barge contacted the 28m tug on the quarter.
40	KEMPF	28m tug pulling unladen 50m barge	Inbound at 3 knots and 100m from the outfall	None	20 minutes before low water slack	A repeat of the previous run. The outcome of this run was the same.
69	KEMPF	28m tug pulling unladen 50m barge	Inbound at 6 knots along 100m line	None	Low water slack	The barge overran the 28m tug when the 28m tug changed course due to the outflow. 28m tug lost control.
70	KEMPF	28m tug pulling unladen 50m barge	Inbound at 6 knots and 100m from the outfall	None	20 minutes before low water slack	The barge overran the 28m tug when the 28m tug changed course due to the outflow. 28m tug lost control.
71	KEMPF	28m tug pulling unladen 50m barge	Inbound at 6 knots and 100m from the outfall	None	40 minutes before low water slack	Moderate effect from the outflow. The desired track was recovered.

Notes: low water slack was identified at 50m adjacent from the CSO

6.1.7 The full table of simulations undertaken on the 5^{th} of March 2024 focused on the transit of tugs, in different configurations, past the CSO outfall are presented in which include the comments on the run, which were agreed by the attendee's following the simulation.

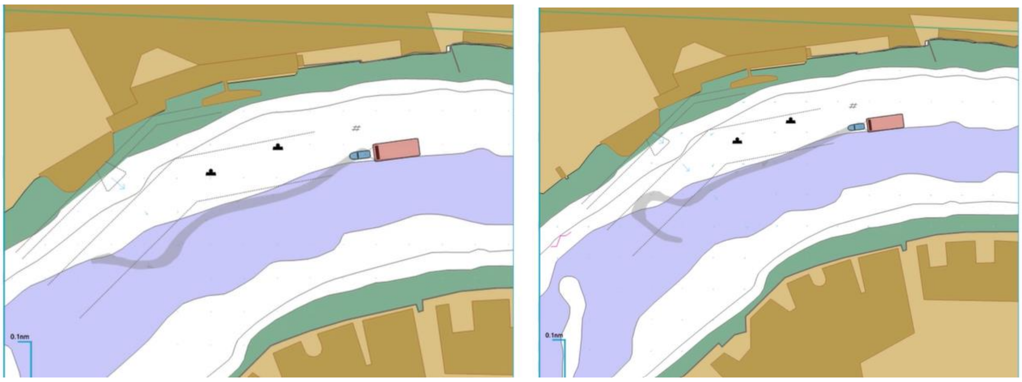
Table 6-1 Simulated cases for KEMPF on the 5th of March 2024

Run ID	Ship	Manoeuvre	Bridge Arch	Tidal Condition	Comments
02	28m tug pulling 50 m unladen barge centreline	Inbound at 6 knots	N/A	Low water Slack	Vessel track deflected by the discharge. However, this did not pose a significant risk in the inbound direction without conflicting traffic.
03	28m tug pulling 50 m unladen barge southerly line	Inbound at 6 knots	N/A	Low water slack	Vessel and tow unaffected by the discharge
04	28m tug pulling 50 m unladen barge 100m line centreline	Inbound at 6 knots	N/A	40 Minutes before low water slack	The barge overran the 28 m tug as the tug changed course due to the outflow. 28 m tug lost control. Assessment is that the issue is caused by managing the turn while the tug and tow are affected by a current shear. The learning point is to consider a more natural line 100-150m
05	28m tug pulling 50 m unladen barge 100m – 150m line	Inbound at 6 knots	N/A	40 Minutes before low water slack	Vessel track deflected by the discharge. However, this did not pose a significant risk without conflicting traffic. Completing the turn before the discharge removed the issue demonstrated in Run 03. Consider looking at 20 mins before LW Slack to check the findings from Autumn work.
06	28m tug pulling 50 m unladen barge 100m – 150m line	Inbound at 6 knots	N/A	20 Minutes before low water slack	Vessel track deflected by the discharge, but the barge did not overrun the tow.
07	28m tug pushing 50 m unladen barge 100m – 150m line	Inbound at 6 knots	N/A	20 Minutes before low water slack	Vessel and tow unaffected by the discharge
08	Thames Clipper	Inbound at 25 knots	N/A	20 Minutes before low water slack	Vessel unaffected by the discharge

6.1.8 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.

6.1.9 The track of each simulated run was recorded so that it could be reviewed shows the recorded track for run 27, which is a Tug towing a barge at 3 knots and passing 100m from the outfall at spring low water and run 28, which is a Tug towing a barge at 6 knots and passing 100m from the outfall at spring low water. The track of the tug and tow from the entire passage is in grey and was determined that the tug lost control of the tow after making corrections in both.

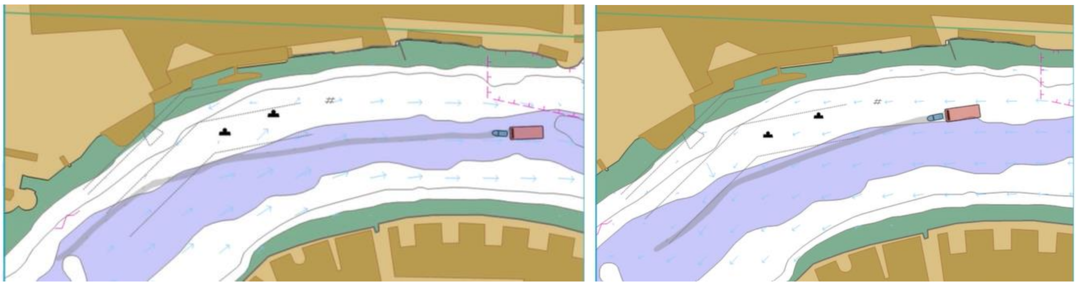
Figure 6-2 Record of runs 27 and 28



6.1.10 To assist in trying to determine the duration of the CSO discharge impact simulations were carried out for a discharge at 40 minutes before low water slacks (Run 71) and 20 minutes after low water slacks (Run38), 6.1.11 In run 71 the vessel transited past the outfall at 6 knots and 100m distance. The outcome was that there was a moderate effect on the tug and tow, but the desired course was recovered.

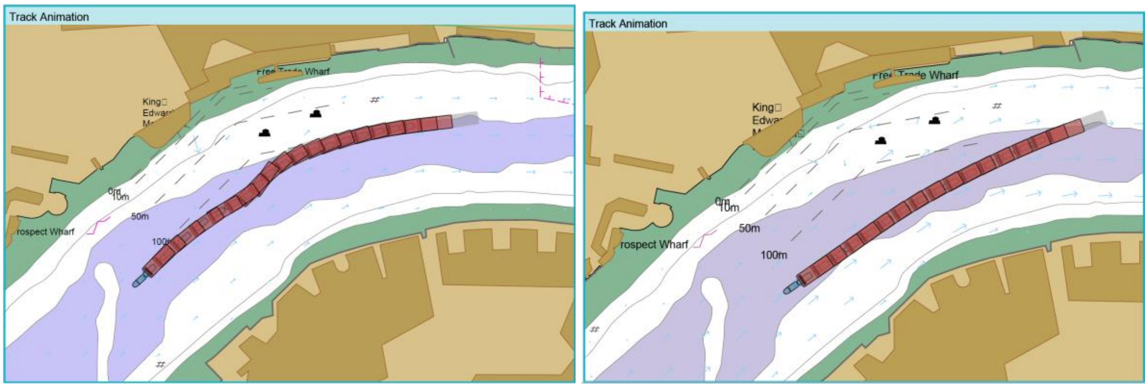
6.1.12 In run 38 the vessel transited past the outfall at 3 knots and 100m distance. The outcome was that there was no noticeable effect of the CSO discharge.

Figure 6-3 Record of runs 71 and 38



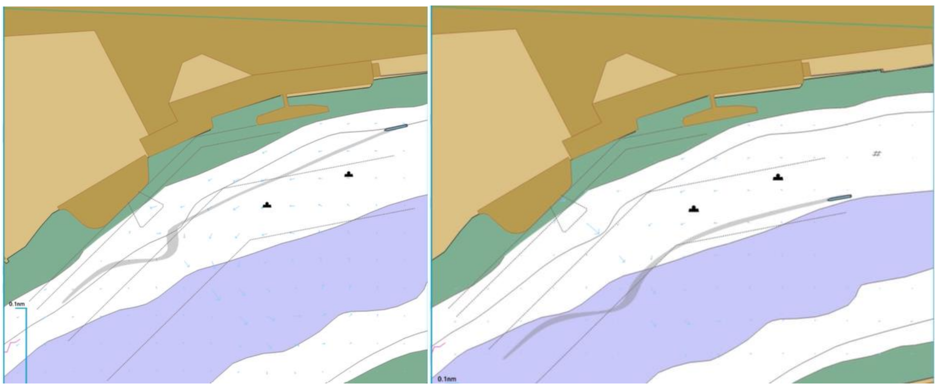
6.1.13 Further runs were undertaken on the 5th March 2024 to indicate if a tug towing a barge could pass the outfall at low water without being impacted by a discharge. Run 02 was of a tug towing a barge at 6 knots at approximately centreline of the river where there was a deflection from the discharge to the barge but the barge recovered Run 03 was of a tug towing a barge at 6 knots on a line to the south of the centreline of the main fairway. It can be seen that running on that line to the south of the centre of the main fairway there was no impact on the tug and tow.

Figure 6-4 Record of runs 02 and 03



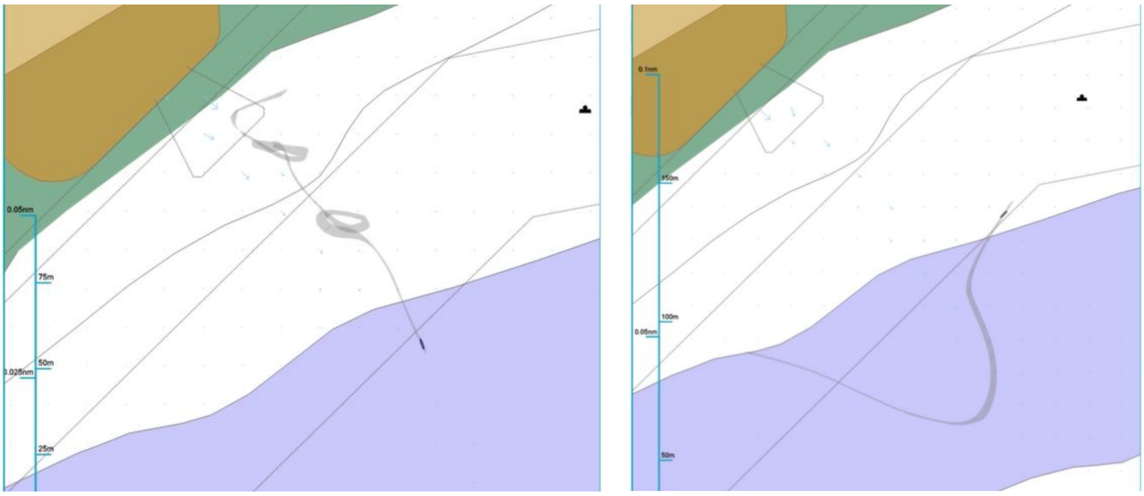
6.1.14 The vessels that provided concern were the narrowboats and unpowered vessels. The narrowboats were modelled in runs 30 and 31 which had the narrowboat transited the CSO outfall at low water slacks. The narrowboat was traveling at 3 knots whilst at 50m and 100m respectively. The simulation showed that whilst there was an impact on the narrowboat it did not cause an impact on vessels transiting upstream.

Figure 6-5 Record of runs 30 and 31



6.1.15 Figure 6-6 presents runs kayak runs 34 and 36. Run 34 was of the kayak travelling at 1 knot past the CSO at low water slacks with operator intervention. There was a significant impact of the discharge on the kayaker who struggled to regain control until they had passed into the main channel. Run 36 was of a Kayaker transiting past the outfall at 1knot whilst passing at 100m form the outfall. There was a significant impact on the kayaker who was taken into the main fairway before being able to recover to their previous course.

Figure 6-6 Record runs 34 and 36



6.1.16 The summary of the ship simulation is that the impacts are broadly in agreement with those assessed in section 5, with the exception of a tug towing upstream at low water. However with the runs undertaken on the 5th of March, it was demonstrated that the tug and tows were impacted within a zone130m to the south of the CSO.

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 NESR 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 structure and the NESR 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 NESR 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) Swamping

ii) Capsizing

iii) Grounding

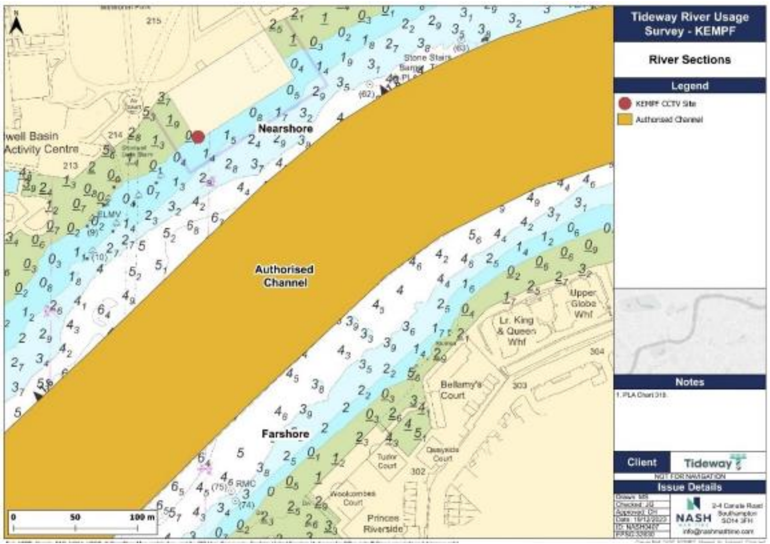
iv) Collision

7.3 Receptors

7.3.1 CCTV surveys of the river were undertaken at KEMPF from the 22nd of September to 31st of December 2023, but the data has been processed from the period 22nd of September to the 10th November 2023 providing a 7 week data set. The analysis of the data is presented in document "Tideway East KEMPF Traffic Survey Report 013l02".

7.3.2 The analysis was carried out to determine the classes of vessel that transit past the CSO outfall and which area of the river the vessel operates. The river is divided into nearshore, authorised channel and farshore, as indicated in Figure 7-1.

Figure 7-1 Nearshore, Authorised Channel and Farshore sections of the River Thames at KEMPF



7.3.3 Table 7-1 presents the data received from the CCTV surveys, which were also correlated with AIS information.

Table 7-1 Number of recorded vessels transiting nearshore, through the authorised channel and farshore

PLA Vessel Class	Nearshore	Authorised Channel	Farshore	Total
Uber Boat	3	4,782	569	5,354
Rib/Emergency Services	95	1,490	1,171	2,756
Class 5 Passenger	24	2,395	643	3,062
Tug	12	196	78	286
Tug (Pushing)	4	83	17	104
Tug (Towing)	1	148	111	260
Workboat	28	404	163	595
Recreational Cruiser	22	167	95	284
Narrowboat	0	18	13	31
Sailing Dinghy	6	1	3	10
Kayak	86	18	86	190
Rowing Boat	3	22	31	56
Coach / Safety Boat	3	20	9	32
Total	287	9,744	2,989	13,020

7.3.4 The key interest from the data is in vessels passing the NESR CSO which have been shown to be significantly impacted by a discharge. The vessel simulations presented concerns about kayakers transiting near to the outfall and 100m from the outfall. The other affected vessel types were tugs that were towing upstream at 100m from the outfall.

7.3.5 The 100m line is within the authorised channel so the important data would be for kayakers passing in the nearshore zone and the authorised channel and for tugs towing upstream within the nearshore zone and the authorised channel. In addition, analysis was carried out to determine the periods in the tidal cycle when tugs towing barges transit past the CSO outfall.

7.3.6 There were 287 movements within the nearshore zone, 86 of which the Kayakers. All but 1 of the 86 kayakers transited past the CSO outfall outside of the tidal impact window of 40 minutes before low water and 20 after low water. In fact the Kayakers typically pass the site between 2 ½ and 4 hours after low water.

7.3.7 The single kayaker that passed the site at within the tidal impact window at 39 minutes before low water, which was the start of the tidal impact window, however the Kayaker was travelling east bound.

7.3.8 There were 149 tugs towing in the authorised channel and one tug towing upstream in the inshore zone during the recorded period. There were nine tugs towing past the outfall at around low water, although only one was in the nearshore channel and 29 minutes after low water, which is within the impact window of act window of 40 minutes before low water and 20 minutes after low water. The remaining 130 tug and tows transited past the site between 1 hour after low water and high water.

7.3.9 Of the other vessel types which may be impacted such as the SUP and Sailing Dinghies, there were no SUP's recorded in the period and 7 records of sailing dinghies transiting past the outfall. The sailing dinghies transited past the site between 5 hours after low water to 3 hours before low water, outside of the window of impact on the main fairway

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) Swamping leading to a major injury or drowning.

ii) Capsizing leading to a major injury or drowning.

iii) Grounding leading to major Injury or illness due to exposure to sewage.

iv) 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.

v) 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.

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 the document King Edward Memorial Park Foreshore CSO discharge assessment and the corroboration of the HR Wallingford ship simulation work. The risk assessment has also established the 30 m^3/sec discharge as most probable worst case.

7.5.3 From analysis of the peak flow velocity plumes it was determined that the tidal window of impact is 120 minutes, from 65 minutes before low water to 55 minutes after low water. The ship simulation tracks indicate that the tidal window for impacting the main channel can be reduced to 40 minutes before low water to 20 minutes after low water. For the nearshore zone the tidal window for impact would be considered as being from mid ebb to mid flood.

7.5.4 A barrier closure could create still water and increase the impact of a discharge at any state of the tide, however this will impact still not be greater than the worst case of low water springs.

7.5.5 The current annual frequency of discharge has been established as an average of 20 with a maximum record of 31 discharges which could impact river users, however when the tunnel starts to intercept flows it is anticipated that this will be reduced to between four and six CSO discharges per year.

7.5.6 Without any data to show the frequency of man powered vessels in the area of the discharge the risk assessment has considered that a non-powered vessel would be present during each of those events and is therefore a conservative approach.

7.5.7 Taking all the above-mentioned factors into consideration the likelihood of harm is considered unlikely for vessels using the main fairway and the inshore zone at low water springs during a LTT maintenance period and highly unlikely for vessels using the main fairway and the inshore zone at low water when the tunnel is in operation and intercepting discharges due to the reduced frequency.

8. Mitigation

8.1.1 The ERIC, the hierarchy of risk management, approach will be adopted to review mitigation for this permanent 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 Once the LTT is commissioned the North East Storm Relief CSO discharges will be substantially reduced as most discharges will be intercepted with a prediction of a four discharges from the new NESR CSO outfall.

8.2.2 To eliminate the flows entirely would require the closing of the new NESR CSO outfall and would flood the upstream catchment area during storm events and is therefore not feasible.

8.3 Reduce

8.3.1 To reduce the risk of impact to the vessels a warning system could be adopted. 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.

8.3.2 Consideration was made to the use of cardinal posts or buoys to warn vessel users of the potential hazard. These were not considered to be not reasonably practicable due to the size of the posts and the variability of the position of a buoy due to the large tidal range and the potential of impact on man powered vessels.

8.4 Inform

8.4.1 During the development in the interim phase warning signs have been developed and designed by the MWC and offered for to the PLA for acceptance. The warning sign installed as part of the agreed interim arrangements should be trialled for adoption as part of the permanent case.

8.4.2 It is likely that the PLA will need to provide a new notice to mariners identifying new CSO operation and mitigations.

8.4.3 It is likely that the PLA will need to issue a notice to mariners during periods of LTT maintenance to identify that there could be an increased in the frequency and severity of a discharge.

8.4.4 Promulgation of the operational plan to the local water sports clubs, Limehouse Basin Lock and Shadwell Basin Outdoor Activity Centre.

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

9. 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) Limited number of CSO discharges once the tunnel in is operation.

(b) The limited impact of CSO discharges on powered vessels,

(c) The introduction of a warning light and sign to advise powered vessels that the CSO is discharging, and to make the tugs aware,of the impact from the discharge within a130m from the CSO.

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

(e) The use of an approved operational plan to be agreed with the PLA.

(f) The use of the HR Wallingford Ship Simulations highlighting a reduction in impacts on most vessels as the pass the NESR CSO, with the exception of tugs towing, during a 1:15 year return period discharge.

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 most powered vessels the risk is considered very low as powered vessels can pass the outfall, within the main channel, during a discharge provided they proceed with caution.

9.1.5 In the case of tugs towing the risk is considered low if the tugs are made aware of the impact of the discharge within 130m from the CSO,.

9.1.6 RIBS, Workboats and Narrowboats are the only powered vessels that are physically able to access the inshore zone due to draft restrictions.

Unpowered Vessels

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

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

Operational Plan

9.1.9 The operational plan will be developed by Tideway and the Main Works Contractor, CVB, 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.

9.1.10 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.

9.1.11 Navigational Risk Assessment

9.1.12 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 NESR CSO outfall.

9.1.13 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.

9.1.14 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,

9.1.15 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.

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

9.1.17 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.

9.2 Key Information

9.2.1 The assessment, modelling and ship simulation has been undertaken based around low water. No consideration has been made to differences between predicted and actual tide heights or deviation of the low tide time due to other factors, such as surge or atmospheric pressure.

9.2.2 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 30m^3/s. The frequency of discharges once the tunnel in in operation is expected to be between 4 and 6 per year.

9.2.3 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.

9.2.4 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 tidal windows presented in table.

Table 9-1 Tidal windows where impacts from a CSO discharge can be expected.

Inshore Zone (beyond 30m)		Main Fairway up to 130m from the CSO	
Start	Finish	Start	Finish
LW -3 hours	LWS+3 hours	LW -40 minutes	LW +20 minutes

9.2.5 It should be noted that table 9.1 should be considered for passing vessels at any slack period at high water or during a Thames barrier closure

9.2.6 It should be noted it is not possible to predict the discharges within 30m of the CSO at any state of the tide and that area should be avoided at any state of the tide during a discharge.

9.2.7 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 and the detailed design undertaken by the MWC.

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

9.2.9 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.
10. Multiple fatalities and catastrophic event

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

Rating	Description
High	HSEID risk resulting from design is unacceptably high. Revise design to reduce HSEID residual risk to an acceptable and manageable level.
Medium	HSEID risk resulting from design is permitted with appropriate design controls and management oversight in place.
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				

Total high risks

Total med risks

18 Total low risks

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.)	18 Action By (Name or Role)	19 Target Date	20 Revised Target Date	21 Date Action Complete	22 Tracker Status	23 Comments	24 Primary Legislation
CDM-KEMPF-020-A	Non-powered craft underway - Low tide	Interim	Kayak/Rower/Dinghy navigating in the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Major injury and/or drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Major injury and/or drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-B	Non-powered craft underway - Low tide	Interim	Kayak/Rower/Dinghy navigating the inshore zone in the vicinity of a CSO discharge	Capsizing due to a CSO discharge event	Public: Major injury and/or drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Major injury and/or drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-C	Non-powered craft underway - Low tide	Interim	Kayak/Rower/Dinghy navigating in the inshore zone in the vicinity of a CSO discharge	Grounding due to a CSO discharge event	Public:Major injury or illness due to exposure to sewage	2	4	8	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	4	4	Public:Major injury or illness due to exposure to sewage	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-D	Non-powered and Rec. powered vessel underway - Low Tide	Interim	Kayak/Rower/Dinghy and recreational powered vessel navigating 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. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-E	Non-powered and Commercial powered vessel underway - Low tide	Interim	Kayak/Rower/Dinghy and commercial powered vessel navigating 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. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-F	Rec. Powered Vessel underway - Low tide	Interim	Rec. Powered Vessel navigating the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury/Illness due to exposure to sewage or Major Injury	2	4	8	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	4	4	Public: Injury/Illness due to exposure to sewage or Major Injury	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-G	Rec. Powered Vessel underway - Low tide	Interim	Rec. Powered Vessel navigating the inshore zone in the vicinity of a CSO discharge	Grounding due to a CSO discharge event	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	4	4	Public: Major Injury	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-H	Rec. Powered Vessel and Commercial Powered Vessel underway - Low tide	Interim	Rec. Powered Vessel navigating 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	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	4	4	Public: Major Injury	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-I	Commercial Powered Vessel underway - Low tide	Interim	Commercial powered vessel navigating the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury/ Illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	3	3	Public: Injury/ Illness due to exposure to sewage	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-J	Commercial Powered Vessel underway - Low tide	Interim	Commercial powered vessel navigating the inshore zone in the vicinity of a CSO discharge	Grounding 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. Weather forecasting system 3. CSO Warning light	1	3	3	Public: Injury	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-K	Non-powered craft underway - All other states of tide	Interim	Kayak/Rower/Dinghy navigating in the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Illness due to exposure to sewage or Drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Illness due to exposure to sewage or Drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-L	Non-powered craft underway - All other states of tide	Interim	Kayak/Rower/Dinghy navigating the inshore zone in the vicinity of a CSO discharge	Capsizing due to a CSO discharge event	Public: Illness due to exposure to sewage or Drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Illness due to exposure to sewage or Drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-M	Non-powered and Rec. powered vessel underway - All other states of tide	Interim	Kayak/Rower/Dinghy and recreational powered vessel navigating 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. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Major injury and or drowning	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
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Low	HSEID risk resulting from design is permitted.

RISK

LIKELIHOOD					
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

Total high risks

Total med risks

18 Total low risks

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.)	18 Action By (Name or Role)	19 Target Date	20 Revised Target Date	21 Date Action Complete	22 Tracker Status	23 Comments	24 Primary Legislation
CDM-KEMPF-020-N	Non-powered and Commercial powered vessel underway - All other states of tide	Interim	Kayak/Rower/Dinghy and commercial powered vessel navigating 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. Weather forecasting system 3. CSO Warning light	1	5	5	Public: Major injury and or drowning	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-O	Rec. Powered Vessel underway -All other states of tide	Interim	Rec. Powered Vessel navigating the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury or illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	3	3	Public: Injury or illness due to exposure to sewage	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-P	Rec. Powered Vessel and Commercial Powered Vessel underway - All other states of tide	Interim	Rec. Powered Vessel navigating 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. Weather forecasting system 3. CSO Warning light	1	4	4	Public: Major injury	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-Q	Powered Emergency Vessels underway - Low tide	Interim	Powered Emergency Vessels responding to an emergency in close proximity of a CSO discharge	Grounding due to CSO discharge event	Public: Injury/ Illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	3	3	Public: Injury/ Illness due to exposure to sewage	MWC's WPP, Notice to Mariners							
CDM-KEMPF-020-R	Powered Emergency Vessels underway - All other states of tide	Interim	Powered Emergency Vessels responding to an emergency in close proximity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury/ Illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. Weather forecasting system 3. CSO Warning light	1	3	3	Public: Injury/ Illness due to exposure to sewage	MWC's WPP, Notice to Mariners							