

Hampshire Water Transfer and Water Recycling Project

Environmental Statement – Appendix 19.10 Degradation Modelling

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The Southern Water logo graphic consists of three stylized, wavy blue lines of varying lengths, positioned to the right of the text 'Southern Water.'

FACTUAL REPORT

Hampshire Water Transfer and Water Recycling Project

Havant Thicket Reservoir - Compensatory Flows Water Quality Degradation Modelling

Client: Southern Water

Reference: PC5223-RHD-XX-XX-RP-X-0001

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Table of Contents

1	Introduction	1
1.1	Overview of the Proposed Development	1
1.2	Purpose of the report	1
1.3	Requirements for dispersion and degradation modelling	1
2	Approach	3
2.1	Summary	3
2.2	Model selection	3
3	Discharge/Ambient Conditions	4
4	MIKE Model Development	8
4.1	Model extent	8
4.2	Bathymetry/survey data	9
4.3	Structures	12
4.4	Model mesh	12
4.5	Model verification	13
5	Dispersion and Degradation Model	15
5.1	Model setup	15
5.1.1	Discharge	15
5.1.2	MIKE ECOLab	15
5.2	Model scenarios	17
5.3	Model outputs	18
5.4	Model Results	19
5.4.1	Dissolved Oxygen (DO)	19
5.4.2	Phosphate (PO ₄)	21
5.4.3	Biological Oxygen Demand (BOD)	23
5.4.4	Nitrate (NO ₃)	25
5.4.5	Ammonium (NH ₄)	26
6	References	29

Table of Tables

Table 3-1: Concentrations of chemical parameters for each model scenario, derived from the Havant Thicket Reservoir modelling (GHD, 2024)	4
Table 3-2: River flow rates for water quality modelling	4

Project related

Table 3-3: Winter and summer temperature of discharged compensatory flow from Havant Thicket reservoir for pre and post WRP scenarios	5
Table 3-4: Baseline mean water quality data for Riders Lane, Hermitage Stream and Langstone Harbour, derived from Atkins (2020) and Environment Agency (2024) sampling data	6
Table 5-1: Winter and summer average temperature for model simulations	15
Table 5-2: Change in minimum dissolved oxygen concentration (mg/l) at eight output locations (degradation and conservative tracer modelling for comparison)	21
Table 5-3: Change in maximum phosphate concentration (mg P/l) at 8 output locations (degradation and conservative tracer modelling for comparison)	23
Table 5-4: Change in maximum BOD concentration (mg/l) at eight output locations (degradation and conservative tracer modelling for comparison)	25
Table 5-5: Change in maximum nitrate concentration (mg N/l) at eight output locations (degradation and conservative tracer modelling for comparison)	26
Table 5-6: Change in maximum ammonium concentration (mg N/l) at eight output locations (degradation and conservative tracer modelling for comparison)	28

Table of Figures

Figure 1-1: Havant Thicket Reservoir and downstream water bodies	2
Figure 3-1: Location of hydrological catchments used to derive river flows	5
Figure 3-2: Location of water quality monitoring points	7
Figure 4-1: Extended IOW model extent for Havant water quality modelling	8
Figure 4-2: Full IOW model extent for Havant Thicket reservoir	9
Figure 4-3: Extent of bathymetry updates	10
Figure 4-4: Survey cross section data covering Riders Lane and Hermitage Streams	11
Figure 4-5: Extended IOW model domain and bathymetry	11
Figure 4-6: Example CAD cross section of culvert from Storm Geomatics survey (XS – RID01_00453) (Storm Geomatics, 2024)	12
Figure 4-7: Refined mesh at the northern end of Langstone Harbour	13
Figure 4-8: Refined quadrangular mesh in the lower reaches of Hermitage Stream down to the tidal limit	13
Figure 4-9: Verification of simulated water levels from the updated IOW model for Havant	14
Figure 5-1: MIKE ECOLab model structure (DHI, 2024)	17
Figure 5-2: Considered physio-bio-chemical processes in MIKE ECOLab (DHI, 2024)	17
Figure 5-3: Model output locations	19
Figure 5-4: Change in minimum dissolved oxygen concentration (mg /l) between HTR Classic and post WRP – Winter	20
Figure 5-5: Change in minimum dissolved oxygen concentration (mg/l) between HTR Classic and post WRP – Summer	21

Project related

Figure 5-6: Change in maximum phosphate concentration (mg P/l) between HTR Classic and post WRP – Winter	22
Figure 5-7: Change in maximum phosphate concentration (mg P/l) between HTR Classic and post WRP – Summer	22
Figure 5-8: Change in maximum BOD concentration (mg /l) between HTR Classic and post WRP – Winter	24
Figure 5-9: Change in maximum BOD concentration (mg /l) between HTR Classic and post WRP – Summer	24
Figure 5-10: Change in maximum nitrate concentration (mg N/l) between HTR Classic and post WRP – Winter	25
Figure 5-11: Change in maximum nitrate concentration (mg N/l) between HTR Classic and post WRP – Summer	26
Figure 5-12: Change in maximum ammonium concentration (mg N/l) between HTR Classic and post WRP – Winter	27
Figure 5-13: Change in maximum ammonium concentration (mg N/l) between HTR Classic and post WRP – Summer	28

1 Introduction

1.1 Overview of the Proposed Development

Southern Water is proposing to develop the Hampshire Water Transfer and Water Recycling Project (hereafter referred to as the 'Proposed Development') through an application for a Development Consent Order (DCO), under the Planning Act 2008. The Proposed Development is a drought resilience scheme comprising a combination of both water transfer and water recycling technology that during drought conditions would play a major role in making up any shortfall in water supply across the Hampshire supply area.

The Proposed Development would use an advanced treatment process to turn treated wastewater into purified recycled water at a proposed Water Recycling Plant (WRP) to be located south of Havant in the vicinity of Budds Farm Wastewater Treatment Works (WTW). The recycled water would then be transferred via a pipeline to Havant Thicket Reservoir. This would supplement the source water proposed to be stored in the reservoir by Portsmouth Water. A proposed Underground Pipeline would be constructed to transfer source water from Havant Thicket Reservoir to the Otterbourne Water Supply Works (WSW), approximately 40km to the north-west. Here it would be treated to strict drinking water standards ready for supply to homes and businesses. Havant Thicket Reservoir, once constructed, will include the provision of compensatory flows to downstream watercourses.

A detailed description of the Proposed Development is contained in Environmental Statement Chapter 3: Description of the Proposed Development, Volume I.

1.2 Purpose of the report

The purpose of this Factual Report is to summarise the results of a water quality dispersion and degradation modelling study, investigating the discharge of compensatory flows from Havant Thicket Reservoir into downstream water bodies (Riders Lane Stream, Hermitage Stream and Langstone Harbour), and how the modelled parameters change over time in response to physical, biological and chemical factors.

This Factual Report presents the model outputs without any interpretation or assessment of environmental effects. Further interpretation will be provided in:

- Environmental Statement Chapter 8 Terrestrial and freshwater biodiversity, Volume I.
- Environmental Statement Chapter 9 Marine biodiversity, Volume I.
- Environmental Statement Chapter 19 Water environment, Volume I.
- Environmental Statement Appendix 19.2 Water Environment Regulations compliance assessment, Volume II.

1.3 Requirements for dispersion and degradation modelling

Detailed modelling of water quality in Havant Thicket Reservoir has been undertaken on behalf of Portsmouth Water and Southern Water (GHD, 2024). This considered the spatial and temporal changes to water quality within the reservoir during the commissioning and operational phases, including those that are likely to result from the discharge of recycled water from the proposed Water Recycling Plant (WRP) into the reservoir. Further modelling is required to examine the impacts of any changes in operational discharges from the reservoir (e.g., compensatory flows) on downstream water bodies.

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Additional water quality modelling has therefore been completed to inform the assessment of the potential impacts on water quality in Riders Lane Stream, Hermitage Stream, and Langstone Harbour.

An overview of the study area for this study is provided in **Figure 1-1**.

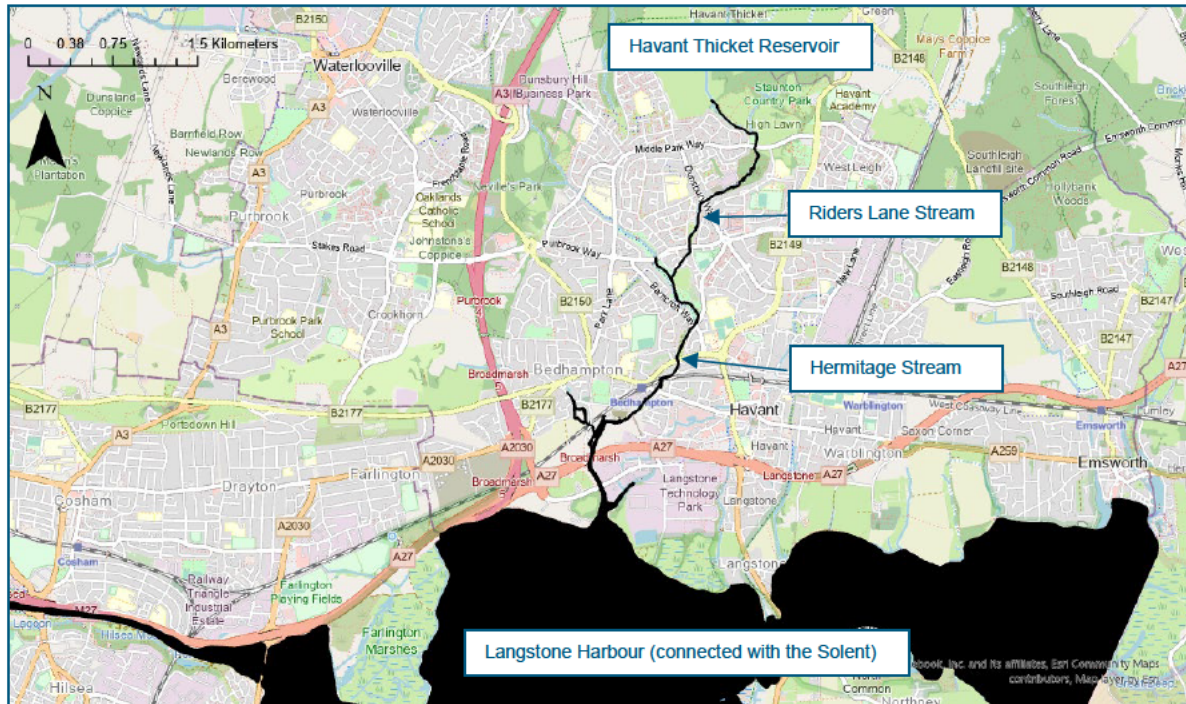


Figure 1-1: Havant Thicket Reservoir and downstream water bodies

2 Approach

2.1 Summary

This study builds upon a previous modelling study (Royal HaskoningDHV, 2024) which predicted excess or deficit concentrations of “conservative” water quality parameters. This “conservative” approach assumed that concentrations of each water quality parameter are not subject to chemical degradation or biological uptake processes and are only affected by physical dispersion processes.

The further modelling study summarised in this Factual Report has utilised a combined dispersion and degradation modelling approach, to investigate both the mixing and dispersion processes in response to hydrodynamics, as well as degradation and accumulation processes in response to surrounding physical, biological and chemical factors; of water discharged from the reservoir into downstream water bodies as it becomes mixed with ambient water.

This modelling exercise considered a subset of parameters that are used to define the physio-chemical status of surface water bodies and therefore have an Environmental Quality Standard (EQS) or equivalent in Schedule 3, Part 1 of the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 (the “WFD Directions 2015”) and were also included in Southern Water and Portsmouth Water’s Havant Thicket Reservoir modelling (GHD, 2024). The GHD (2024) study defined concentrations of parameters for pre and post the utilisation of the reservoir for the storage of recycled water from the proposed WRP. These scenarios are discussed further in **Section** Error! Reference source not found..

The concentration of parameters within the baseline model were defined from measured data of the ambient environment in Riders Lane Stream, Hermitage Stream and Langstone Harbour, obtained from Portsmouth Water (Atkins, 2020) and the Environment Agency’s Water Quality Data Archive (EA, 2024). The model simulations predict the fate of parameters discharged from the reservoir in response to mixing with the ambient environment, producing absolute values of each parameter over a 30 day simulation of two spring-neap tidal cycles.

2.2 Model selection

The modelling study utilised the Solent and Isle of Wight 2-dimensional MIKE21 Flow Model (FM) (referred to as the ‘Isle of Wight (IOW) model’) originally developed by Royal HaskoningDHV on behalf of Southern Water for modelling discharges from the Eastney Long Sea Outfall (LSO). The model has been calibrated and verified to tide levels and measured currents speeds in the area, for a variety of other mixing and dispersion modelling studies, assessing the impact of outfall discharges around the Solent and Isle of Wight for Southern Water’s projects. Further information on the previous model calibration is provided in Environmental Statement Appendix 19.5 Eastney LSO dispersion modelling, Volume I.

The existing IOW model covered up to the tidal limit of Langstone Harbour. For this study, the model domain was extended and model mesh refined to include the upstream reaches of the Hermitage Stream and the full extent of Riders Lane Stream up to the proposed discharge point from Havant Thicket Reservoir. A detailed description of this model update, including input data and model verification is presented in **Section** Error! Reference source not found.. The calibrated MIKE hydrodynamic model was coupled with the ECOLab module of the MIKE software package. The MIKE ECOLab module is a numerical tool for ecological modelling, it is an open and generic tool for customising aquatic ecosystem models to describe water quality parameters, eutrophication potential and ecology. The tool enables mathematical descriptions of physio-bio-chemical processes to be coupled with the MIKE hydrodynamic model, to predict dispersion and degradation of pollutants in water bodies.

3 Discharge/Ambient Conditions

The dispersion and degradation modelling considered a range of chemical parameters derived from the Havant Thicket Reservoir modelling study completed by GHD (2024) for Southern Water and Portsmouth Water, as highlighted in **Table 3-1**. The table shows maximum or minimum concentrations of chemical parameters within the compensatory flows from Havant Thicket Reservoir (HTR), for two key scenarios.

1. **HTR Classic (Pre WRP) (March 2029 – May 2032)** – “Pre-implementation”: classic operation phase prior to the input of recycled water from the proposed WRP (i.e. Pre WRP);
2. **WRP Scenario (Post WRP) (June 2032 – December 2041)** – “Post implementation”: recycling operation phase which includes water from the WRP (i.e. Post WRP).

Table 3-1: Concentrations of chemical parameters for each model scenario, derived from the Havant Thicket Reservoir modelling (GHD, 2024)

Parameter	Unit	Statistic	HTR Classic – Pre WRP (Mar 2029 – May 2032)	WRP Scenario (Jun 2032 – Dec 2041)
Nitrate (NO ₃)	mg N/l	Max	5.3141	2.4598
Ammonium (NH ₄)	mg N/l	Max	0.0732	0.0910
Phosphate (PO ₄)	mg P/l	Max	0.0066	0.0186
Biological Oxygen Demand (BOD)	mg/l	Max	2.4074	5.4176
Dissolved Oxygen (DO)	mg/l	Min	7.1189	7.2861

The Q_{mean} river flow was applied for Riders Lane and Hermitage Stream. The flow rates were derived from the Environment Agency’s flow gauge on the Hermitage Stream at Bedhampton (Environment Agency, 2025) and calculated using LowFlows 2 (WHS, 2025), a catchment modelling software package. The flow rates and associated catchments are presented in **Table 3-2**, where ID 1 is the flow from Havant Thicket Reservoir, ID 2 is derived from the Riders Lane Stream catchment and ID 3 is derived from the Hermitage Stream catchment down to the Riders Lane Stream confluence (**Figure 3-1**).

The discharge temperature of the compensatory flow from Havant Thicket Reservoir under both scenarios is presented in **Table 3-3**. These values were derived from the Havant Reservoir Modelling study (GHD, 2024). Temperature is an important parameter in the ECOLab calculations, to effectively predict the fate of parameters through degradation and respiration processes. The discharge temperatures presented in **Table 3-3** show an increase during winter and a decrease during summer under the WRP scenario, when compared to the HTR Classic scenario.

Table 3-2: River flow rates for water quality modelling

ID	Watercourse	Location	Upstream Catchment Area (km ²)	Annual Flow (m ³ /s)
				Q_{mean}
1	Riders Lane Stream	Havant Thicket Reservoir compensatory flow outfall	2.211	0.025

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ID	Watercourse	Location	Upstream Catchment Area (km ²)	Annual Flow (m ³ /s)
				Qmean
2	Riders Lane Stream	Confluence with Hermitage Stream	4.591	0.051
3	Hermitage Stream	Confluence with Riders Lane Stream	11.480	0.131

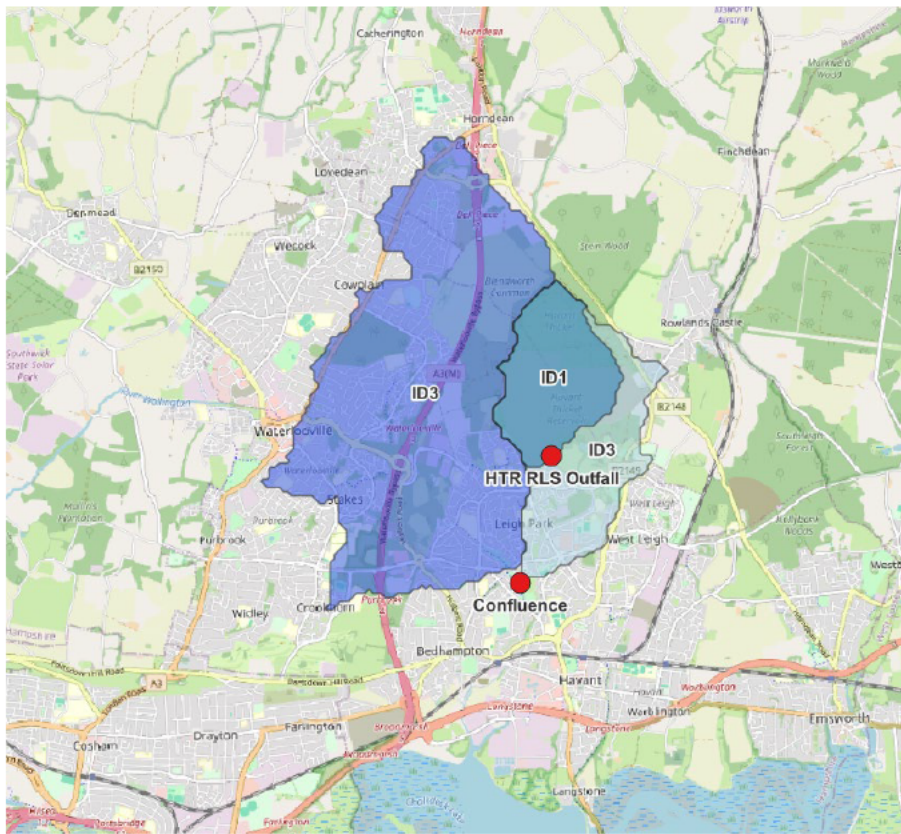


Figure 3-1: Location of hydrological catchments used to derive river flows

Table 3-3: Winter and summer temperature of discharged compensatory flow from Havant Thicket reservoir for pre and post WRP scenarios

Scenario	Winter	Summer
HTR Classic - Pre WRP (baseline)	6.03°C	20.05°C
Post WRP (WRP scenario)	6.17°C	19.53°C

The ambient conditions to describe the current baseline water quality parameters within Riders Lane Stream, Hermitage Stream and Langstone Harbour were derived from measured water quality data from both Atkins (2020) and the Environment Agency (2024), to obtain winter (December, January and February) and summer (June, July and August) average values for modelling (Table 3-4 and Figure 3-2). These values were set as the initial conditions throughout the model domain to describe the parameter concentrations for the ambient environment, before any discharge from Havant Thicket Reservoir.

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This was achieved by taking the long timeseries dataset (2000 – 2024) of sampled water quality parameters at each of the three locations highlighted in **Figure 3-2**, and filtering based on parameter (nitrate, ammonium, BOD, phosphate and DO) and season (winter and summer). Average values were then obtained from these filtered lists to give the concentrations outlined in **Table 3-4**. Due to lack or limited measured data, the following assumptions were made to provide ambient concentrations for the model:

- No measured dissolved oxygen data available for Rider’s Lane stream, therefore, concentration for Hermitage Stream is assumed constant for both regions.
- No measured BOD data available for Langstone Harbour, therefore, concentrations for Hermitage Stream is assumed constant for both regions.

An example calculation for ammonium is presented in **Appendix A**.

Table 3-4: Baseline mean water quality data for Riders Lane, Hermitage Stream and Langstone Harbour, derived from Atkins (2020) and Environment Agency (2024) sampling data

Parameter	Season	Location		
		Riders Lane	Hermitage Stream	Langstone Harbour
DO (mg/l)	Winter	12.4484	12.4484	9.3247
	Summer	14.1840	14.1840	7.6341
BOD (mg/l)	Winter	1.6800	2.0307	2.0307
	Summer	4.1800	2.9557	2.9557
NH ₄ (mg N/l)	Winter	0.0307	0.0953	0.0348
	Summer	0.0531	0.0717	0.0186
NO ₃ (mg N/l)	Winter	1.4300	8.8822	0.2921
	Summer	2.7222	12.9077	0.0569
PO ₄ (mg P/l)	Winter	0.0478	0.0847	0.0220
	Summer	0.1748	0.1505	0.0090

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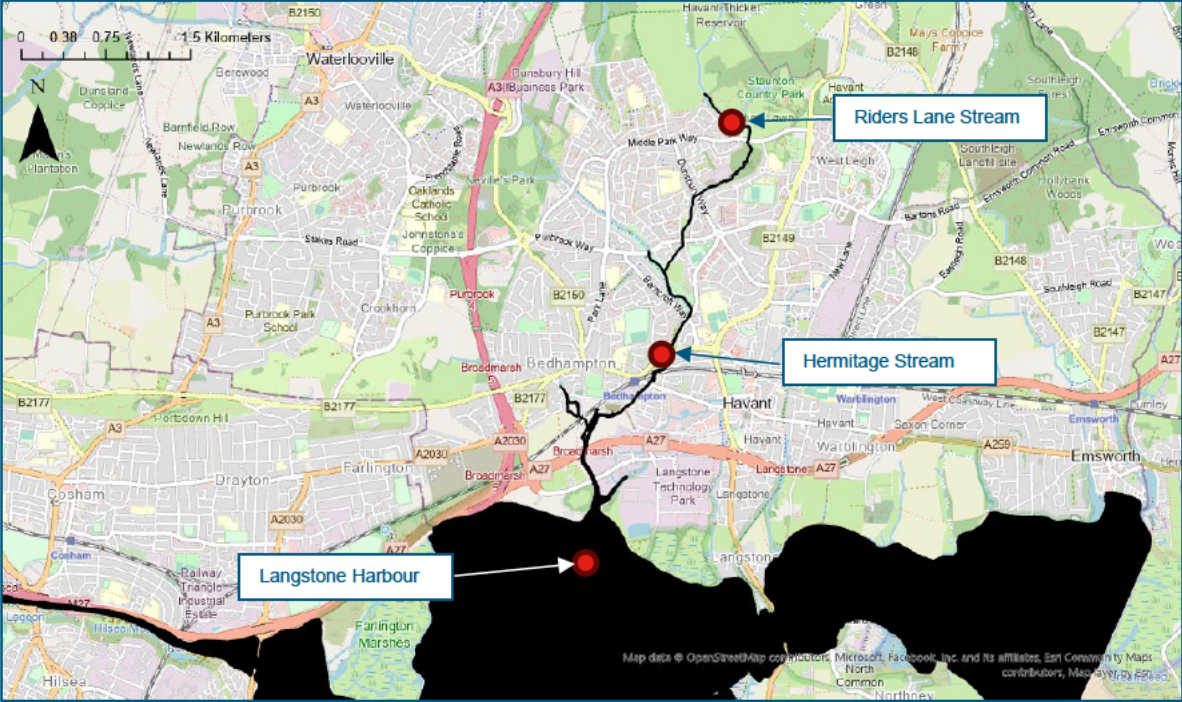


Figure 3-2: Location of water quality monitoring points

4 MIKE Model Development

This section presents the relevant updates to the Royal HaskoningDHV IOW model and an additional validation exercise to ensure that simulated water levels compare to the predicted tides within Langstone Harbour.

The key model updates included an update of bathymetry data where new surveys were available and an extension upstream of the tidal limit of Langstone Harbour into Hermitage Stream and to the upper limit of Riders Lane Stream at the Havant Thicket Reservoir compensatory flow outfall.

4.1 Model extent

The updated IOW model extent is presented in **Figure 4-1**, where the domain has been extended to the top of Riders Lane Stream and to the Purbrook Way road bridge crossing Hermitage Stream. In addition to this, the coastline details of the inner Langstone Harbour and Portsbridge Creek have also been refined. The full model extent is presented **Figure 4-2**.

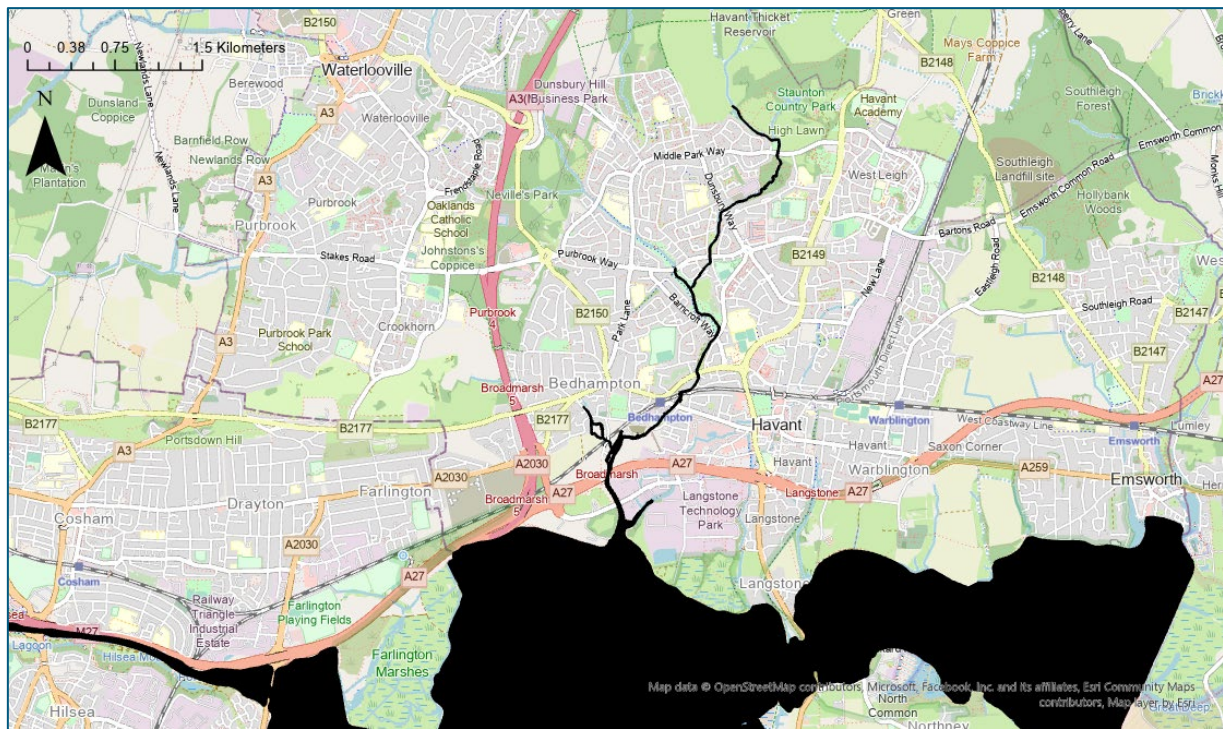


Figure 4-1: Extended IOW model extent for Havant water quality modelling

Project related

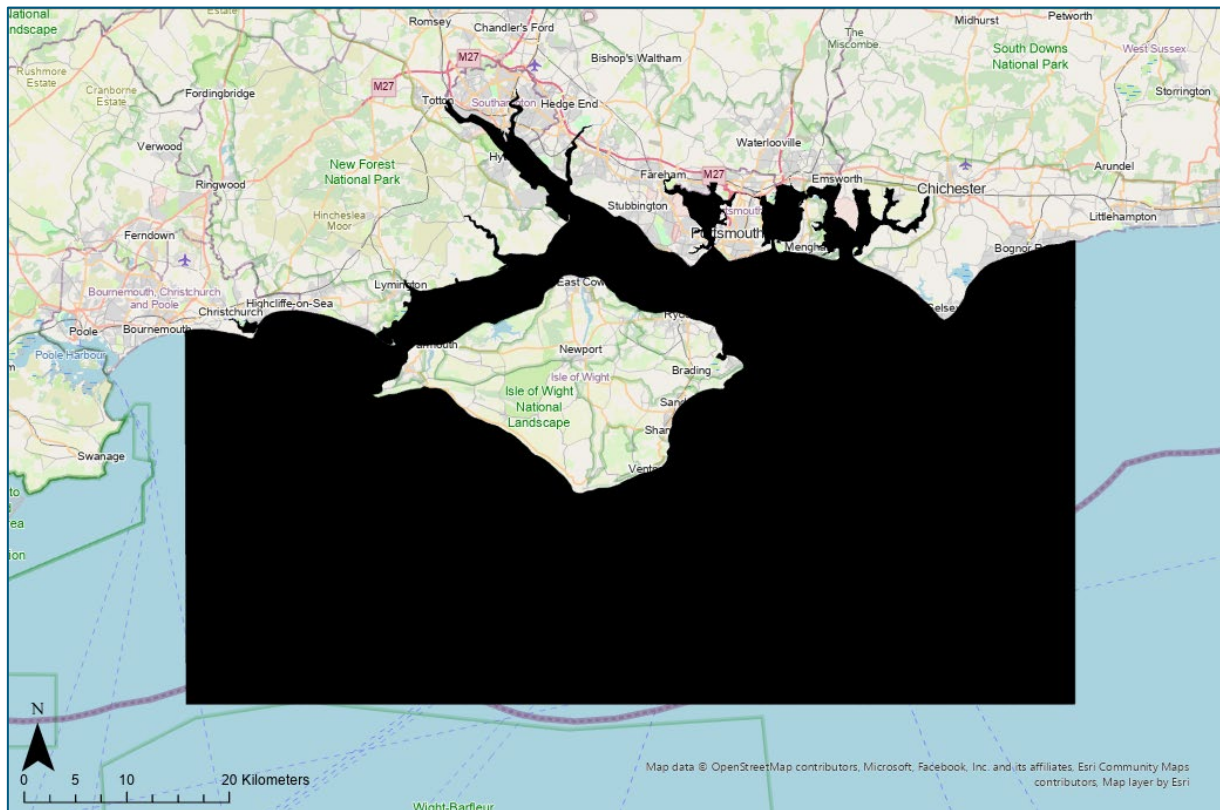


Figure 4-2: Full IOW model extent for Havant Thicket reservoir

4.2 Bathymetry/survey data

The existing bathymetry for the model domain was made up of the Marine Themes Digital Elevation Model (DEM) (2021) bathymetry data from OceanWise Ltd. The data comprises a number of sources including UKHO bathymetry and navigational charts (UKHO, 2024). For Langstone Harbour this data is reasonably coarse, therefore, it was necessary to update the bathymetry data in this region using the following data sources from the UKHO Admiralty Data Portal (UKHO, 2024) and the Environment Agency (2022) (**Figure 4-3**):

- 2005 – 2006 Langstone Harbour – single beam bathymetric survey covering a large extent of Langstone Harbour (UKHO, 2024).
- 2019 Langstone Harbour – high resolution single beam transects of the main channels throughout Langstone Harbour (UKHO, 2024).
- 2022 Langstone Harbour and Approaches – high resolution multibeam bathymetric survey of the approach channel into Langstone Harbour (UKHO, 2024).
- 2022 LiDAR – digital terrain model (DTM) of the low-lying mudflats and grass islands in the north of Langstone Harbour (EA, 2022).

A variety of cross-sectional surveys were used to define the bed levels throughout Hermitage Stream and Riders Lane Stream, these are summarised as follows and their extent visualised in **Figure 4-4**:

- 2024 Storm Geomatics Riders Lane stream channel survey ('24SOW012351_RPT_Riders Lane Stream Channel Survey Report.pdf') – cross section data and structure drawings for Riders Lane Stream (Storm Geomatics, 2024).

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- 2005 Longdin & Browning Surveys Ltd topographic and section surveys ('5279 Report.doc') – cross section surveys of Hermitage Stream and Riders Lane Stream (Longdin & Browning Surveys Ltd, 2005).
- River boundary was created using the OS OpenMap Local data set that is freely available for download from the Ordnance Survey Open Data Portal (OS, 2023).

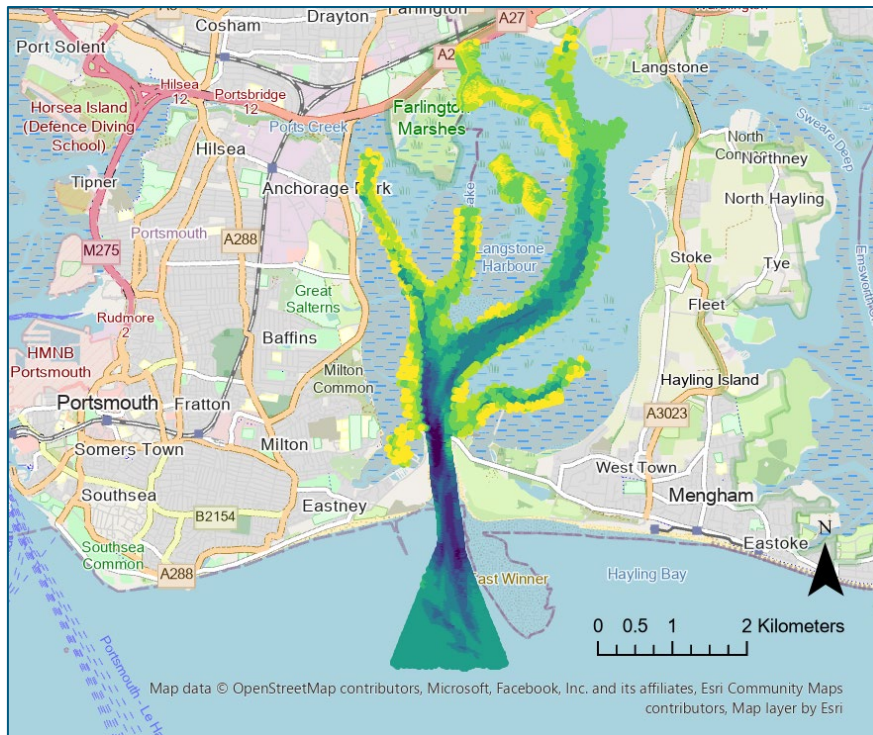


Figure 4-3: Extent of bathymetry updates

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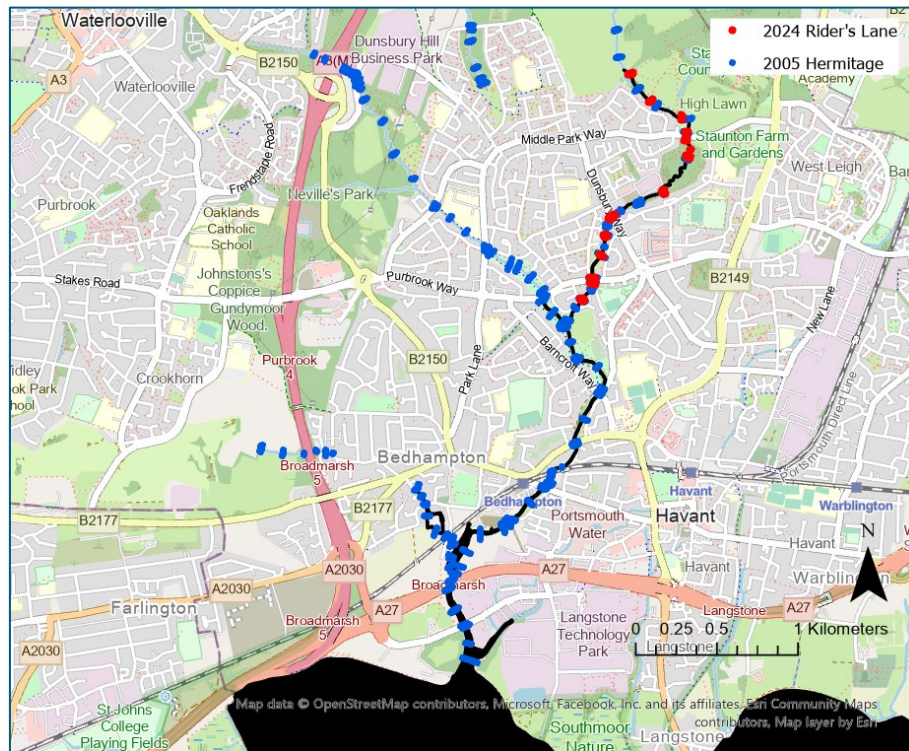


Figure 4-4: Survey cross section data covering Riders Lane and Hermitage Streams

Combining the above bathymetry and survey data, the complete model domain and bathymetry is presented in **Figure 4-5**.

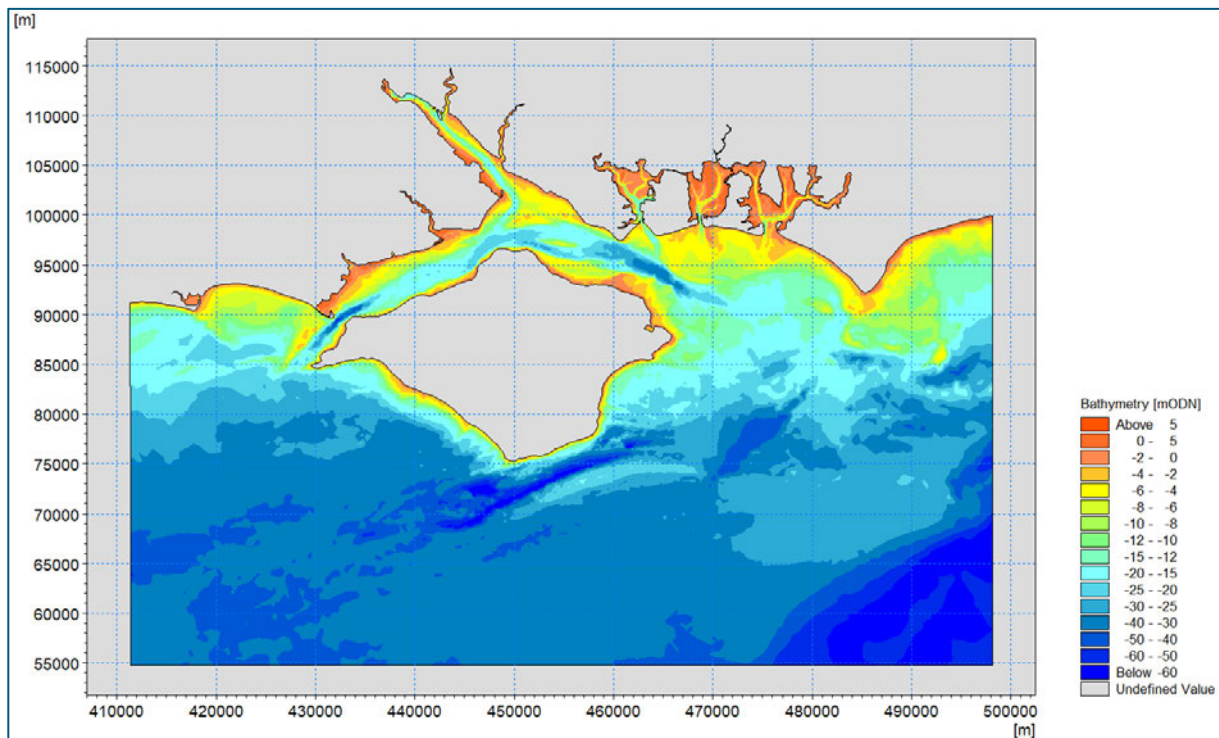


Figure 4-5: Extended IOW model domain and bathymetry

4.3 Structures

The fluvial structures throughout Hermitage Stream and Riders Lane Stream were defined by both the 2024 and 2005 topographic surveys. The weir at the tidal limit as well as the series of culverts between Havant Thicket Reservoir and Langstone Harbour were included in the model. Foot bridges and road bridges were disregarded in the model simulations as the soffit of the structures was assumed sufficiently raised beyond the water levels for the Q95 and Qmean flows considered in the study.

An example of a culvert structure for Riders Lane Stream is presented in **Figure 4-6**, which is a CAD drawing from the 2024 Storm Geomatics survey. For the simulations the model required invert level, culvert diameter and culvert length.

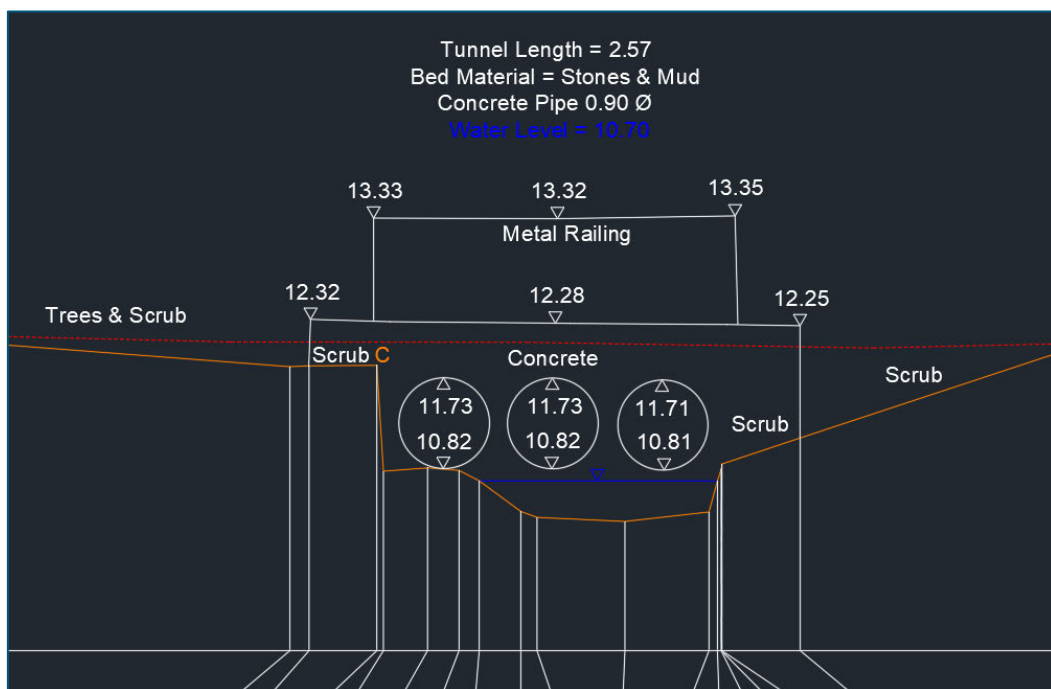


Figure 4-6: Example CAD cross section of culvert from Storm Geomatics survey (XS – RID01_00453) (Storm Geomatics, 2024)

4.4 Model mesh

The computational mesh of the MIKE21 model is refined within Langstone Harbour and throughout both Hermitage Stream and Riders Lane Stream, as presented in **Figure 4-7** and **Figure 4-8**, respectively. Where possible, quadrangular mesh was applied within the fluvial sections of the model, as computational cells are aligned with the flow direction and stability of calculations is improved through uniform cell characteristics. Other areas utilised MIKE's flexible triangular unstructured grid for suitable meshing around complex coastal geometries.

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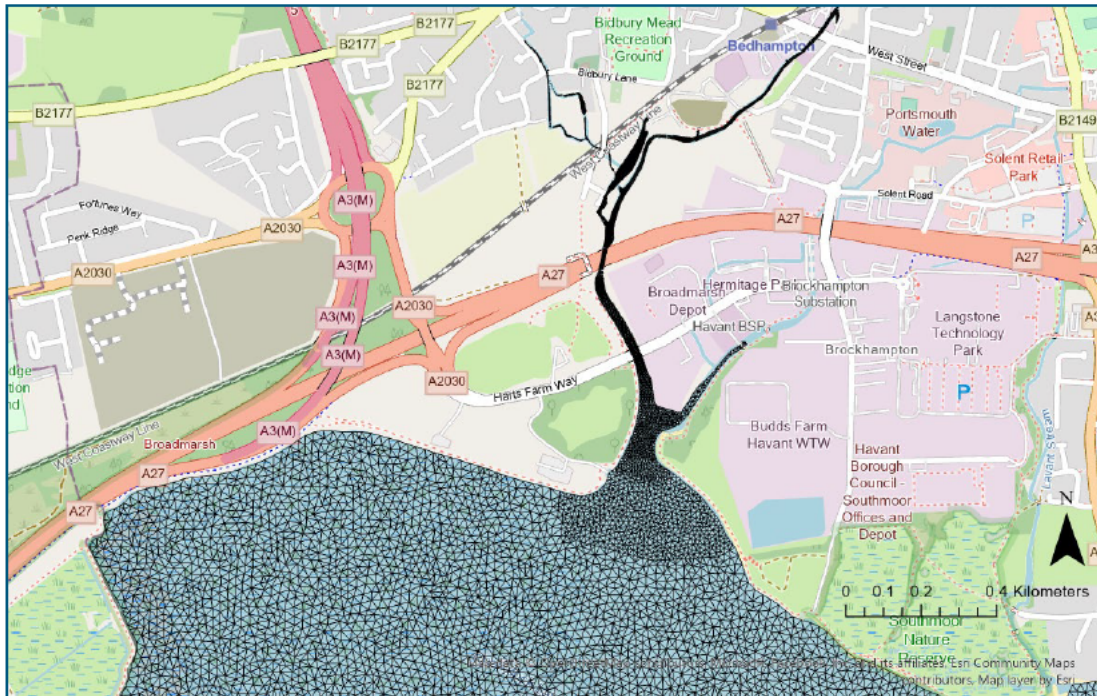


Figure 4-7: Refined mesh at the northern end of Langstone Harbour



Figure 4-8: Refined quadrangular mesh in the lower reaches of Hermitage Stream down to the tidal limit

4.5 Model verification

For verification of the updated model, simulations were carried out for one month during July 2020 to compare modelled water levels with astronomic tide levels (UKHO, 2020) at locations throughout the model domain (Portsmouth, Langstone Harbour, Sandown and Cowes). These results are presented in **Figure 4-9**. The model verification confirms that simulated water levels throughout the domain compare well with both the tidal range and phase of the astronomic levels.

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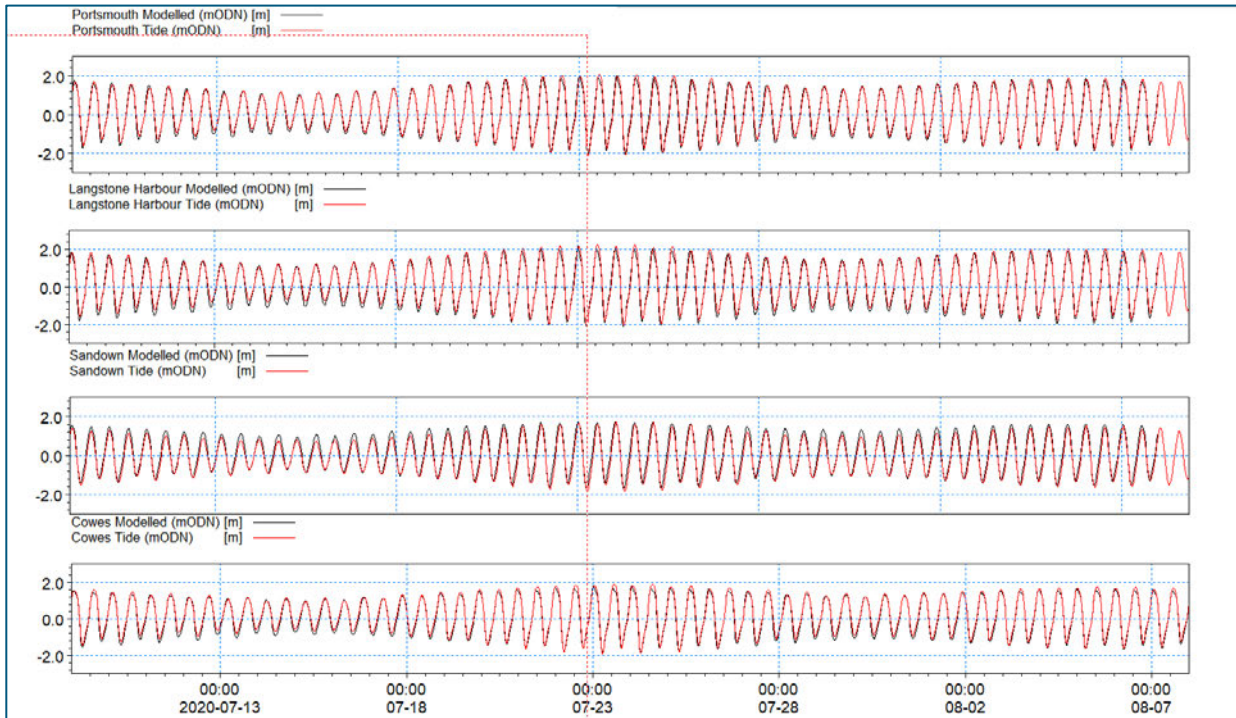


Figure 4-9: Verification of simulated water levels from the updated IOW model for Havant

5 Dispersion and Degradation Model

5.1 Model setup

5.1.1 Discharge

Ambient temperature for summer and winter scenarios was derived from measured data within the Solent for the offshore boundary and domain, and from sample data in Hermitage Stream for the river flow boundary conditions. The temperature of the compensatory flow from the Havant Thicket Reservoir is previously discussed in the discharge conditions description (**Section Error! Reference source not found.**).

A 15-year timeseries of measured sea surface temperature (°C) was obtained from the Channel Coastal Observatory (CCO) at Bracklesham Bay wave buoy (CCO, 2024). The timeseries was used to derive winter and summer average temperatures for offshore boundary conditions and initial conditions throughout the model domain. These values are presented in **Table 5-1**.

A salinity of 34.1 PSU was selected at the offshore boundary and 0 PSU at the river flow boundaries. This ambient salinity is based on a seasonal average (July – August), derived from 5-year (2015-2020) coastal sampling data provided by Southern Water.

A 24-year dataset from the Environment Agency’s online Water Quality Data Archive was obtained at the Hermitage Stream site (Site ID SO-G0003625, as shown in **Figure 3-2**), which included a total of 242 samples (EA, 2024). This dataset was used to derive winter and summer average temperatures for the river boundary conditions at the Hermitage Stream and Riders Lane Stream lateral inflow. These values are presented in **Table 5-1**.

Table 5-1: Winter and summer average temperature for model simulations

Season Average	Offshore/Domain Temperature (°C)	River Flow Temperature (°C)
Winter	7.78	6.78
Summer	18.22	17.69

The offshore boundary conditions for the model were derived from Royal HaskoningDHV’s English Channel regional model, as discussed in Section 4, where a spatially and temporally varying water level is specified at the offshore boundary to cover the full one month simulation period.

5.1.2 MIKE ECOLab

The MIKE21/3 ‘Water Quality with Nutrients’ ECOLab template was used for this study, which predicts the physical, chemical and biological interactions of the following ‘state variables’:

- Biological Oxygen Demand (dissolved), BOD_{dissolved}
- Biological Oxygen Demand (suspended), BOD_{suspended}
- Biological Oxygen Demand (sedimented), BOD_{sedimented}
- Dissolved Oxygen, DO
- Nitrate
- Ammonium
- Phosphate

Project related

The input ambient concentrations in the model for these parameters were derived from the measured water quality data as described in **Section 0** and **Table 3-4**, and the boundary conditions of discharged water from the Havant Thicket reservoir were derived from the GHD modelling study (GHD, 2024) as detailed in **Table 3-1**. For the purpose of this modelling exercise, it is assumed that BOD concentrations in suspended sediment and bed sediment are 0mg/l, therefore all reference to BOD from here refers to dissolved concentrations only. These assumptions are based on the below information:

- **BOD_{sedimented}** – the hydrodynamic forcing (erosion and deposition) which influences the BOD_{sedimented} concentrations, do not change between pre WRP and post WRP scenarios, so when focussing on change in concentration in this study, the results would cancel each out.
- **BOD_{suspended}** – the results of the GHD modelling show that the maximum total suspended sediment concentration (TSS) in the reservoir discharge is 0.46 mg/l for the post WRP scenario (GHD, 2024), which is understandable as the discharge is treated water. In addition to this, the nature of the river system originating from a chalk groundwater source, naturally low suspended sediment concentrations would be expected in the receiving water. As this concentration is very low it is reasonable to assume that associated BOD_{suspended} concentrations would be insignificant compared to BOD_{dissolved}.

For each state variable, the ECOLab module contains a set of mathematical equations which describe the processes which alter parameter concentrations over the period of the simulation, where this is coupled with the hydrodynamic model (**Figure 5-1**). The MIKE documentation provides a full description of the model structure and processes affecting each variable (DHI, 2024). A summary of these processes responsible for the balance of each parameter relevant for this study, is presented in **Figure 5-2**, extracted from the MIKE ECOLab documentation (DHI, 2024). However, as an example, the primary processes listed below could affect dissolved oxygen concentrations:

- **Reaeration** – interchange of oxygen in water and atmosphere.
- **Nitrification** – transforming ammonia into nitrite reducing oxygen.
- **Photosynthesis** – release of oxygen dependant on day/night, light levels and depth.
- **Respiration** – reducing oxygen levels through respiring species in the water column, dependant on temperature.
- **Degradation** – break down of organic matter is a process which consumes oxygen in the water column, dependant on temperature and oxygen concentration.

To feed into the above processes for each state variable, the ECOLab module contains a list of relevant constants, for example the Secchi disk depth (m), a measure of visibility in the water and potential for light penetration. For the purpose of this modelling study all constants were kept as default as suggested by the software developer, DHI.

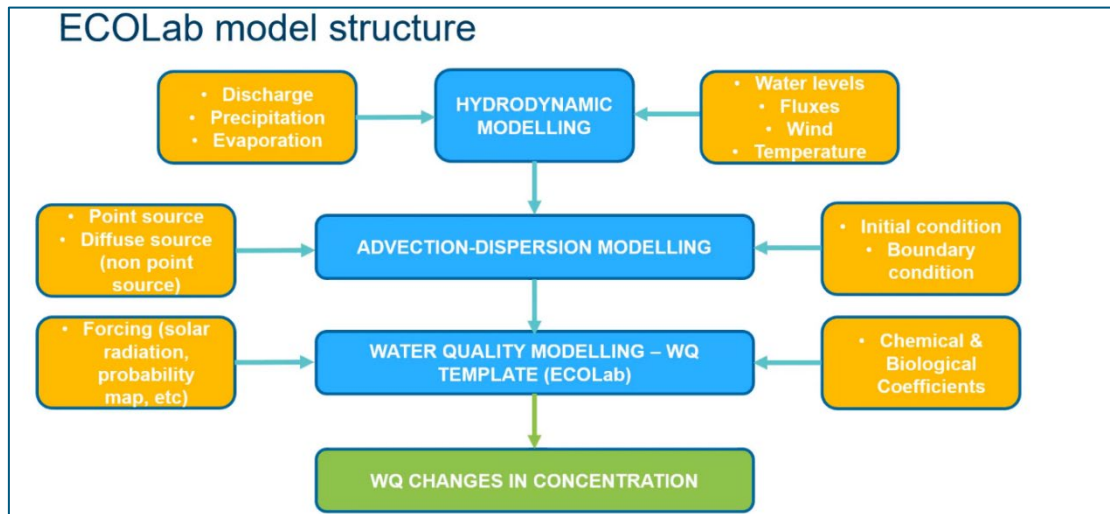


Figure 5-1: MIKE ECOLab model structure (DHI, 2024)

<p>Level 3, Oxygen with nutrients</p> $\frac{dDO}{dt} =$ <ul style="list-style-type: none"> + reaeration (only at water surface) - $Y_1 \cdot$ nitrification (Y₁: yield factor for oxygen) (1 or 3 fractions) - BOD decay + photosynthesis - respiration - sediment oxygen demand (only at water bed) 	DO	<p>The balance describing the ammonium/ammonia mass balance:</p> $\frac{dNH_3}{dt} =$ <ul style="list-style-type: none"> + ammonium yield from BOD decay - transformation of ammonium tonitrate - ammonium uptake by plants - ammonium uptake by bacteria + heterotroph respiration 	NH₄
<p>One fraction of BOD</p> <p>The mass balance for organic matter if only one fraction is chosen can be described as</p>		$\frac{dNO_3}{dt} =$ <ul style="list-style-type: none"> + transformation of nitrite to nitrate - denitrification 	NO₃
$\frac{dBOD}{dt} =$ <ul style="list-style-type: none"> -BOD decay 	BOD		
<p>Taking into account the uptake of orthophosphate in the production of algae the equation governing the orthophosphate concentration reads:</p> $\frac{dPO_4}{dt} =$ <ul style="list-style-type: none"> + phosphorus yield from BOD decay - phosphorus uptake by plants - phosphorus uptake by bacteria - heterotrophic respiration 			PO₄

Figure 5-2: Considered physio-bio-chemical processes in MIKE ECOLab (DHI, 2024)

Figure 5-2 shows levels of BOD and nitrate (NO₃) are subject to decay process (i.e. concentration would reduce with time). However, phosphate (PO₄) and ammonium (NH₄) would gain from the BOD decay process in which water temperature has influence. DO level would be subject to gain from reaeration and photosynthesis in addition to loss due to the BOD decay process.

5.2 Model scenarios

The range of model simulations are summarised in the list as follows, to cover seasonal changes in water temperature, concentrations of parameters and pre or post WRP discharge scenarios. Results from the first

stage of the modelling, where no degradation was considered, predicted the mean annual flow (Q_{mean}) scenario produced the greatest difference between pre WRP and post WRP, therefore, Q_{mean} flow was selected for the degradation modelling (Royal HaskoningDHV, 2024)

- HTR Classic (Pre WRP), winter, Q_{mean} flow
- HTR Classic (Pre WRP), summer, Q_{mean} flow
- WRP scenario (Post WRP), winter, Q_{mean} flow
- WRP scenario (Post WRP), summer, Q_{mean} flow

5.3 Model outputs

In the following sections model results are presented as the difference in parameter concentrations between the pre WRP (HTR Classic) and post WRP scenarios for both winter and summer. The results are presented as 2D contour plots of the lower Hermitage Stream and Langstone Harbour and also table outputs to show results further upstream towards the top of Riders Lane, as per **Figure 5-3** and the following list, for all five state variables specified above in **Section 5.1.2**:

- Boundary – Immediately downstream of Havant Thicket Reservoir compensatory flow outfall outlet.
- P1 – Upper Riders Lane Stream.
- P2 – Upstream of Riders Lane Stream and Hermitage Stream confluence.
- P3 – Downstream of Riders Lane Stream and Hermitage Stream confluence.
- P4 – Upstream of Hermitage Stream/Langstone Harbour tidal limit.
- P5 – Downstream of Harts Way Road Bridge
- P6 – Hermitage Stream approach channel.
- P7 – Upper Langstone Harbour.

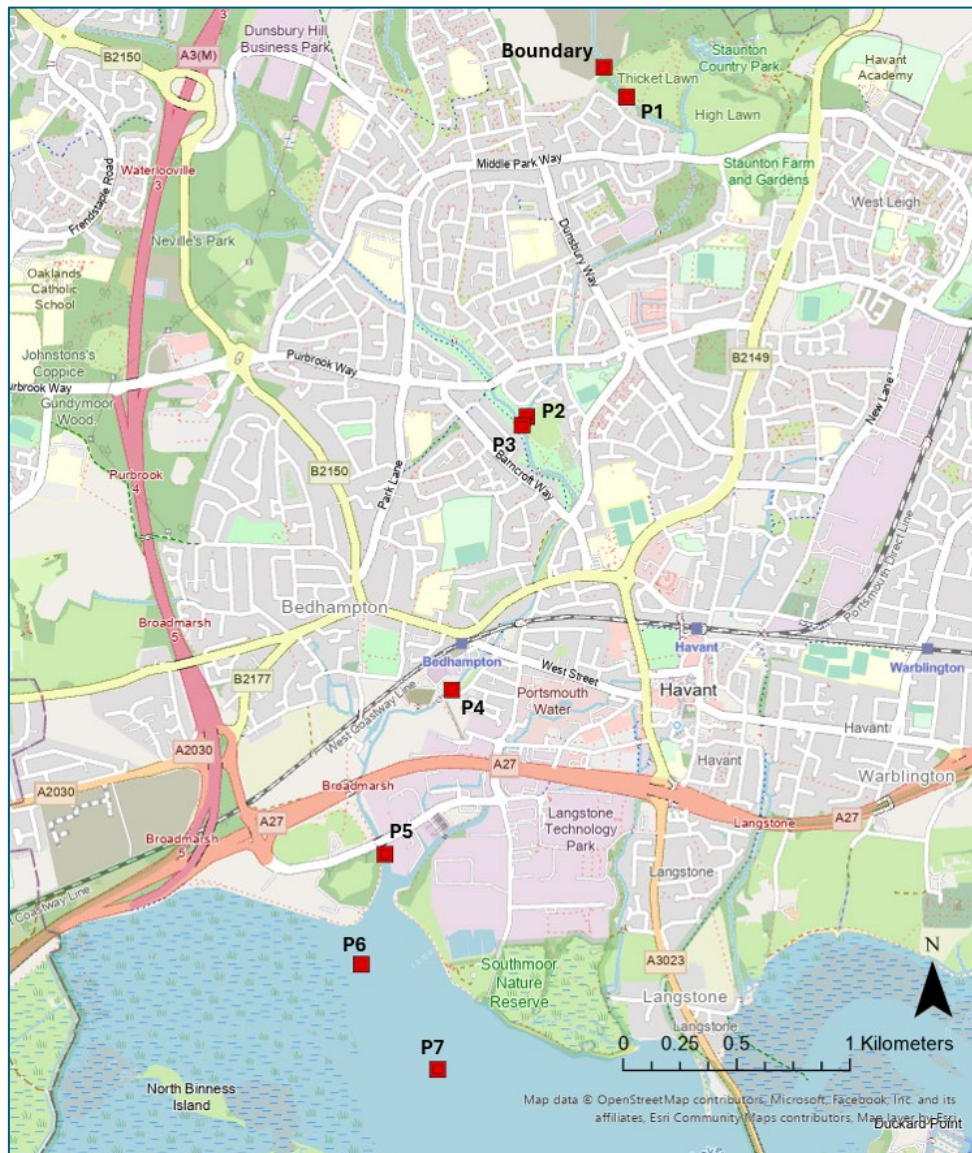


Figure 5-3: Model output locations

5.4 Model Results

5.4.1 Dissolved Oxygen (DO)

Figure 5-5 and Figure 5-5 present modelled change in minimum DO concentration (mg/l) between the pre WRP – HTR Classic and post WRP scenarios, for the winter and summer seasons, respectively. Table 5-2 shows the change in minimum DO concentration (mg/l) between the pre WRP and post WRP scenarios at eight output locations between Havant Thicket Reservoir and Langstone Harbour, as per Figure 5-3. In addition to this, the table also includes respective results for the conservative tracer model simulation.

The results of the degradation modelling of DO for the winter scenario, predict that there is an increase in DO concentration between pre WRP and post WRP for the upper Riders Lane Stream very close to the reservoir discharge, yet downstream of this location (P2 and further downstream) there is a decrease in concentration. This reduction is likely to be attributable to an increase in the temperature of water discharged

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from the reservoir under the Post WRP scenario (6.03°C to 6.17°C), increasing respiration processes in the stream.

However, for the summer scenario there is a decrease in the temperature of the water discharged from the reservoir (20.05°C to 19.53°C), which leads to an increase in DO concentrations throughout Riders Lane Stream, Hermitage Stream and the reach of Hermitage Stream immediately downstream of the tidal limit before Langstone Harbour.

Comparing to the results of the degradation model, the conservative tracer model produces a greater change of DO as it does not consider the BOD decay process and influence of temperature.

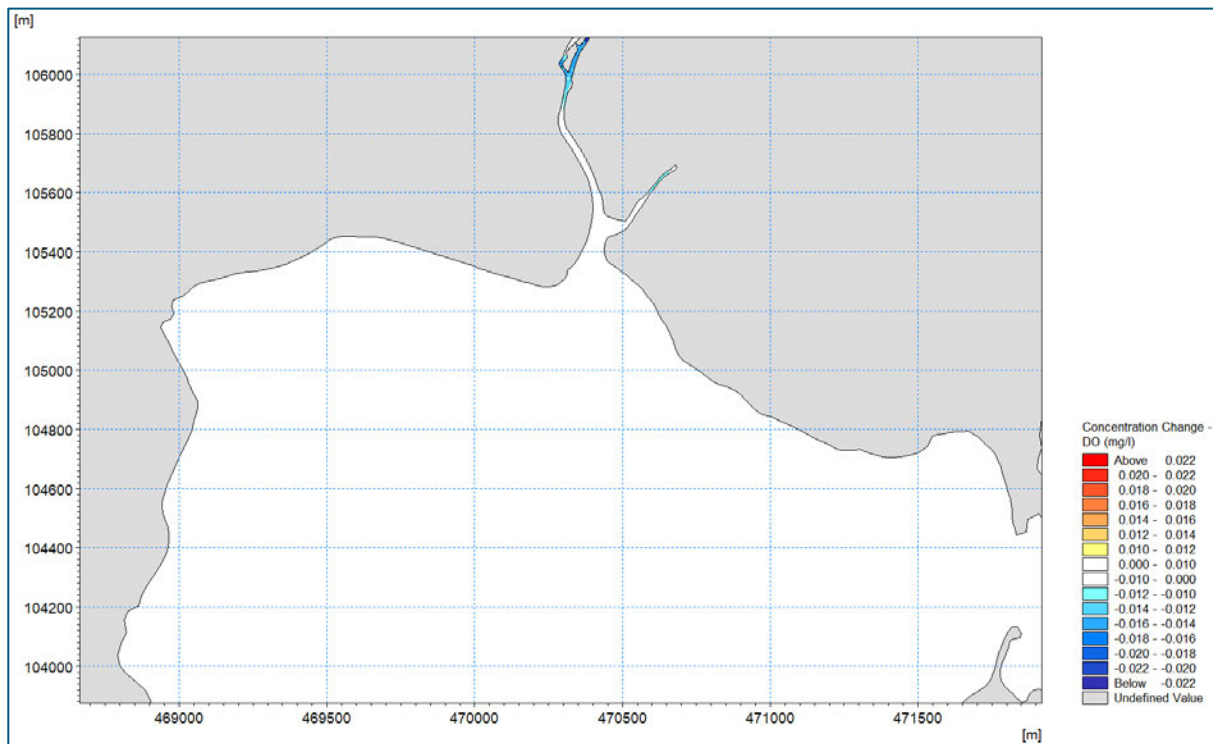


Figure 5-4: Change in minimum dissolved oxygen concentration (mg/l) between HTR Classic and post WRP – Winter

Project related

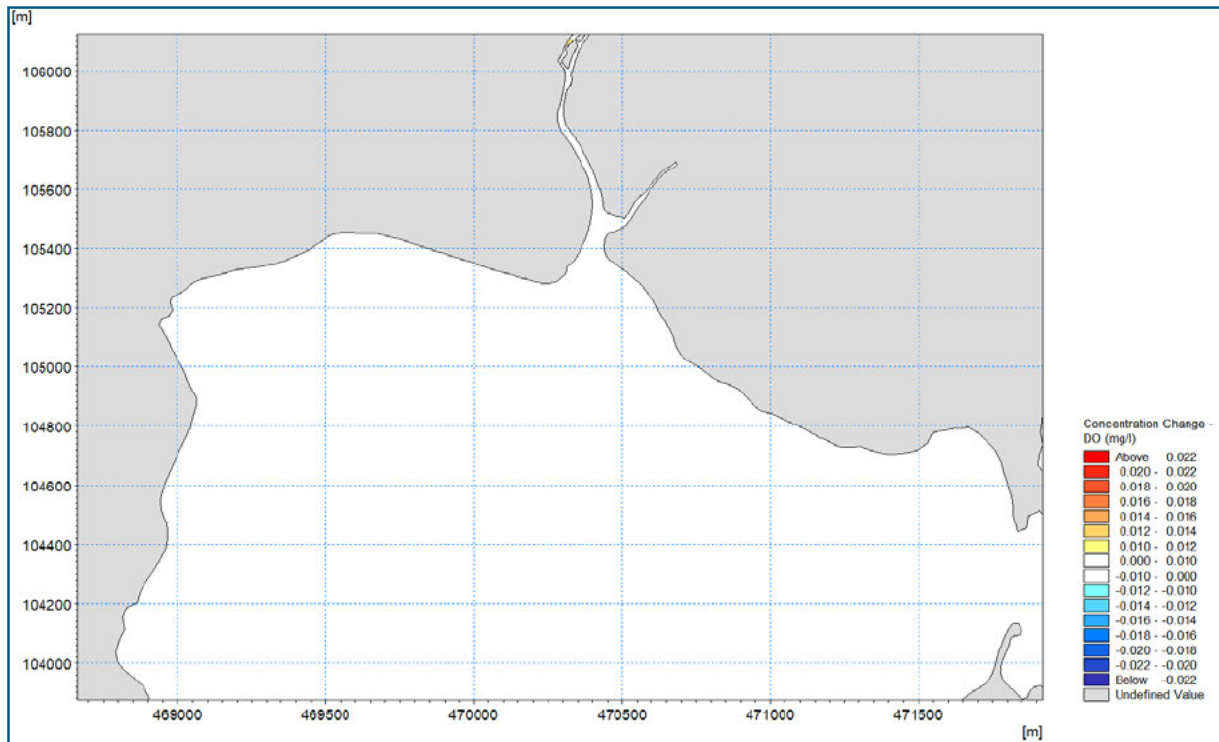


Figure 5-5: Change in minimum dissolved oxygen concentration (mg/l) between HTR Classic and post WRP – Summer

Table 5-2: Change in minimum dissolved oxygen concentration (mg/l) at eight output locations (degradation and conservative tracer modelling for comparison)

Scenario	Concentration Change (mg/l)							
	Riders Lane Stream			Hermitage Stream		Langstone Harbour		
	Boundary	P1	P2	P3	P4	P5	P6	P7
Winter	0.129	-0.023	-0.023	-0.012	-0.007	-0.001	0.000	0.000
Summer	0.154	0.102	0.047	0.012	0.012	-0.001	0.000	0.000
Conservative tracer	0.167	0.167	0.081	0.022	0.022	0.023	0.010	0.003

5.4.2 Phosphate (PO₄)

Figure 5-7 and Figure 5-7 present modelled change in maximum phosphate (mg P/l) between the pre WRP – HTR Classic and post WRP scenarios, for the winter and summer seasons, respectively. Table 5-3 shows the change in maximum phosphate (mg P/l) between the pre WRP and post WRP scenarios at eight output locations between the Havant Thicket reservoir and Langstone Harbour, as per Figure 5-3. In addition to this, the table also includes respective results for the conservative tracer model simulation.

The results of the degradation modelling indicate an increase in phosphate concentration between the Pre WRP and Post WRP scenarios. During the summer season this difference in phosphate concentrations between pre WRP and post WRP scenarios is slightly larger than the winter season and conservative tracer case, likely associated with additional BOD decay in warmer water during the summer (Figure 5-2).

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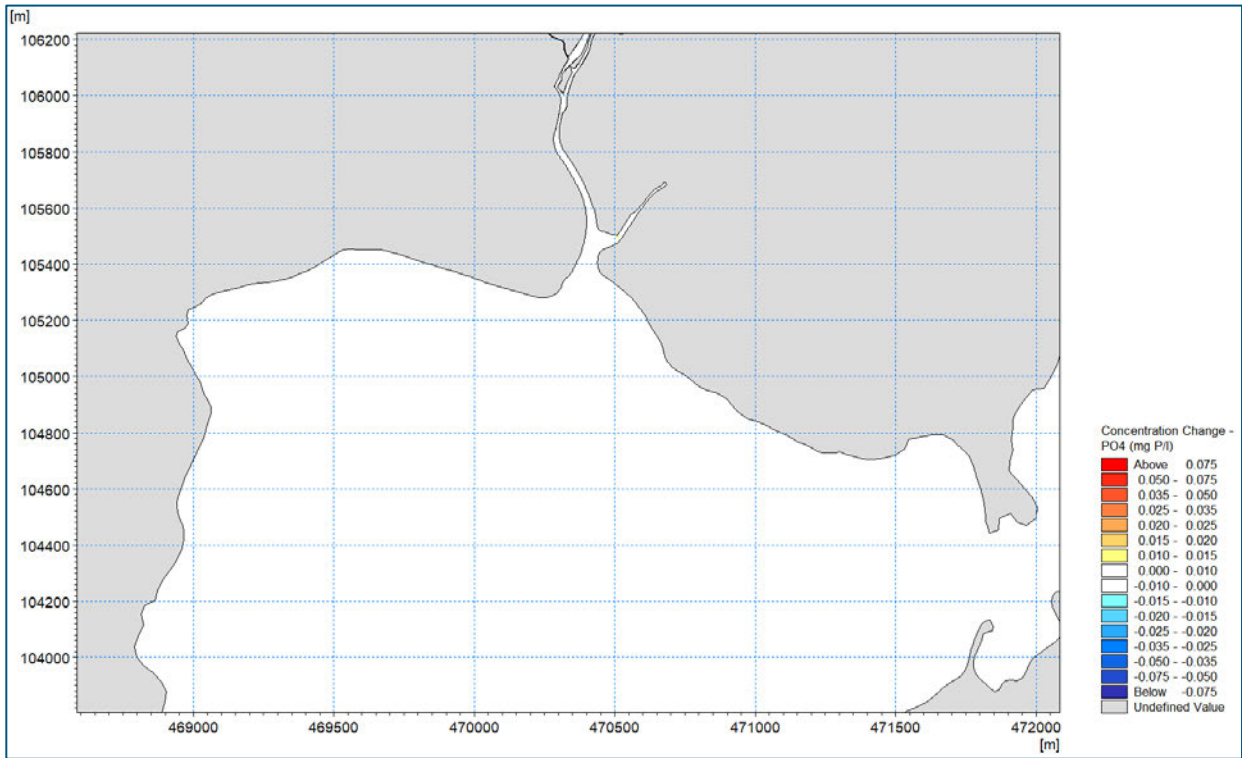


Figure 5-6: Change in maximum phosphate concentration (mg P/l) between HTR Classic and post WRP – Winter

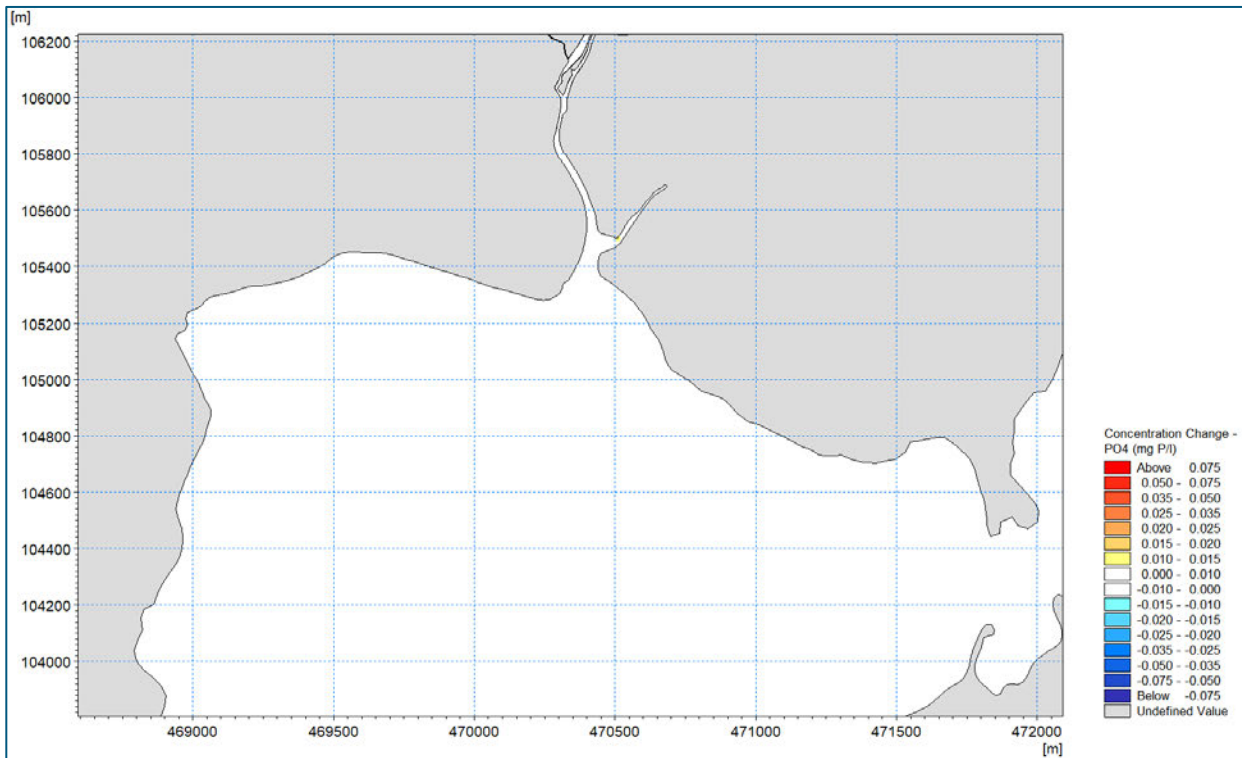


Figure 5-7: Change in maximum phosphate concentration (mg P/l) between HTR Classic and post WRP – Summer

Project related

Table 5-3: Change in maximum phosphate concentration (mg P/l) at 8 output locations (degradation and conservative tracer modelling for comparison)

Scenario	Concentration Change (mg P/l)							
	Riders Lane Stream			Hermitage Stream		Langstone Harbour		
	Boundary	P1	P2	P3	P4	P5	P6	P7
Winter	0.012	0.012	0.006	0.002	0.002	0.003	0.002	0.001
Summer	0.012	0.012	0.008	0.002	0.003	0.004	0.003	0.001
Conservative tracer	0.012	0.012	0.006	0.002	0.002	0.002	0.001	0.000

Comparing to the results of the degradation model, the conservative model produces less change of phosphate level because it does not consider the gain from the BOD decay process and influence of temperature. Because this difference occurs for changes in concentration of <0.01mg P/l, this is not seen as a significant change and the conservative tracer approach is representative to model the dispersion of phosphate.

5.4.3 Biological Oxygen Demand (BOD)

Figure 5-9 and Figure 5-9 present modelled changes in maximum BOD (mg/l) between the pre WRP – HTR Classic and post WRP scenarios, for the winter and summer seasons, respectively. Table 5-4 shows the change in maximum BOD (mg/l) between the pre WRP and post WRP scenarios at eight output locations between Havant Thicket Reservoir and Langstone Harbour, as per Figure 5-3. In addition to this, the table also includes respective results for the conservative tracer model simulation.

The results of the degradation modelling of BOD indicate an increase in concentration between the pre WRP and post WRP scenarios, with no significant difference between winter and summer seasons. Comparing the change in concentrations in Table 5-4, it is clear the conservative tracer results provide a conservative estimate of BOD concentrations within Riders Lane Stream, Hermitage Stream and Langstone Harbour. This is because it does not consider the decay process.

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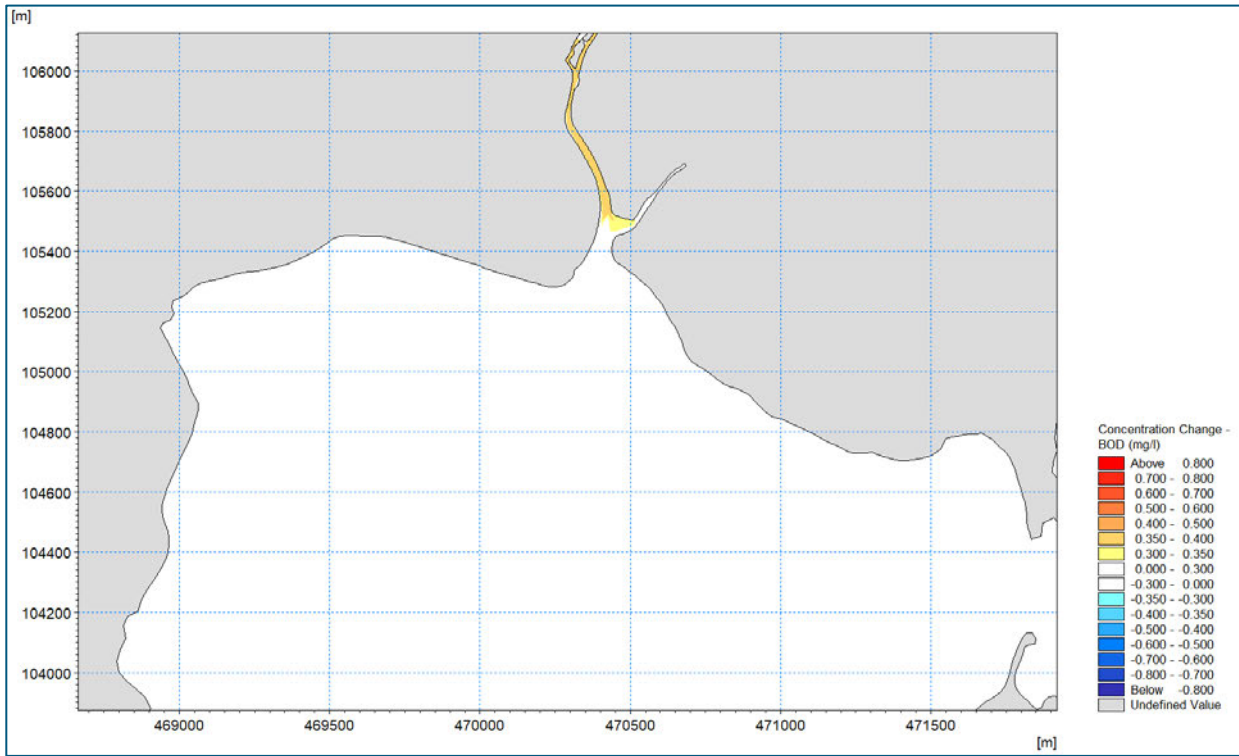


Figure 5-8: Change in maximum BOD concentration (mg/l) between HTR Classic and post WRP – Winter

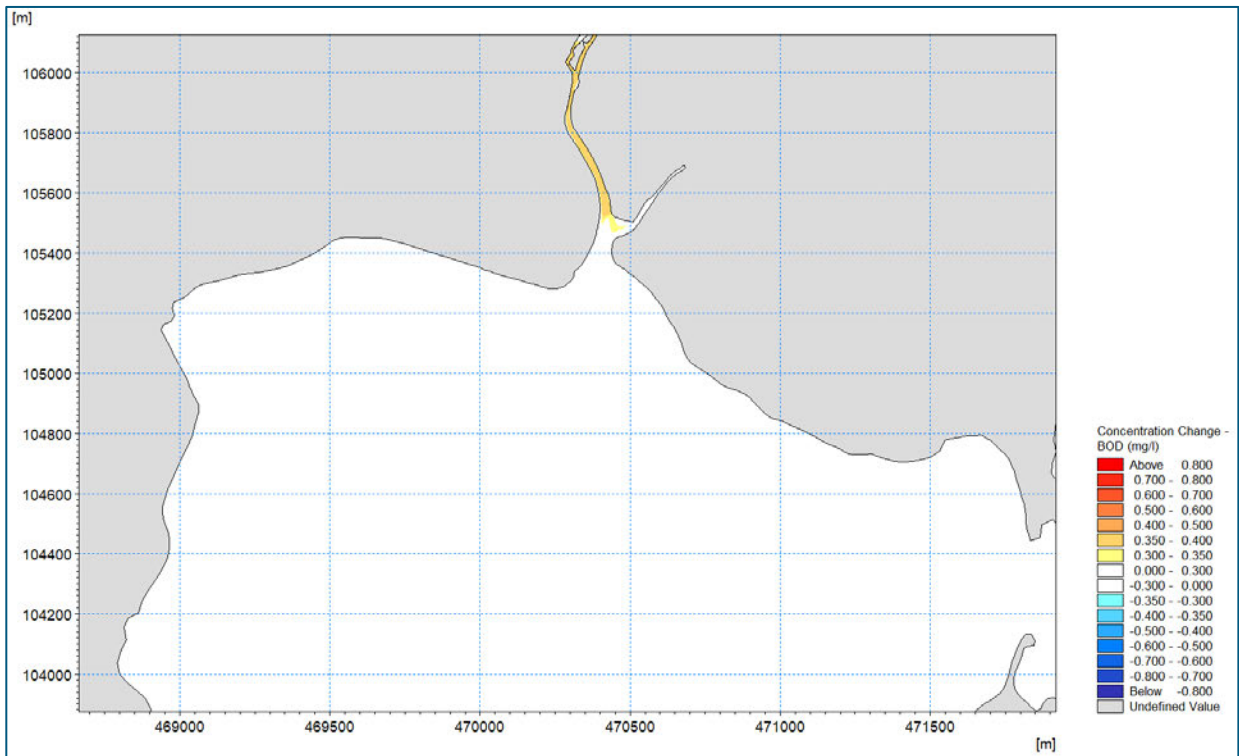


Figure 5-9: Change in maximum BOD concentration (mg/l) between HTR Classic and post WRP – Summer

Project related

Table 5-4: Change in maximum BOD concentration (mg/l) at eight output locations (degradation and conservative tracer modelling for comparison)

Scenario	Concentration Change (mg/l)							
	Riders Lane Stream			Hermitage Stream		Langstone Harbour		
	Boundary	P1	P2	P3	P4	P5	P6	P7
Winter	3.010	3.007	1.434	0.397	0.395	0.393	0.159	0.035
Summer	3.010	3.004	1.405	0.388	0.383	0.379	0.140	0.027
Conservative tracer model	3.010	3.010	1.460	0.403	0.406	0.406	0.187	0.048

5.4.4 Nitrate (NO₃)

Figure 5-10 and Figure 5-11 present modelled changes in maximum nitrate (mg N/l) between the pre WRP – HTR Classic and post WRP scenarios, for the winter and summer seasons, respectively. Table 5-5 shows the change in maximum nitrate (mg N/l) between the pre WRP and post WRP scenarios at eight output locations between Havant Thicket Reservoir and Langstone Harbour, as per Figure 5-3. In addition to this, the table also includes respective results for the conservative model simulation.

The results of the degradation modelling of nitrate indicate a reduction in concentration between the pre WRP and post WRP scenarios, with no significant difference between winter and summer seasons. Comparing the change in concentrations in Table 5-5, it is clear the conservative tracer model results provide a conservative estimate of nitrate concentrations within Riders Lane Stream, Hermitage Stream and Langstone Harbour. This is because it does not consider the decay process.

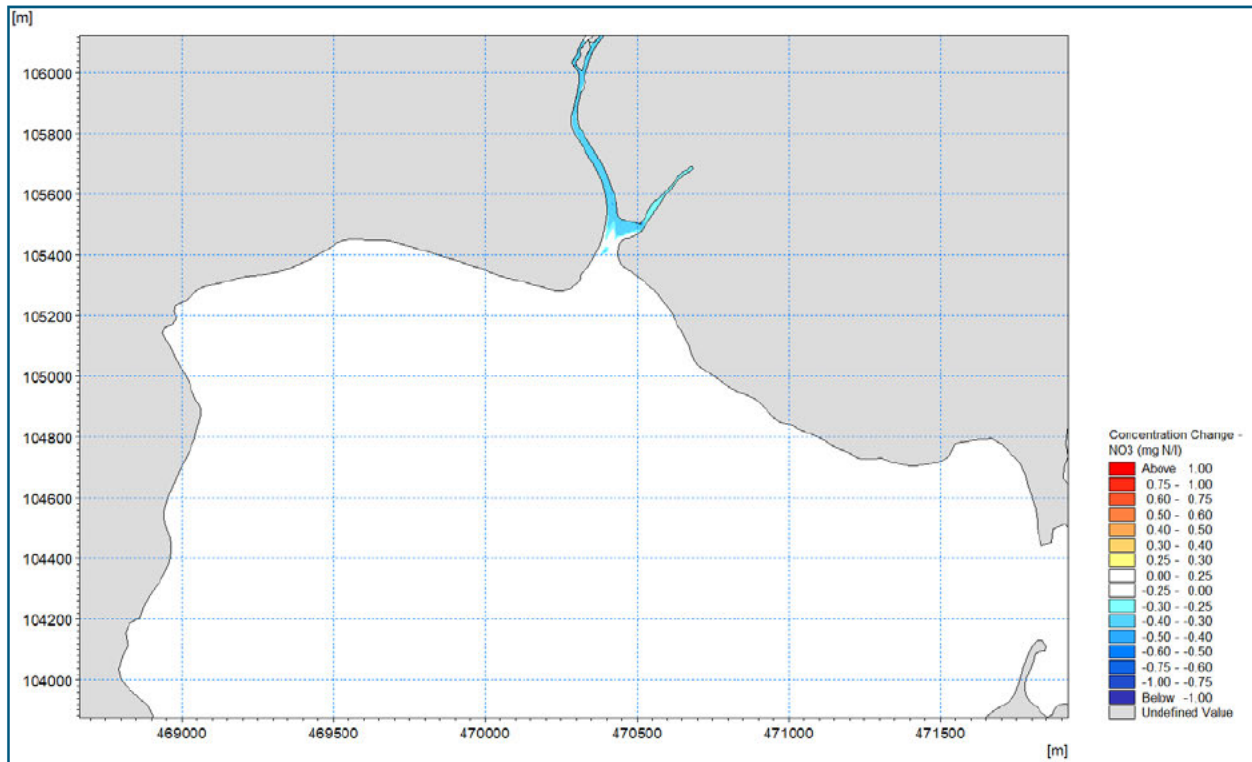


Figure 5-10: Change in maximum nitrate concentration (mg N/l) between HTR Classic and post WRP – Winter

Project related

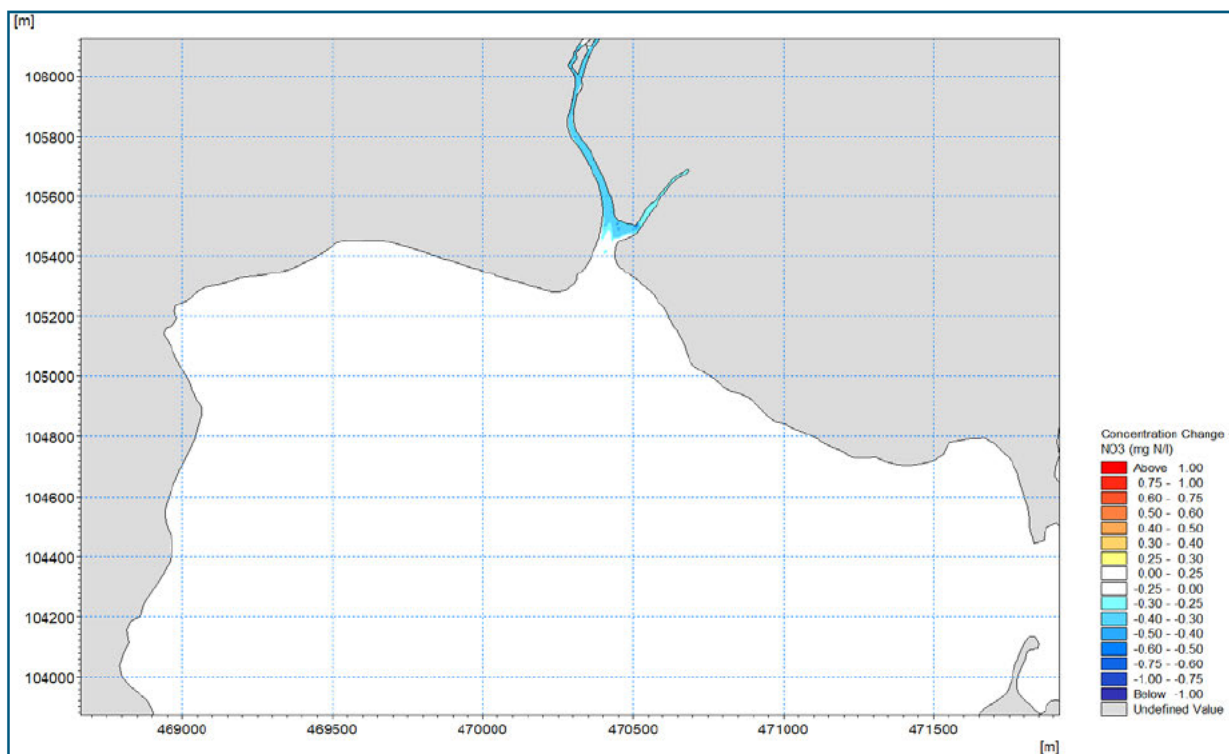


Figure 5-11: Change in maximum nitrate concentration (mg N/l) between HTR Classic and post WRP – Summer

Table 5-5: Change in maximum nitrate concentration (mg N/l) at eight output locations (degradation and conservative tracer modelling for comparison)

Scenario	Concentration Change (mg N/l)							
	Riders Lane Stream			Hermitage Stream		Langstone Harbour		
	P0	P1	P2	P3	P4	P5	P6	P7
Winter	-2.854	-2.853	-1.370	-0.379	-0.391	-0.390	-0.166	-0.039
Summer	-2.854	-2.853	-1.370	-0.379	-0.387	-0.386	-0.165	-0.039
Conservative tracer	-2.854	-2.854	-1.384	-0.383	-0.385	-0.385	-0.177	-0.046

5.4.5 Ammonium (NH₄)

Figure 5-13 and Figure 5-13 present modelled changes in maximum ammonium (mg N/l) between the pre WRP – HTR Classic and post WRP scenarios, for the winter and summer seasons, respectively. Table 5-6 shows the change in maximum ammonium (mg N/l) between pre WRP and post WRP scenarios at eight output locations between Havant Thicket Reservoir and Langstone Harbour, as per Figure 5-3. In addition to this, the table also includes respective results for the conservative tracer model simulation.

The results of the degradation modelling of ammonium indicate an increase in concentration between the Pre WRP and Post WRP scenarios. During the summer season this difference in ammonium concentrations between pre WRP and post WRP is slightly larger than the winter season and conservative tracer case, this is likely to be associated with additional BOD decay in warmer water during the summer (Figure 5-2).

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Although as this difference occurs for a change in concentration of $<0.015\text{mg N/l}$, this is not seen as a significant change and the conservative tracer approach is representative to model the dispersion of ammonium.

Comparing to the results of the degradation model, the conservative tracer model produces less change of ammonium level because it does not consider the gain from the BOD decay process and the influence of temperature.

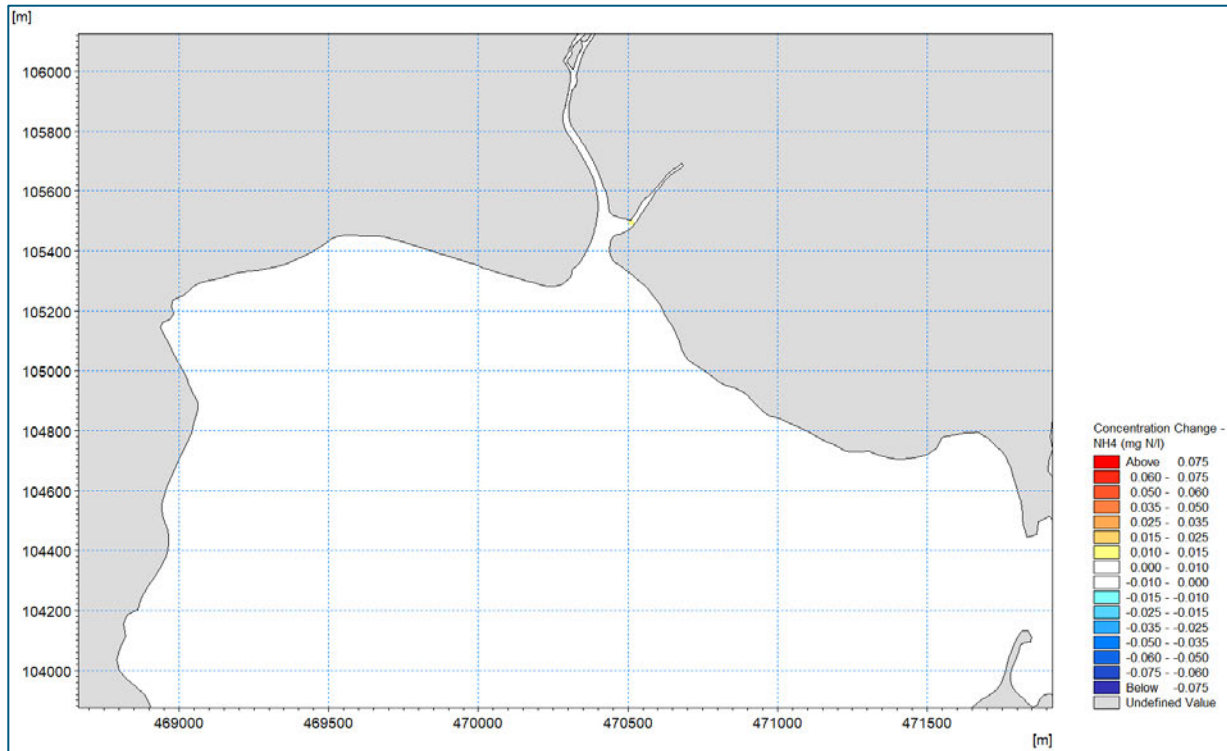


Figure 5-12: Change in maximum ammonium concentration (mg N/l) between HTR Classic and post WRP – Winter

Project related

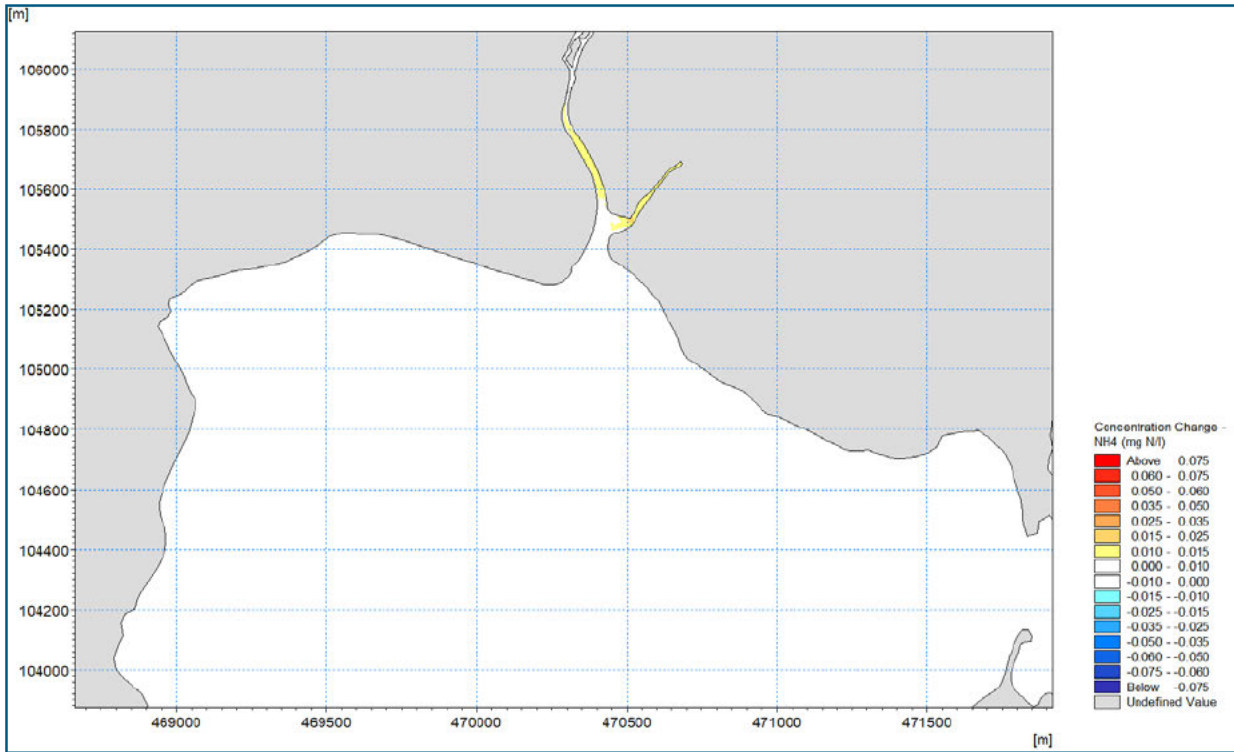


Figure 5-13: Change in maximum ammonium concentration (mg N/l) between HTR Classic and post WRP – Summer

Table 5-6: Change in maximum ammonium concentration (mg N/l) at eight output locations (degradation and conservative tracer modelling for comparison)

Scenario	Concentration Change (mg N/l)							
	Riders Lane Stream			Hermitage Stream		Langstone Harbour		
	P0	P1	P2	P3	P4	P5	P6	P7
Winter	0.018	0.018	0.008	0.002	0.003	0.006	0.004	0.002
Summer	0.018	0.018	0.011	0.003	0.004	0.010	0.007	0.003
Conservative tracer	0.018	0.018	0.009	0.002	0.002	0.002	0.001	0.000

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Appendix A – Ambient Water Quality Derivation

This section presents the process for deriving the ambient water quality data, in this example presented, the derivation of average ammonium concentrations (mg/l) for Riders Lane Stream (**Figure A. 1**), Hermitage Stream (**Figure A. 2**) and Langstone Harbour. The mean concentrations here can be found in **Table 3-4**.

Atkins (2020) - Rider's Lane Stream								Mean (mg/l)	
Sample Date	Numeric Result	Property Description	Qualifier	Result including Qualifier	<LOD halved	Units of Measure	Property Id		
11/12/2008	0.031	Ammonium as N	<	<0.031	0.0155	mg/l as N	NH4	0.0307	
24/02/2009	0.031	Ammonium as N	<	<0.031	0.0155	mg/l as N	NH4		
17/02/2010	0.031	Ammonium as N	<	<0.031	0.0155	mg/l as N	NH4		
15/12/2010	0.031	Ammonium as N	<	<0.031	0.0155	mg/l as N	NH4		
12/12/2018	0.022	Ammonium as N		0.022	0.022	mg/l as N	NH4		
21/01/2019	0.032	Ammonium as N		0.032	0.032	mg/l as N	NH4		
11/02/2019	0.037	Ammonium as N		0.037	0.037	mg/l as N	NH4		
Atkins (2020) - Rider's Lane Stream									
Sample Date	Numeric Result	Property Description	Qualifier	Result including Qualifier	<LOD halved	Units of Measure	Property Id		Mean (mg/l)
18/06/2009	0.033	Ammonium as N		0.033	0.033	mg/l as N	NH4	0.0531	
20/08/2009	0.032	Ammonium as N		0.032	0.032	mg/l as N	NH4		
21/07/2010	0.076	Ammonium as N		0.076	0.076	mg/l as N	NH4		
06/06/2018	0.054	Ammonium as N		0.054	0.054	mg/l as N	NH4		
11/07/2018	0.027	Ammonium as N		0.027	0.027	mg/l as N	NH4		
14/08/2018	0.064	Ammonium as N		0.064	0.064	mg/l as N	NH4		
20/06/2019	0.102	Ammonium as N		0.102	0.102	mg/l as N	NH4		
29/07/2019	0.037	Ammonium as N		0.037	0.037	mg/l as N	NH4		

Figure A. 1: Derivation of average ammonium concentration (mg/l) for Riders Lane Stream (average of cells C3:C9 for winter and cells C13:C20 for summer)

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For Langstone Harbour the 5 Environment Agency sample locations shown in **Figure A. 3** were all used to provide a spatial mean concentration (mg/l) for the entire Langstone Harbour, there locations are named ID6, ID7, ID8, ID9 and ID10. Derivation of average concentrations for winter are shown in **Figure A. 4** and **Figure A. 5** and for summer in **Figure A. 6** and **Figure A. 7**.

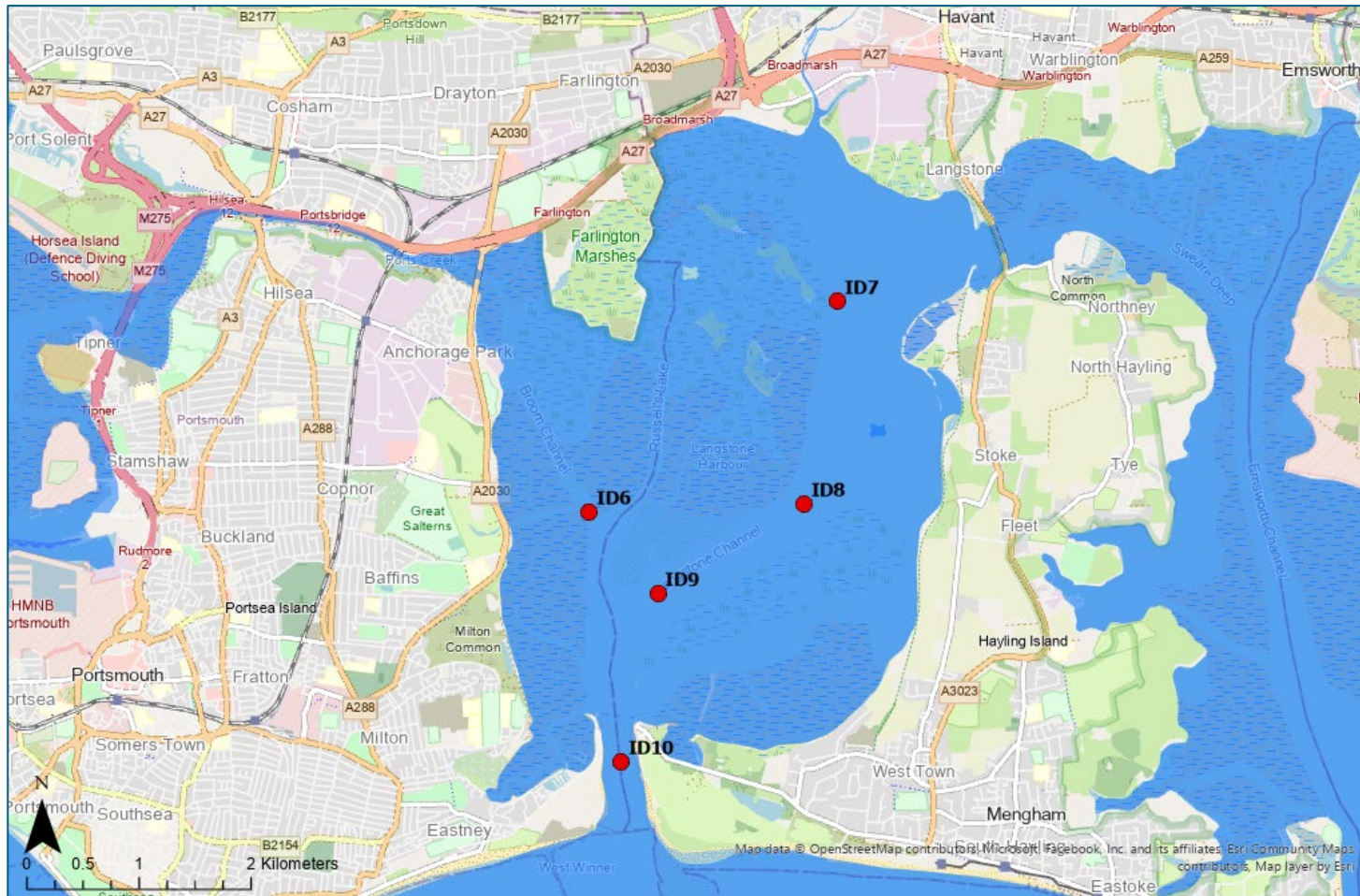


Figure A. 3: Environment Agency water quality sampling points used to define Langstone Harbour ambient concentrations (labelled ID6 – ID10 for this study)

Project related

The screenshot shows an Excel spreadsheet with the following data table:

Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location								
13/1/2017	0.02	NH4	mg/l	ID9	16/2/2004	0.001	NH4	mg/l	ID9	9/1/2008	0.035	NH4	mg/l	ID10	9/2/2006	0.052	NH4	mg/l	ID10	10/1/2019	0.02	NH4	mg/l
7/2/2007	0.03	NH4	mg/l	ID9	21/1/2005	0.048	NH4	mg/l	ID9	6/2/2008	0.02	NH4	mg/l	ID10	15/12/2009	0.0236	NH4	mg/l	ID10	13/2/2019	0.022	NH4	mg/l
4/12/2017	0.02	NH4	mg/l	ID9	21/2/2005	0.029	NH4	mg/l	ID9	5/12/2018	0.048	NH4	mg/l	ID10	27/2/2007	0.072	NH4	mg/l	ID10	17/12/2001	0.021	NH4	mg/l
9/1/2008	0.044	NH4	mg/l	ID9	9/2/2006	0.052	NH4	mg/l	ID9	10/1/2019	0.02	NH4	mg/l	ID10	4/12/2007	0.05	NH4	mg/l	ID10	17/1/2020	0.02	NH4	mg/l
6/2/2008	0.02	NH4	mg/l	ID9	15/12/2000	0.0557	NH4	mg/l	ID9	13/2/2019	0.023	NH4	mg/l	ID10	4/2/2008	0.025	NH4	mg/l	ID10	13/2/2020	0.02	NH4	mg/l
5/12/2018	0.05	NH4	mg/l	ID9	27/2/2007	0.07	NH4	mg/l	ID9	17/12/2001	0.023	NH4	mg/l	ID10	10/12/2000	0.022	NH4	mg/l	ID10	2/12/2020	0.02	NH4	mg/l
9/10/1/2019	0.02	NH4	mg/l	ID9	4/12/2007	0.05	NH4	mg/l	ID9	17/12/2020	0.02	NH4	mg/l	ID10	21/1/2009	0.034	NH4	mg/l	ID10	12/1/2021	0.02	NH4	mg/l
13/2/2019	0.03	NH4	mg/l	ID9	4/2/2008	0.028	NH4	mg/l	ID9	13/2/2020	0.02	NH4	mg/l	ID10	23/2/2009	0.035	NH4	mg/l	ID10	7/2/2001	0.02	NH4	mg/l
11/12/2001	0.041	NH4	mg/l	ID9	10/12/2000	0.02	NH4	mg/l	ID9	2/12/2020	0.02	NH4	mg/l	ID10	7/12/2009	0.027	NH4	mg/l	ID10	2/12/2021	0.02	NH4	mg/l
17/1/2020	0.02	NH4	mg/l	ID9	21/1/2009	0.035	NH4	mg/l	ID9	13/2/2021	0.02	NH4	mg/l	ID10	4/2/2010	0.021	NH4	mg/l	ID10	16/1/2022	0.02	NH4	mg/l
13/2/2020	0.02	NH4	mg/l	ID9	23/2/2009	0.032	NH4	mg/l	ID9	7/2/2021	0.02	NH4	mg/l	ID10	18/2/2010	0.02	NH4	mg/l	ID10	2/2/2022	0.02	NH4	mg/l
4/12/2020	0.02	NH4	mg/l	ID9	7/12/2009	0.026	NH4	mg/l	ID9	2/12/2021	0.02	NH4	mg/l	ID10	25/1/2011	0.021	NH4	mg/l	ID10	5/12/2022	0.02	NH4	mg/l
12/1/2021	0.02	NH4	mg/l	ID9	4/2/2010	0.021	NH4	mg/l	ID9	16/1/2022	0.02	NH4	mg/l	ID10	22/2/2011	0.02	NH4	mg/l	ID10	17/1/2023	0.039	NH4	mg/l
7/2/2021	0.02	NH4	mg/l	ID9	18/2/2010	0.02	NH4	mg/l	ID9	2/2/2022	0.02	NH4	mg/l	ID10	7/12/2011	0.032	NH4	mg/l	ID10	8/2/2023	0.02	NH4	mg/l
2/12/2021	0.02	NH4	mg/l	ID9	25/1/2011	0.023	NH4	mg/l	ID9	5/12/2022	0.022	NH4	mg/l	ID10	12/1/2012	0.02	NH4	mg/l	ID10	11/12/2002	0.01	NH4	mg/l
16/1/2022	0.02	NH4	mg/l	ID9	22/2/2011	0.02	NH4	mg/l	ID9	17/12/2023	0.033	NH4	mg/l	ID10	21/2/2012	0.02	NH4	mg/l	ID10	13/1/2024	0.01	NH4	mg/l
2/2/2022	0.02	NH4	mg/l	ID9	7/12/2011	0.036	NH4	mg/l	ID9	8/2/2023	0.02	NH4	mg/l	ID10	6/12/2012	0.038	NH4	mg/l	ID10	7/2/2024	0.014	NH4	mg/l
5/12/2022	0.039	NH4	mg/l	ID9	12/1/2012	0.02	NH4	mg/l	ID9	11/12/2002	0.027	NH4	mg/l	ID10	14/1/2013	0.023	NH4	mg/l	ID10				
17/1/2023	0.042	NH4	mg/l	ID9	21/2/2012	0.02	NH4	mg/l	ID9	13/1/2024	0.01	NH4	mg/l	ID10	18/2/2013	0.029	NH4	mg/l	ID10				
8/2/2023	0.02	NH4	mg/l	ID9	6/12/2012	0.04	NH4	mg/l	ID9	7/2/2024	0.014	NH4	mg/l	ID10	8/1/2014	0.028	NH4	mg/l	ID10				
11/12/2022	0.022	NH4	mg/l	ID9	14/1/2013	0.02	NH4	mg/l	ID10	2/2/2000	0.065	NH4	mg/l	ID10	13/2/2014	0.024	NH4	mg/l	ID10				
13/1/2024	0.011	NH4	mg/l	ID9	18/2/2013	0.031	NH4	mg/l	ID10	28/2/2000	0.052	NH4	mg/l	ID10	7/12/2014	0.02	NH4	mg/l	ID10				
7/2/2024	0.016	NH4	mg/l	ID9	8/1/2014	0.033	NH4	mg/l	ID10	18/12/01	0.049	NH4	mg/l	ID10	13/1/2015	0.02	NH4	mg/l	ID10				
2/2/2000	0.061	NH4	mg/l	ID9	13/2/2014	0.02	NH4	mg/l	ID10	20/2/2001	0.048	NH4	mg/l	ID10	11/2/2015	0.02	NH4	mg/l	ID10				
28/2/2000	0.052	NH4	mg/l	ID9	7/12/2014	0.02	NH4	mg/l	ID10	25/1/2002	0.046	NH4	mg/l	ID10	16/1/2016	0.02	NH4	mg/l	ID10				
18/1/2001	0.048	NH4	mg/l	ID9	13/1/2015	0.02	NH4	mg/l	ID10	7/2/2002	0.047	NH4	mg/l	ID10	4/2/2005	0.02	NH4	mg/l	ID10				
20/2/2001	0.042	NH4	mg/l	ID9	11/2/2015	0.02	NH4	mg/l	ID10	10/12/2000	0.003	NH4	mg/l	ID10	7/12/2016	0.027	NH4	mg/l	ID10				
25/1/2002	0.055	NH4	mg/l	ID9	16/1/2016	0.02	NH4	mg/l	ID10	13/1/2003	0.001	NH4	mg/l	ID10	13/1/2017	0.02	NH4	mg/l	ID10				
7/2/2002	0.043	NH4	mg/l	ID9	4/2/2015	0.02	NH4	mg/l	ID10	3/2/2003	0.024	NH4	mg/l	ID10	7/2/2017	0.02	NH4	mg/l	ID10				
10/12/2000	0.009	NH4	mg/l	ID9	7/12/2016	0.031	NH4	mg/l	ID10	3/12/2003	0.024	NH4	mg/l	ID10	4/12/2017	0.02	NH4	mg/l	ID10				
13/1/2003	0.001	NH4	mg/l	ID9	13/1/2017	0.02	NH4	mg/l	ID10	18/2/2004	0.001	NH4	mg/l	ID10	9/1/2008	0.021	NH4	mg/l	ID10				
13/2/2003	0.002	NH4	mg/l	ID9	7/2/2017	0.02	NH4	mg/l	ID10	21/1/2005	0.072	NH4	mg/l	ID10	6/2/2008	0.02	NH4	mg/l	ID10				
3/12/2003	0.02	NH4	mg/l	ID9	4/12/2017	0.02	NH4	mg/l	ID10	21/2/2005	0.071	NH4	mg/l	ID10	5/12/2018	0.044	NH4	mg/l	ID10				

Figure A. 5: Derivation of average winter ammonium concentration (mg/l) for Langstone Harbour (average of cells highlighted red) – part 2

Project related

Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location	Date	Value	Parameter Unit	Location																
12/7/2011	0.0082	NH ₄	mg/l	ID8	23/8/2007	0.02	NH ₄	mg/l	ID8	16/8/2018	0.0172	NH ₄	mg/l	ID9	6/6/2006	0.007	NH ₄	mg/l	ID9	9/6/2017	0.02	NH ₄	mg/l	ID10	8/8/2003	0.011	NH ₄	mg/l	ID10	5/7/2005	0.02	NH ₄	mg/l	ID10	5/7/2005	0.02	NH ₄	mg/l	ID10
11/6/2011	0.023	NH ₄	mg/l	ID8	12/6/2008	0.02	NH ₄	mg/l	ID8	16/6/2009	0.007	NH ₄	mg/l	ID9	6/7/2006	0.02	NH ₄	mg/l	ID9	14/7/2017	0.02	NH ₄	mg/l	ID10	26/6/2004	0.02	NH ₄	mg/l	ID10	3/8/2005	0.02	NH ₄	mg/l	ID10	3/8/2005	0.02	NH ₄	mg/l	ID10
12/6/2012	0.007	NH ₄	mg/l	ID8	15/7/2008	0.02	NH ₄	mg/l	ID8	5/7/2011	0.007	NH ₄	mg/l	ID9	18/8/2006	0.02	NH ₄	mg/l	ID9	10/8/2017	0.02	NH ₄	mg/l	ID10	12/7/2004	0.027	NH ₄	mg/l	ID10	2/6/2006	0.02	NH ₄	mg/l	ID10	2/6/2006	0.02	NH ₄	mg/l	ID10
13/7/2012	0.007	NH ₄	mg/l	ID8	27/8/2008	0.02	NH ₄	mg/l	ID8	7/8/2011	0.018	NH ₄	mg/l	ID9	27/6/2007	0.02	NH ₄	mg/l	ID9	19/6/2018	0.007	NH ₄	mg/l	ID10	11/8/2004	0.047	NH ₄	mg/l	ID10	8/7/2006	0.02	NH ₄	mg/l	ID10	8/7/2006	0.02	NH ₄	mg/l	ID10
12/8/2012	0.011	NH ₄	mg/l	ID8	6/6/2009	0.02	NH ₄	mg/l	ID8	12/6/2011	0.007	NH ₄	mg/l	ID9	26/7/2007	0.02	NH ₄	mg/l	ID9	4/7/2008	0.007	NH ₄	mg/l	ID10	26/8/2004	0.006	NH ₄	mg/l	ID10	11/8/2016	0.02	NH ₄	mg/l	ID10	11/8/2016	0.02	NH ₄	mg/l	ID10
8/8/2013	0.007	NH ₄	mg/l	ID8	22/7/2009	0.02	NH ₄	mg/l	ID8	12/7/2011	0.007	NH ₄	mg/l	ID9	23/8/2007	0.02	NH ₄	mg/l	ID9	16/8/2018	0.0173	NH ₄	mg/l	ID10	6/8/2005	0.088	NH ₄	mg/l	ID10	9/6/2007	0.02	NH ₄	mg/l	ID10	14/7/2017	0.02	NH ₄	mg/l	ID10
13/8/2013	0.019	NH ₄	mg/l	ID8	12/8/2009	0.02	NH ₄	mg/l	ID8	11/8/2011	0.018	NH ₄	mg/l	ID9	12/8/2006	0.02	NH ₄	mg/l	ID9	16/6/2019	0.007	NH ₄	mg/l	ID10	6/7/2005	0.02	NH ₄	mg/l	ID10	10/8/2017	0.02	NH ₄	mg/l	ID10	10/8/2017	0.02	NH ₄	mg/l	ID10
13/8/2013	0.019	NH ₄	mg/l	ID8	22/8/2010	0.02	NH ₄	mg/l	ID8	12/6/2012	0.007	NH ₄	mg/l	ID9	15/7/2008	0.02	NH ₄	mg/l	ID9	5/7/2009	0.007	NH ₄	mg/l	ID10	18/8/2006	0.02	NH ₄	mg/l	ID10	10/8/2017	0.02	NH ₄	mg/l	ID10	10/8/2017	0.02	NH ₄	mg/l	ID10
8/8/2013	0.007	NH ₄	mg/l	ID8	20/7/2010	0.02	NH ₄	mg/l	ID8	13/7/2012	0.007	NH ₄	mg/l	ID9	27/8/2008	0.02	NH ₄	mg/l	ID9	7/8/2009	0.023	NH ₄	mg/l	ID10	27/8/2007	0.028	NH ₄	mg/l	ID10	19/6/2018	0.0103	NH ₄	mg/l	ID10	19/6/2018	0.0103	NH ₄	mg/l	ID10
10/7/2014	0.013	NH ₄	mg/l	ID8	31/8/2010	0.02	NH ₄	mg/l	ID8	12/6/2012	0.007	NH ₄	mg/l	ID9	8/6/2009	0.02	NH ₄	mg/l	ID9	12/6/2021	0.007	NH ₄	mg/l	ID10	26/7/2007	0.044	NH ₄	mg/l	ID10	4/7/2008	0.007	NH ₄	mg/l	ID10	4/7/2008	0.007	NH ₄	mg/l	ID10
3/8/2014	0.007	NH ₄	mg/l	ID8	28/6/2011	0.02	NH ₄	mg/l	ID8	22/7/2009	0.0079	NH ₄	mg/l	ID9	22/7/2009	0.02	NH ₄	mg/l	ID9	12/7/2021	0.007	NH ₄	mg/l	ID10	23/8/2007	0.045	NH ₄	mg/l	ID10	16/8/2018	0.0128	NH ₄	mg/l	ID10	16/8/2018	0.0128	NH ₄	mg/l	ID10
26/6/2010	0.013	NH ₄	mg/l	ID8	14/7/2011	0.02	NH ₄	mg/l	ID8	13/7/2013	0.007	NH ₄	mg/l	ID9	12/8/2009	0.02	NH ₄	mg/l	ID9	11/8/2021	0.015	NH ₄	mg/l	ID10	12/6/2008	0.02	NH ₄	mg/l	ID10	16/6/2019	0.007	NH ₄	mg/l	ID10	16/6/2019	0.007	NH ₄	mg/l	ID10
11/7/2010	0.026	NH ₄	mg/l	ID8	10/6/2012	0.02	NH ₄	mg/l	ID8	13/8/2013	0.007	NH ₄	mg/l	ID9	22/6/2010	0.02	NH ₄	mg/l	ID9	12/6/2022	0.007	NH ₄	mg/l	ID10	15/7/2008	0.02	NH ₄	mg/l	ID10	5/7/2009	0.007	NH ₄	mg/l	ID10	5/7/2009	0.007	NH ₄	mg/l	ID10
9/8/2010	0.012	NH ₄	mg/l	ID8	10/7/2012	0.02	NH ₄	mg/l	ID8	8/6/2012	0.007	NH ₄	mg/l	ID9	20/7/2010	0.02	NH ₄	mg/l	ID9	13/7/2022	0.007	NH ₄	mg/l	ID10	27/8/2008	0.02	NH ₄	mg/l	ID10	7/8/2009	0.021	NH ₄	mg/l	ID10	7/8/2009	0.021	NH ₄	mg/l	ID10
14/6/2011	0.009	NH ₄	mg/l	ID8	8/8/2012	0.02	NH ₄	mg/l	ID8	10/7/2014	0.015	NH ₄	mg/l	ID9	31/8/2010	0.02	NH ₄	mg/l	ID9	12/8/2022	0.007	NH ₄	mg/l	ID10	8/6/2009	0.02	NH ₄	mg/l	ID10	12/6/2021	0.007	NH ₄	mg/l	ID10	12/6/2021	0.007	NH ₄	mg/l	ID10
16/7/2011	0.018	NH ₄	mg/l	ID8	7/6/2013	0.02	NH ₄	mg/l	ID8	3/8/2014	0.007	NH ₄	mg/l	ID9	28/6/2011	0.02	NH ₄	mg/l	ID9	8/6/2023	0.007	NH ₄	mg/l	ID10	22/7/2009	0.02	NH ₄	mg/l	ID10	12/7/2021	0.007	NH ₄	mg/l	ID10	12/7/2021	0.007	NH ₄	mg/l	ID10
28/6/2011	0.021	NH ₄	mg/l	ID8	18/7/2013	0.02	NH ₄	mg/l	ID8	26/6/2010	0.013	NH ₄	mg/l	ID9	14/7/2011	0.02	NH ₄	mg/l	ID9	13/7/2023	0.007	NH ₄	mg/l	ID10	12/8/2009	0.02	NH ₄	mg/l	ID10	11/8/2021	0.016	NH ₄	mg/l	ID10	11/8/2021	0.016	NH ₄	mg/l	ID10
20/6/2012	0.023	NH ₄	mg/l	ID8	11/8/2013	0.02	NH ₄	mg/l	ID8	11/7/2010	0.024	NH ₄	mg/l	ID9	10/6/2012	0.02	NH ₄	mg/l	ID9	13/8/2023	0.007	NH ₄	mg/l	ID10	22/6/2010	0.02	NH ₄	mg/l	ID10	12/6/2022	0.007	NH ₄	mg/l	ID10	12/6/2022	0.007	NH ₄	mg/l	ID10
21/7/2012	0.012	NH ₄	mg/l	ID8	5/6/2014	0.02	NH ₄	mg/l	ID8	9/8/2010	0.013	NH ₄	mg/l	ID9	10/7/2012	0.02	NH ₄	mg/l	ID9	8/6/2024	0.007	NH ₄	mg/l	ID10	20/7/2010	0.02	NH ₄	mg/l	ID10	13/7/2022	0.007	NH ₄	mg/l	ID10	13/7/2022	0.007	NH ₄	mg/l	ID10
5/8/2012	0.06	NH ₄	mg/l	ID8	2/7/2014	0.02	NH ₄	mg/l	ID8	14/6/2011	0.009	NH ₄	mg/l	ID9	8/8/2012	0.02	NH ₄	mg/l	ID9	10/7/2024	0.011	NH ₄	mg/l	ID10	8/6/2010	0.02	NH ₄	mg/l	ID10	12/8/2022	0.007	NH ₄	mg/l	ID10	12/8/2022	0.007	NH ₄	mg/l	ID10
25/6/2013	0.017	NH ₄	mg/l	ID8	2/8/2014	0.02	NH ₄	mg/l	ID8	16/7/2011	0.021	NH ₄	mg/l	ID9	7/6/2013	0.02	NH ₄	mg/l	ID9	3/8/2024	0.007	NH ₄	mg/l	ID10	28/6/2011	0.02	NH ₄	mg/l	ID10	8/6/2023	0.007	NH ₄	mg/l	ID10	8/6/2023	0.007	NH ₄	mg/l	ID10
24/7/2013	0.009	NH ₄	mg/l	ID8	9/6/2015	0.02	NH ₄	mg/l	ID8	28/8/2011	0.017	NH ₄	mg/l	ID9	18/7/2013	0.02	NH ₄	mg/l	ID9	26/6/2010	0.011	NH ₄	mg/l	ID10	14/7/2011	0.02	NH ₄	mg/l	ID10	13/7/2023	0.011	NH ₄	mg/l	ID10	13/7/2023	0.011	NH ₄	mg/l	ID10
8/8/2013	0.015	NH ₄	mg/l	ID8	5/7/2015	0.02	NH ₄	mg/l	ID8	6/6/2012	0.019	NH ₄	mg/l	ID9	11/8/2013	0.02	NH ₄	mg/l	ID9	11/7/2010	0.024	NH ₄	mg/l	ID10	10/6/2012	0.278	NH ₄	mg/l	ID10	13/8/2023	0.007	NH ₄	mg/l	ID10	13/8/2023	0.007	NH ₄	mg/l	ID10
28/6/2014	0.005	NH ₄	mg/l	ID8	3/8/2015	0.02	NH ₄	mg/l	ID8	2/7/2012	0.019	NH ₄	mg/l	ID9	5/6/2014	0.02	NH ₄	mg/l	ID9	9/8/2010	0.029	NH ₄	mg/l	ID10	10/7/2012	0.02	NH ₄	mg/l	ID10	8/6/2024	0.007	NH ₄	mg/l	ID10	8/6/2024	0.007	NH ₄	mg/l	ID10
12/7/2014	0.022	NH ₄	mg/l	ID8	2/6/2016	0.02	NH ₄	mg/l	ID8	5/8/2012	0.037	NH ₄	mg/l	ID9	2/7/2014	0.02	NH ₄	mg/l	ID9	14/6/2011	0.009	NH ₄	mg/l	ID10	8/8/2012	0.02	NH ₄	mg/l	ID10	10/7/2024	0.015	NH ₄	mg/l	ID10	10/7/2024	0.015	NH ₄	mg/l	ID10
29/6/8/2014	0.048	NH ₄	mg/l	ID8	8/7/2016	0.02	NH ₄	mg/l	ID8	25/6/2013	0.027	NH ₄	mg/l	ID9	2/6/2014	0.02	NH ₄	mg/l	ID9	16/7/2011	0.025	NH ₄	mg/l	ID10	7/6/2015	0.02	NH ₄	mg/l	ID10	3/8/2024	0.007	NH ₄	mg/l	ID10	3/8/2024	0.007	NH ₄	mg/l	ID10
26/8/2014	0.005	NH ₄	mg/l	ID8	11/8/2016	0.02	NH ₄	mg/l	ID8	24/7/2013	0.014	NH ₄	mg/l	ID9	9/6/2015	0.02	NH ₄	mg/l	ID9	28/8/2011	0.018	NH ₄	mg/l	ID10	18/7/2013	0.02	NH ₄	mg/l	ID10	18/7/2013	0.02	NH ₄	mg/l	ID10	18/7/2013	0.02	NH ₄	mg/l	ID10
6/6/2016	0.007	NH ₄	mg/l	ID8	9/6/2017	0.02	NH ₄	mg/l	ID8	8/8/2013	0.011	NH ₄	mg/l	ID9	5/7/2015	0.02	NH ₄	mg/l	ID9	6/6/2012	0.024	NH ₄	mg/l	ID10	11/8/2013	0.02	NH ₄	mg/l	ID10	11/8/2013	0.02	NH ₄	mg/l	ID10	11/8/2013	0.02	NH ₄	mg/l	ID10
6/7/2016	0.02	NH ₄	mg/l	ID8	14/7/2017	0.02	NH ₄	mg/l	ID8	28/6/2014	0.005	NH ₄	mg/l	ID9	3/8/2015	0.02	NH ₄	mg/l	ID9	2/7/2012	0.026	NH ₄	mg/l	ID10	5/6/2014	0.02	NH ₄	mg/l	ID10	5/6/2014	0.02	NH ₄	mg/l	ID10	5/6/2014	0.02	NH ₄	mg/l	ID10
18/8/2016	0.02	NH ₄	mg/l	ID8	10/8/2017	0.02	NH ₄	mg/l	ID8	12/7/2014	0.022	NH ₄	mg/l	ID9	2/6/2016	0.02	NH ₄	mg/l	ID9	5/8/2012	0.038	NH ₄	mg/l	ID10	2/7/2014	0.02	NH ₄	mg/l	ID10	2/7/2014	0.02	NH ₄	mg/l	ID10	2/7/2014	0.02	NH ₄	mg/l	ID10
27/6/2017	0.02	NH ₄	mg/l	ID8	19/6/2018	0.0085	NH ₄	mg/l	ID8	11/8/2014	0.052	NH ₄	mg/l	ID9	8/7/2016	0.02																							