Cambridge Waste Water Treatment Plant Relocation Project
Anglian Water Services Limited

Appendix 20.8: Update to Contaminant Transport Model

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Summary

During the construction and operation of the proposed waste water treatment plant (WWTP), the potential exists for contamination from the proposed WWTP to migrate in shallow groundwater through the West Melbury Marly Chalk Formation to the Black Ditch watercourse. Modelling of this migration has been undertaken to better understand the risks from the possible relocation site to the nearby environmental receptors connected to the Black Ditch i.e., Stow Cum Quy Fen Site of Special Scientific Interest (SSSI) and Allicky Farm Pond County Wildlife Site (CWS).

This technical note provides a subsequent revision of the contaminant transport assessment that formed Section 6 of the Hydrological Impact Assessment (HIA), as a result of an update to the contaminant transport model with data collected during the subsequent ground investigation.

ConSim models were run to simulate the fate and transport of dissolved contaminants in groundwater, sourced from the proposed WWTP, with the aim of estimating concentrations that would reach a drain that enters the Black Ditch. The model assumes that any contamination would result from normal site operation and not a failure incident resulting in significant contamination, due to the unlikely nature of these events.

The results from the updated modelling indicate that once contaminants reach the groundwater in the West Melbury Marly Chalk Formation, downgradient migration of contaminants will likely occur in the fractures which provide preferential pathways in the strata. Based on a Darcy's Law calculation with the maximum recorded flow rate, the groundwater flow rate across the width of the site would be in the region of 3.15 l/s that would act to cause this migration but would also lead to dilution.

Sensitivity testing of the model identified that the value for the effective porosity in the fracture flow is not a sensitive parameter for the model. It also indicated the hydraulic conductivity of the matrix does not vary the outputs much when using a value less than that used in the main model. Therefore, the results of the main model can be considered to be reasonable and conservative.

Overall, the results from the main models indicate that for most of the inorganic determinands, the retarded travel time to the receptors is significant (>1,000 years) and therefore no further assessment is considered to be required for these contaminants.

Contaminants including hydrocarbons, ammoniacal nitrogen and potassium, did reach the receptors within 1,000 years. However, even if these were able to enter the subsurface, their concentrations would be reduced through physical, geochemical and biological processes prior to reaching the compliance points, and even further before reaching the ultimate environmental receptors of Stow Cum Quy Fen SSSI, and Allicky Farm Pond CWS. This is due to the significant dilution and greater sorption that would occur in the surface water compared to that indicated by the model in the Chalk groundwater, due to the prevalence of organic material onto which the contaminants could sorb.

Despite the modelling results, it is highlighted that the design and construction of the proposed WWTP will include mitigation against major pollution incidents and will include mitigation to minimise the generation and mobilisation of contamination. During construction, these would include a foundation works risk assessment, code of construction practice and operational environmental management plan, which would assess the risks from potential on-site activities and assign appropriate mitigation, in order

to reduce the likelihood and impacts of any pollution events to the environment. During operation, the works would be managed under appropriate and robust management plans, including an Environmental Management System, which will continue to mitigate against leaks and spills, which are considered to be the main source of contaminants entering the environment from the proposed WWTP. Through these mitigation measures, the potential for the release of contaminants into the ground will be limited.

In conclusion, it is unlikely that significant concentrations of potential contaminants will reach Black Ditch within a significant timeframe (1,000 years). For some of the hydrocarbons, the retarded travel time has been modelled within 1,000 years, although solubility limits and dilution greatly reduce any impacts that would occur from the release of these determinands. In addition, the modelling assumes an infinite source of the contaminants whereas, in reality, any contaminant spill would comprise an isolated occurrence with limited volume or mobilisation.

As such, with appropriate design, construction, management and operational management, including mitigation features, it is unlikely there will be an adverse impact on groundwater quality in the West Melbury Marly Chalk Formation or surface water quality in Black Ditch. Furthermore, as a result, nature conservation sites at Stow Cum Quy Fen SSSI and Allicky Farm Pond CWS should not be affected by the presence of the proposed WWTP.

1 Introduction

1.1 Background

1.1.1 As part of the regeneration of North East Cambridge, the existing Cambridge waste water treatment plant (WWTP), run by Anglian Water Services Limited (Anglian Water) is to be relocated. To allow this to happen, an application for a development consent order (DCO) for the Cambridge Waste Water Treatment Plant (WWTP) Relocation project is to be submitted in due course. During consultation in relation to the project proposals submitted during the first phase of public consultation, the Environment Agency indicated that a Hydrogeological Impact Assessment (HIA) should be carried out to support the selection of a final site for the relocation of the existing Cambridge WWTP.

1.1.2 Mott MacDonald was commissioned to produce a HIA that built on the high-level assessment of the potential impacts on the water environment provided in the Water Resources Statement (Mott MacDonald Ltd, 2020) and provided an initial hydrogeological assessment of the potential impacts that could arise as a result of construction or operation of a new WWTP. The HIA utilised the results of a preliminary phase of ground investigation, a site visit to Quy Fen Site of Special Scientific Interest (SSSI) and further desk-based study to improve the understanding of local hydrogeology and assess potential impacts. The HIA also presented an initial contaminant transport model (developed in ConSim v2.5 (Golder Associates Ltd, 2009)) to better understand risks from contamination migrating from the site to nearby sensitive receptors.

1.1.3 Since the production of the HIA, the preferred location has been selected (Site 3 in the HIA) and the new treatment plant design progressed. Additionally, further ground investigation has been undertaken in this area to refine baseline conditions at the land required for construction of the new WWTP. As a result, the ConSim model produced for Site 3 requires updating with the refined information now available, to support the submission of the Environmental Statement for the DCO.

1.2 Report aims and scope

1.2.1 During the construction and operation of the proposed WWTP, the potential exists for contamination from the proposed WWTP to migrate in shallow groundwater through the West Melbury Marly Chalk Formation to the Black Ditch watercourse. Modelling of this migration was undertaken to better understand the risks from the possible relocation site to nearby environmental receptors connected to the Black Ditch i.e., Stow Cum Quy Fen SSSI and Allicky Farm Pond County Wildlife Site (CWS).

1.2.2 This technical note provides a subsequent revision of the contaminant transport assessment that formed Section 6 of the HIA, as a result of an update to the contaminant transport model using data collected during the recent ground investigation.

1.2.3 It provides a summary of the data used in the modelling to allow replicability of the technical assessment, and is aimed at professionals who have prior knowledge and understanding of the methodology and principles of the ConSim model. For further information on the theory behind the model, please refer to the ConSim user guide.

1.3 Assumptions and limitations

1.3.1 This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

1.3.2 We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

1.3.3 To the extent that this document is based on information obtained in previous or recent ground investigations, persons using or relying on it should recognise that any such investigation can examine only a fraction of the subsurface conditions.

1.3.4 The modelling undertaken for this assessment has been conducted using ConSim, developed by Golder Associates on behalf of the Environment Agency. ConSim is designed to provide a means of assessing the risk that is posed to groundwater by leaching contaminants. Uncertainties in the environment are taken into account by the model through the use of parameter input ranges and a Monte Carlo probabilistic calculation methodology. Despite this, the model is inherently an over-simplification of the actual conditions present at a site, and outputs provide an approximate of potential scenarios only. However, in keeping with the principles of tiered risk assessment (Environment Agency, 2021), a simplified approach is considered to be conservative due to the nature of the assumptions made. The model outputs give an order of magnitude indication of travel times for potential contaminants which is considered sufficient for this assessment.

1.3.5 The modelling assumes that any contaminants would result from normal operation of the proposed WWTP, including leaks and spills, and not an incident resulting in significant contamination, such as a sudden and largescale failure of infrastructure (digester, tunnel pipework etc). This is due to the very low likelihood of incidents occurring that would result in significant volumes of contamination being released to the environment as a result of the presence of the proposed WWTP.

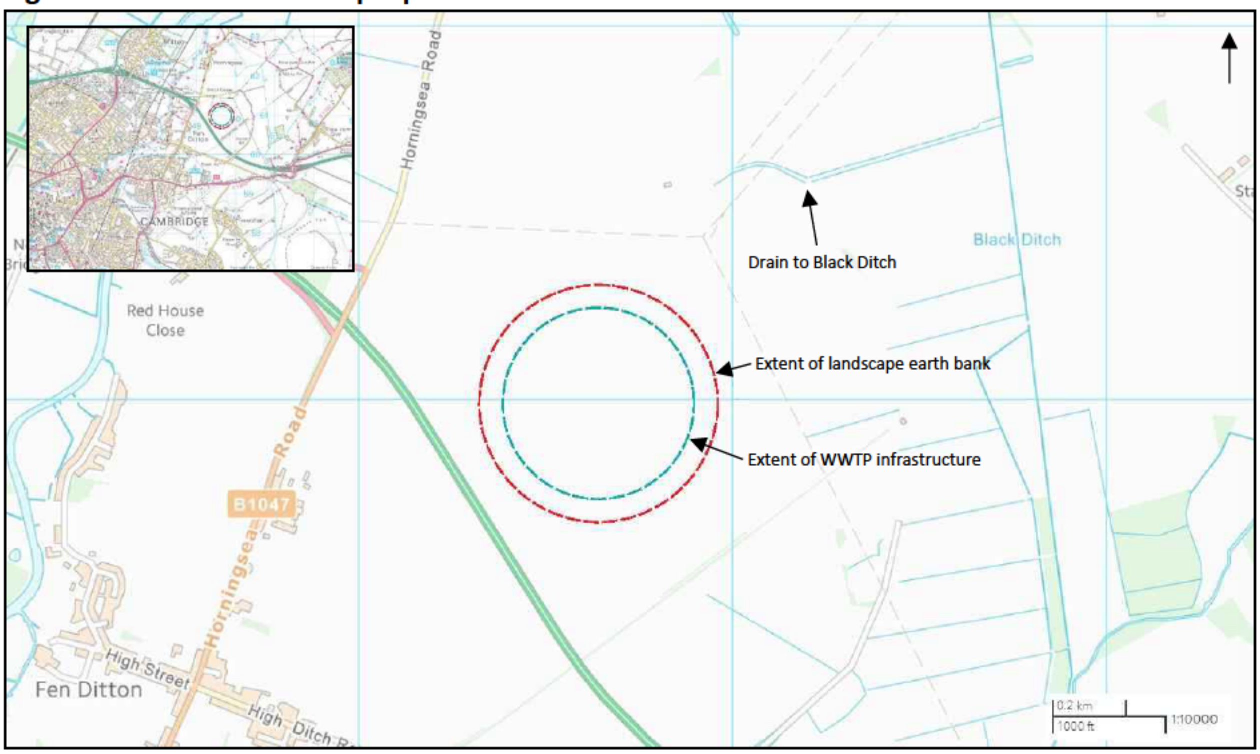
2 Environmental site setting

2.1 Location

2.1.1 The proposed WWTP is located 2km to the east of the existing Cambridge WWTP, within the administrative boundary of South Cambridgeshire District Council. The proposed WWTP lies between the villages of Horningsea to the north, Stow Cum Quy to the east and Fen Ditton to the south-west. The A14 extends along the south-western boundary of the proposed WWTP and Low Fen Drove Way, an unclassified road and public byway follows parts of the eastern and north-eastern boundary of the proposed WWTP area.

2.1.2 A plan of the location for the proposed WWTP can be seen in Figure 2.1.

Figure 2.1: Location of the proposed WWTP



2.2 Topography

2.2.1 Ordnance Survey (OS) mapping indicates that the land required for the landscape masterplan spans the 10mAOD contour on the east side of the River Cam. The topographic elevation reduces from west to east across much of the site, towards the set of drainage features connected to the Black Ditch. As the Chalk is at outcrop, any groundwater flow would be expected to follow topography, with groundwater levels at a shallower depth in lower parts of the proposed WWTP. It is likely, therefore, that most of the groundwater flow is towards the network of land drainage feeding into the Black Ditch (which has been confirmed by groundwater level monitoring). OS mapping indicates that the 5mAOD contour is located in this area of land drains, with the elevation declining overall to the north.

2.3 Geology

2.3.1 Geological mapping (BGS GeoIndex) indicates that no superficial deposits are present at the site of the proposed WWTP. BGS mapping indicates that this area is underlain by bedrock comprising the West Melbury Marly Chalk Formation (part of the Grey Chalk Subgroup). The total thickness of the West Melbury Marl Chalk Formation in the area was indicated to be approximately 10m based on historical geological logs from boreholes along the A14 and Low Fen Drove Way.

2.3.2 The geological description of the area of the proposed WWTP has been further refined through ground investigation of the site by Soil Engineering (Soil Engineering Ltd, 2022), with the findings summarised as:

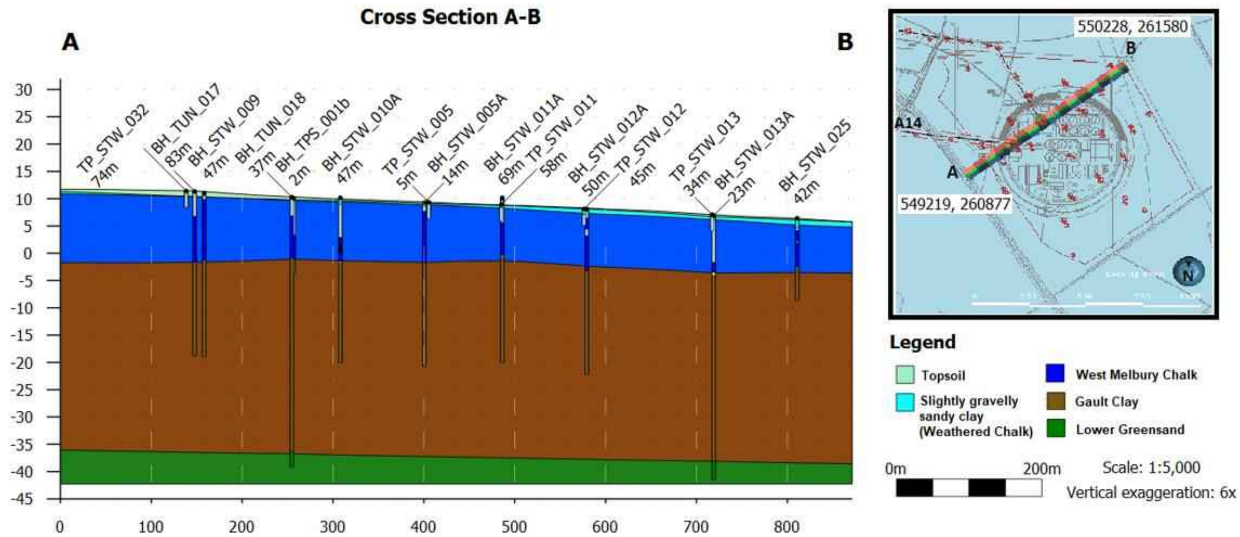
Table 2.1: Encountered geology

Encountered Strata	Typical description	Typical thickness (m)	Depth to base (m bgl)
Topsoil	Slightly gravelly sandy clay	0.3 - 0.5	0.3-0.5
Made ground (TP_STW_004, TP_STW_005, TP_STW_021 and BH_STW_12A only)	Slightly sandy gravelly clay. Gravel is brick, flint and quartz.	0.3-0.5	0.3-0.5
River Terrace Deposits (limited locations only)	Sandy gravelly clay, fine to coarse calcareous sand and fine to coarse gravel.	0.2- 1.7	0.3 – 2.0
West Melbury Marly Chalk	Structureless Chalk comprised of calcareous clay	7.25-13.41	9.0-13.5
Cambridge Greensand Member	Very stiff greenish slightly gravelly clay and fine sand. Gravel is coprolite.	0.15 - 0.5	9.25-13.87
Gault Formation	Very stiff dark grey clay.	Proven to 34.0-35.4	Proven to 45.0-46.6
Lower Greensand	Greenish grey sandy clay	Proven to 3.5	Not proven

* Made ground was encountered in discrete areas of Scheme Order Limits only. No evidence of visual or olfactory contamination.

2.3.3 A simplified geological cross-section of the area has been developed, and can be seen in Figure 2.2. Note that the River Terrace Deposits were not identified in on site boreholes and are therefore not shown.

Figure 2.2: Geological cross-section



2.4 Hydrogeology

2.4.1 The Environment Agency has classified the Chalk, of which the West Melbury Marly Chalk Formation and the Cambridge Greensand form a part, as a Principal aquifer, and the Gault Formation as Unproductive strata. Superficial deposits in the wider area (Alluvium and River Terrace Deposits) are classified as a Secondary A aquifer, and any water within these may be in connectivity with the Principal aquifer.

2.4.2 During the 2022 ground investigation, groundwater strikes were encountered between 4.32mAOD (2.12mbgl) and 6.30mAOD (3.60mbgl) in the Chalk. The gradient of the groundwater surface generally follows the topographic gradient, declining towards the Black Ditch to the north-east.

2.4.3 Permeability testing of the saturated Chalk has been undertaken during two investigations on the proposed WWTP, however results have been variable. The more recent Ground Investigation (GI) (Soil Engineering Ltd, 2022) indicated hydraulic conductivities generally in the range of 4.9×10^{-6} to 5.5×10^{-5} m/s[1] which are significantly higher than inferred from previous investigation (A F Howland Associates, 2020) of 7.0×10^{-8} m/s. When comparing these results, and those in literature of typical unfractured Chalk, the results indicate that the Chalk in the vicinity of the proposed WWTP has some fractures allowing preferential flow, but where these are not encountered, the matrix flow through the Marly Chalk is slow.

[1] Based on low and high end transmissivity values of 9m^2/day and 34m^2/day, calculated from a Boulton curve fit against test pumping data collected from the proposed WWTP shaft site.

2.5 Surface water network

2.5.1 There is a series of parallel drainage ditches which extend in an easterly direction from Low Fen Drove Way, and discharge to the Black Ditch. A drainage ditch which originates close to the proposed WWTW appears to connect into the Black Ditch to the north-east of Low Fen Drove Way. The Black Ditch drains in a northerly direction from the area to the south-east of the land required for the proposed WWTP and landscaping, towards Stow Cum Quy Fen SSSI. The course of the ditch continues in a north-easterly direction along, and just within, parts of the boundary of the SSSI, before discharging towards Bottisham Lode.

2.5.2 Considering the groundwater level below the proposed WWTP, and assuming a hydraulic gradient which is consistent with the topography, indicates that groundwater in the Grey Chalk over much of the area is likely to be in hydraulic connectivity with surface water in the area of drainage ditches that feed into the Black Ditch. However, due to the low permeability of the lowermost section of the Grey Chalk present in this area, it is considered that the baseflow contribution to the Black Ditch is also likely to be low.

2.5.3 There are a number of open waterbodies in the area, including Allicky Farm Pond CWS, and pools at Stow Cum Quy Fen SSSI that are formed partly or wholly on the Grey Chalk, and may be in hydraulic continuity with groundwater. In the case of Allicky Farm Pond CWS, the site is located across a ribbon of peat deposits which appears to have formed the original course of the Black Ditch. Hence this feature may be dependent on groundwater in the superficial deposits, or on a combination of groundwater in the superficial deposits and bedrock (likely in hydraulic continuity).

3 Proposed Development

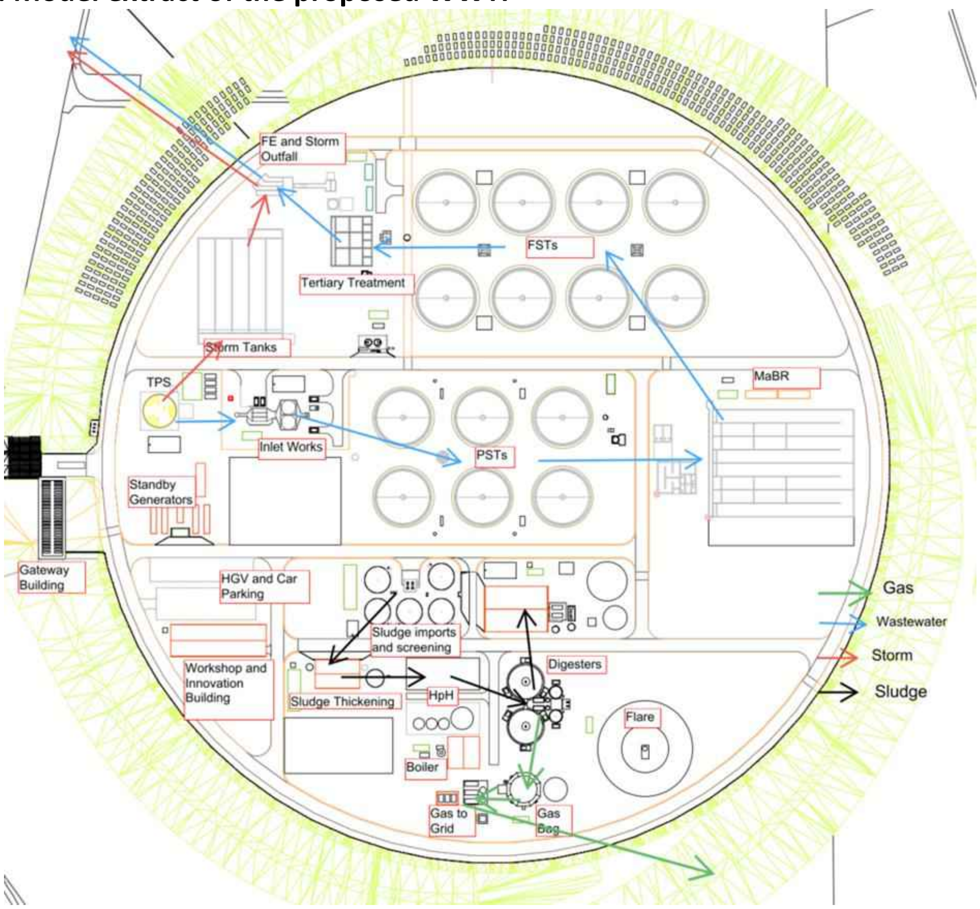
3.1 Project scope

3.1.1 The Proposed Development involves the construction of a new waste water treatment plant (WWTP) which will include water recycling and a Sludge Treatment Centre (STC) together with the associated developments. These associated developments include waste water and treated effluent transfer infrastructure, comprising a waste water transfer tunnel, treated effluent transfer pipelines coupled with a discharge outfall to the River Cam, and a transfer pipeline corridor from a pumping station off Bannold Drove, Waterbeach (hereafter referred to as the Waterbeach pipeline). Other associated development includes a new access road connecting the proposed WWTP to Horningsea Road and the diversion of several rising mains at the site of the existing Cambridge WWTP to relocate their discharge point from the existing inlet works to the new waste water transfer tunnel.

3.1.2 Alongside waste water treatment, the Proposed Development will store and/or treat storm flows during heavy rainfall, and treat imported sludge produced by surrounding WWTPs and commercial enterprises (e.g. trade effluent). The sludge treatment process will also produce an enhanced treated sludge product, referred to as biosolids, suitable for use as bio-fertiliser for land application. As well as the bio-fertiliser, the sludge treatment process will produce biogas which will be used on site to raise the heat needed to operate the process, with the surplus biogas upgraded to produce biomethane for injection into the local gas network. The proposed WWTP will also include the installation of photovoltaic panels to harness solar energy for conversion into electricity to service some of the power demand within the proposed WWTP.

3.1.3 Figure 3.3 below provides an indicative layout for the proposed WWTP, although this is still in the design phase and therefore may differ from the final design.

Figure 3.3: Model extract of the proposed WWTP



3.2 Details of infrastructure relevant to this assessment

Surface water drainage

3.2.1 All surface water within the proposed WWTP that has the potential to be contaminated will be contained within an enclosed drainage system and fed back through the works process to be treated prior to being discharged to the river via final effluent (FE) outfall pipes.

3.2.2 Where there is no potential for surface water to be contaminated, it may be disposed of in a number of ways:

- Collection through an enclosed drainage system before being pumped directly to river via the FE pipeline;
- Allowed to run off via a soakaway, where there is no detriment to the existing drainage; and

- Collected by and dealt with via a sustainable drainage system (SuDS) arrangement where appropriate and feasible. The SuDS may incorporate aspects of the previously two mentioned options.

3.2.3 Highway drainage is proposed to be gullies and piped system on the 'embankment' section of the access road, discharging to a swale on southern side of the access road, with the eastern section of the access road to discharge directly to swale from carriageway. Surface water would discharge into the drainage system for non-contaminated flows within the proposed WWTP. Surface water would be attenuated on site where appropriate.

3.2.4 A containerised unit for refuelling the tankers will be located on an area of concrete hard standing. The area will have its own closed drainage system to prevent any discharges to watercourses or into the works.

3.2.5 Drainage for the landscaped earth bank will likely be via French drains within the embankment itself connecting into a catcher drain at the toe of the bank. This will then connect into either the existing land drainage network (with or without a swale to attenuate flows) or connect into the proposed drainage system within the proposed WWTP for non-contaminated flows.

Tanks

3.2.6 Many tanks associated with the operation processes of the proposed WWTP will be present on site. Most will be constructed 1-3m below the finished ground level (bfgl), although some are anticipated to be as much as 8mbfgl (note that the exact depths are to be determined once the hydraulic profile through the works has been determined).

3.2.7 Catastrophic failure is most common in assets that are either nearing the end of their asset life or are built with an inherent defect that must be managed through other maintenance procedures. The tanks to be constructed at the proposed WWTP will therefore be early in their design life for many years to come, during which any defects will be spotted through regular maintenance inspections, but also their construction will be supervised to ensure the structures are fit for purpose and compliant with the relevant specifications and standards. This ensures that the two biggest risks to catastrophic failure have been minimised (aging assets, and unspotted defects), however it is accepted that some minor leakage from tanks may be possible.

3.2.8 A Mott MacDonald review of the Environment Agency's report "A Review of Environmental Incidents at Anaerobic Digestion (AD) Plants and Associated Sites between 2010 and 2018" identified that catastrophic failure is highly unlikely without a significant, unforeseen incident taking place and that instead, the most likely impact from digesters is a small loss of contents due to a foaming incident resulting in a small amount of weeping down the digester wall. This would also be applicable to other tanks in that 'weeping' from small cracks in the sides is more likely than sudden failure.

3.2.9 As with all major infrastructure in the UK, any new structure built must adhere to the relevant standard of the time, for the Proposed Development that will include such standards as BS EN 1992-3 (design of concrete structures) and have a design life of a minimum of 50 years. In practice, there will also be inevitable improvements to the structures over time which will lead to increased life for the assets. Any significant leaks from the site infrastructure are therefore considered to be extremely unlikely.

3.2.10 The inherent structural properties of the plant, materials used, and arrangement put in place means a catastrophic failure from the tanks is highly unlikely and that any leaks will be small volume rather than a sudden loss of contents. The resulting dilution of any small volumes of contaminants leaked from the tanks would be significant when it enters the groundwater, rendering the impacts of entry to groundwater and onward migration as negligible.

Chemical storage

3.2.11 Chemical dosing is required at certain stages of the water treatment or sludge production process. The chemicals for the dosing are often harmful or toxic if they were able to enter the environment, such as ferric sulphate, sodium hydroxide (caustic soda) etc.

3.2.12 Measures will be put in place to prevent and control the spillage of oil, chemicals and other potentially harmful liquids in accordance with the Control of Pollution (Oil Storage) (England) Regulations 2001 and Dangerous Substances and Explosive Atmospheres Regulations 2002. This will include a risk assessment to identify, eliminate or mitigate the risk and ensure suitable control measures are in place. These will include, but not be limited to, controls such as:

- Storage containers will be required to have sufficient strength and structural integrity to ensure that they are unlikely to burst or leak in ordinary use. Secondary containers and bunding will be used where required by the Regulations, the base and walls of which will be required to be impermeable to water or oil;
- Suitable spill kits and containment will be made accessible including drain seals/filter membranes and chemical spill kits;
- All diesel and oil storage facilities will be locked to prevent un-authorised use;
- Any spillages will be reported to the relevant Site Manager and cleaned up immediately; and
- Machinery will be routinely checked to ensure it is in good working condition.

4 Contaminant transport assessment

4.1 Background and methodology

4.1.1 A ConSim model was run to simulate the fate and transport of dissolved contaminants in groundwater, sourced from the proposed WWTP, with the aim of estimating concentrations that would reach a drain that enters the Black Ditch. The model assumes that any contaminants would result from normal operation of the proposed WWTP and not an incident resulting in significant contamination, such as a failure of a digester, for the reasons described in Section 3.2.

4.1.2 ConSim has a fixed conceptual site model; it is used to assess the potential for leaching of contaminants from contaminated soil, or direct input of liquid contamination, followed by migration and attenuation in the unsaturated zone and subsequently the aquifer system. Dilution, retardation and biodegradation/decay may be incorporated and multiple sources, contaminants and receptors are able to be modelled. The output includes contaminant concentrations at specific locations, both retarded and unretarded travel times, and aquifer throughflow. Multiple unsaturated pathways may also be included to take account of the effects that different materials will have on infiltration and contaminant migration. The software allows a tiered assessment approach where Level 1 is the simplest and most conservative as it directly compares leachate concentrations with relevant water quality standards. Level 2 builds on the data from Level 1 and introduces transport and attenuation through the unsaturated zone and dilution at the water table. Level 3 includes the advection and attenuation of the contamination through the aquifer to a user defined receptor. The uncertainty inherent in the environment is taken into account by the software through the use of parameter input ranges and a Monte Carlo probabilistic calculation methodology. It should be noted that ConSim is not suitable for modelling the migration of non-aqueous phase liquids (NAPL), and does not consider risk to human health.

4.1.3 ConSim uses several simplifying assumptions when making the model calculations, which allow the model to run, however the likelihood of all assumptions being true in the environment is unlikely. These assumptions include:

- homogeneous & isotropic transport zones;
- laminar flow, in one direction only with constant velocity;
- no diffusion other than that specifically included;
- constant contaminant and geosphere properties, both those defined and those implicitly assumed (such as water viscosity, temperature, density etc.);
- sorption approximated by a linear isotherm; and

- desorption can be approximated by a linear isotherm and no geochemical or other processes are restricting this release.

4.1.4 On the basis of the assumptions used by the model and the occurrence of these in the environment, the model outputs should be used to gain an understanding of the order of magnitude of travel times or concentration for potential contaminants, rather than absolute values. However, this indication of receptor concentrations and travel times is considered sufficient for this assessment, and despite the limitations of the model, ConSim is considered to be appropriate for this assessment when taking into account the availability of data and the nature of the concern.

4.1.5 The design and construction of the proposed WWTP (see Section 0) will include mitigation against major pollution incidents and to limit any contamination during normal operating procedures. The proposed WWTP will operate a closed loop process monitored by a remote control system (SCADA[2]), which would detect any shortfalls in delivery of product[3] (indicating a leak) and shut off the system as required to limit escape of the product to the environment. Additionally, all underground pipework on the proposed WWTP is understood to be gravity fed lines (ie not pressurised) containing sewage or wastewater, whereas any pipework transferring sludge (at pressure to force it through the system) is above ground and therefore any potential leaks from these will be captured by the designed containment and drainage system, and the automated isolation valves will shut off the infrastructure with the issue. The twin Waterbeach pipelines are below ground and pressurised, however these will be constructed using standard techniques to minimise risks from failure and pressure monitored to detect any issues.

4.1.6 Significant leaks from the tunnel, shaft or underground tanks are highly unlikely (as discussed in Section 3.2) and therefore not considered within this model. Therefore, the most likely scenario through which contaminants from the proposed WWTP would enter the ground is an accidental spill of a substance directly onto permeable ground, a small leak within the drainage system before the leak was detected via maintenance activities, weeping from above ground tanks or ingress through a small crack in the hardstanding, all of which would be limited in volume.

4.1.7 On the basis of the conceptual model, the ConSim model was created with consideration of the following factors:

- A level 3 (unsaturated and saturated zone transport) scenario was run to simulate saturated transport of contaminants from the ground surface through the West Melbury Marly Chalk Formation to the compliance point of a drain that feeds into the Black Ditch. This does not account for any dilution that would occur in the

[2] Supervisory control and data acquisition 'SCADA' - control system architecture comprising computers, networked data communications and graphical user interfaces for high-level supervision of machines and processes.
[3] The Design Team for the new WWTP have indicated that although this will be defined by instrument accuracy, dual validation will be employed which will result in the expected magnitude of accuracy in the millilitre range.

drain before the impacted waters reach the Black Ditch and downstream sensitive receptors, providing conservatism in the model.

- The West Melbury Marly Chalk Formation is underlain by >10 m of Gault Formation, which is known to have very low permeability and transmissivity. Therefore, the saturated pathway is modelled to exist only in the Chalk.
- The same determinands have been modelled as in the HIA (certain metals, hydrocarbons and ammoniacal nitrogen), which are known to exceed water quality standards in the area or are considered to be potentially sourced from a WWTP and highly mobile in the environment. Site specific target levels (SSTL) have been developed for these determinands through a calculation of the relative difference of the input concentration to the concentration at the receptor, and the applicable water quality standard at the receptor that should not be exceeded. The model only considers determinands in the dissolved phase, therefore NAPL are not included in the modelling.
- The model was run for 1001 iterations to increase the confidence level (or percentile) in the results to 99%. Results focus on steady state conditions.
- Input concentrations of determinands were all set to 0.001 mg/l to calculate the SSTL. Input concentrations are irrelevant when calculating the SSTL as it is a calculation on relative values.

4.1.8 The following assumptions were also made:

- Groundwater flow in the West Melbury Marly Chalk Formation is assumed to be through preferential flow in fractures, diffusion from the fractures into the matrix, and via matrix flow, therefore the model has been run for all three of these scenarios to calculate a likely range of values. The likely “real-world” value will sit between these. However, the fracture flow will be an overestimate of the likely flow rate as it is highly unlikely that the fractures in the subsurface are all orientated linearly, continuous across the full distance to the receptor and across the full depth of the aquifer as inferred within the model.
- Nitrate has not been included in this model, although it is a potential contaminant to be sourced from a WWTP. This is due to the complexities and interactions of denitrifying bacteria on the process, which are unknown and modelling nitrate could therefore be unrepresentative. Ammoniacal nitrogen, which is a precursor to other forms of nitrogen in sewage, has been included.

4.2 Model input parameters

4.2.1 Parameter values were assigned from site specific data and a variety of literature sources where site specific data were unavailable. A full list of the physical parameters used for the modelling are presented in Table 4.1. Chemical parameters are presented in Table 4.3.

4.2.2 The same chemical parameters have been used as in the modelling for the HIA for consistency, however as some of these were chosen based on the site selection process (specifically, known groundwater exceedances from a landfill near to one of the other potential locations), they may not present a significant contaminant of concern from the proposed WWTP (eg potassium) based on the substances that are anticipated to be used and produced on site.

Table 4.1: ConSim model physical input parameters

Parameter	Distribution	Value	Justification
Analysis level	3		
Source			
Area (m^2)	Single	318,000	Area calculated from drawings – to outside extent of the earth bank
Thickness (m)	Single	0.01	Assumes spill/leak at surface
Unsaturated zone - West Melbury Marly Chalk			
Unsaturated thickness (m)	Uniform	3.1, 4.94	Recorded during ground investigation from boreholes on the proposed WWTP site
Dry bulk density (g/cm^3)	Triangular	1.55, 1.78, 2.01	Reported values during recent site investigation
Fraction of organic carbon	Uniform	0.0005, 0.003	Min and max values during site investigation. <detection given as half detection limit
Total porosity	Triangular	0.26, 0.33, 0.39	Reported from laboratory tests of samples
Water filled porosity (fraction)	Uniform	0.13, 0.28	Calculated from moisture content of samples and dry density
Unsaturated conductivity (m/s)	Single	1e-7	Price (1987) Fluid flow in the Chalk of England – matrix hydraulic conductivity of 0.01m/d (on basis of any fractures being predominantly horizontal approximately aligned with bedding planes).
Vertical dispersivity (m)	Uniform	0.31, 0.494	10% zone thickness (considered worst case)
Infiltration (mm/year)	Triangular	75, 110, 125	Average recharge (1961-2014) for area of proposed works based on Newmarket groundwater model produced by Mott MacDonald for Anglian Water (2020). Calculated using SWaCMOD[4].
Aquifer – West Melbury Marly Chalk			

[4] Surface Water Accounting Model (SWAcMOD)

Parameter	Distribution	Value	Justification
Saturated thickness (m)	Uniform	6.72, 7.92	Aquifer saturated thickness from pumping test data collected during recent GI
Dry bulk density (g/cm^3)	Triangular	1.55, 1.78, 2.01	Reported values during recent site investigation
Fraction of organic carbon	Uniform	0.0005, 0.003	Min and max values during site investigation. <detection given as half detection limit
Saturated hydraulic conductivity – fractures (m/s)	Triangular	4.9e-6, 2.9e-5, 5.5e-5	Values calculated from Boulton curve fit to dewatering test results from recent GI, considered to be fracture flow.
Saturated hydraulic conductivity – matrix (m/s)	Single	1e-7	Price (1987) Fluid flow in the Chalk of England – matrix hydraulic conductivity of 0.01m/d
Effective porosity – fractures (fraction)	Uniform	0.03, 0.05	Considered to be representative of fracture flow. Values for chalk (Allen, D.J. et al., 1997)
Effective porosity – matrix (fraction)	Uniform	0.13, 0.28	Porosity for Chalk based on GI results
Hydraulic gradient (m/m)	Single	0.0044	Based on elevations during GI
Groundwater flow direction (°)	Single	40	Based on elevations during GI
Longitudinal dispersivity 1 (m)	Uniform	7.91	Xu and Eckstein (Xu and Eckstein, 1995) calculation for CP1
Lateral dispersivity 1 (m)	Uniform	0.791	Xu and Eckstein calculation for CP1
Longitudinal dispersivity 2 (m)	Uniform	2.98	Xu and Eckstein calculation for CP2
Lateral dispersivity 2 (m)	Uniform	0.298	Xu and Eckstein calculation for CP2
Receptors			
Compliance point 1 (m)	Single	350	Distance downgradient of earth bank to Snout Corner (drain) connecting to Black Ditch
Compliance point 2 (m)	Single	50	Standard aquifer compliance point

4.2.3 To account for the three contaminant migration scenarios in the dual porosity West Melbury Marly Chalk Formation, the combinations of hydraulic conductivity and effective porosity have been used as shown in Table 4.2.

Table 4.2: Model scenarios

Scenario	Saturated hydraulic conductivity (m/s)	Effective porosity (fraction)
Preferential flow in fractures	4.9e-6, 2.9e-5, 5.5e-5 (triangular distribution)	0.03, 0.05 (uniform distribution)
Diffusion from fractures into matrix	4.9e-6, 2.9e-5, 5.5e-5 (triangular distribution)	0.13, 0.28 (uniform distribution)
Matrix flow	1e-7	0.13, 0.28

Table 4.3: ConSim model chemical input parameters

Contaminant	Koc/Kd (ml/g)	Henry's Law constant	Max solubility (mg/l)	Half life (years) (water)
Cadmium	100[1]	0	10000000	10000000
Copper	35[6]	0	10000000	10000000
Mercury	500[1]	0	10000000	10000000
Nickel	500[1]	0	10000000	10000000
Potassium	5.5[6]	0	10000000	10000000
Zinc	38[1]	0	10000000	10000000
Aliphatic C5-C6	794[2]	33[2]	36[2]	1.95[2]
Aliphatic C6-C8	3981[2]	50[2]	5.4[2]	1.95[2]
Aromatics EC5-7	79[2]	0.23[2]	1800[2]	2[3]
Aromatics EC7-8	251[2]	0.27[2]	520[2]	0.55[3]
Naphthalene	1288[4]	0.0174[4]	31[4]	0.71[3]
Ammoniacal nitrogen	0.65-6.5[5]	0.000658[6]	10000000	10000000[5]

[1] Nathanail et al 2015: "The LQM / CIEH S4ULs for Human Health Risk Assessment", Copyright Land Quality Management Limited reproduced with permission: Publication No. S4UL3389

[2] Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG), 1999. Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach, Volume 5, Table 1.

[3] Howard et al. 1991. Environmental Degradation Rates. Max values.

[4] Environment Agency/Atkins, 2003. Review of the Fate and Transport of Selected Contaminants in the Soil Environment. Tables 2.4, 3.2 & 4.3.

[5] Buss et al., 2004. A Review of Ammonium Attenuation in Soil and Groundwater. QJEGH v37. Kd values chosen for clay. Half life is maximum for strata with mean pore size of >1um assuming anaerobic conditions

[6] RAIS database (Risk Assessment Information System, http://rais.ornl.gov/tools/)

4.3 Results

4.3.1 A summary of the modelling results is presented in Table 4.4 and Table 4.5, with full results provided in Appendix A, alongside an image of the model setup. SSTL have been calculated to understand the concentrations of determinands that could leave the site, without exceeding water quality standards at the receptor.

Table 4.4: ConSim model results summary – CP1 (drain leading to Black Ditch)

Contaminant	Retarded travel time (years)			SSTL (mg/l)		
	Fracture flow	Matrix diffusion	Matrix flow	Fracture flow	Matrix diffusion	Matrix flow
Cadmium	20,000	19,000	28,000	0.00010	0.00010	0.000080
Copper	6,900	6,800	9,900	0.0013	0.0013	0.0010
Mercury	98,000	97,000	140,000	0.000087	0.0001	*
Nickel	98,000	97,000	140,000	0.0070	0.010	*
Potassium	1,100	1,100	1,600	15	15	12
Zinc	7,500	7,400	11,000	0.014	0.014	0.011
Aliphatic C5-C6	13	25	36	0.20	2.4	12
Aliphatic C6-C8	24	36	51	0.20	2.4	12
Aromatics EC5-7	10	23	33	0.19	2.2	10
Aromatics EC7-8	11	23	34	31	77,000	16,000,000
Naphthalene	15	27	39	2.0	880,000	56,000
Ammoniacal nitrogen	480	490	800	0.49	0.49	0.38

Results presented to 2 s.f.
** No breakthrough at 95%ile. SSTL not able to be calculated.*

Table 4.5: ConSim model results summary – CP2 (50m)

Contaminant	Retarded travel time (years)			SSTL (mg/l)		
	Fracture flow	Matrix diffusion	Matrix flow	Fracture flow	Matrix diffusion	Matrix flow
Cadmium	12,000	13,000	16,000	0.00010	0.00010	0.000080
Copper	4,300	4,400	5,600	0.0013	0.0013	0.0010
Mercury	62,000	63,000	80,000	0.000068	0.000067	0.000050
Nickel	62,000	63,000	80,000	0.0054	0.0054	0.0040
Potassium	690	700	900	15	15	12
Zinc	4,700	4,800	6,100	0.014	0.014	0.011
Aliphatic C5-C6	10	16	20	0.11	0.28	0.32
Aliphatic C6-C8	17	23	29	0.11	0.28	0.32
Aromatics EC5-7	8.6	14	18	0.10	0.26	0.30
Aromatics EC7-8	9.0	15	19	4.0	73	280
Naphthalene	11	17	22	0.29	2.9	8.0
Ammoniacal nitrogen	190	220	320	0.49	0.48	0.38

Results presented to 2 s.f.

4.3.2 Unretarded travel times to CP1 (the drain leading to Black Ditch) were between 10 years (fracture flow) and 32 years (matrix flow), and CP2 (50m in the aquifer) were between 8.4 years (fracture flow) and 18 years (matrix flow).

4.3.3 The interpretation of these results is presented in Section 4.4.1.

4.4 Sensitivity test

4.4.1 Sensitivity testing was undertaken on the CP1 (drain to Black Ditch) model to assess the impacts of variable input parameters, particularly: effective porosity (due to the unquantified effective porosity in the fractures of the Chalk) and hydraulic conductivity (as this is known to be a sensitive input parameter of groundwater models).

4.4.2 A summary of the findings for the test are provided in Table 4.6. The test was run with three of the contaminants that were considered to give a range of results based on their relatively different chemical input parameters.

Table 4.6: Sensitivity test results

Contaminant	Input value	Justification for value	SSTL (mg/l)	Unretarded travel time to CP (years)	Retarded travel time to CP (years)
Test 1 – effective porosity in fractures (fracture flow scenario)					
Potassium	0.01, 0.03	Representative of larger fractures	27	7.9	730
	0.03, 0.05	**Representative of fracture flow**	**15**	**10**	**1,100**
	0.05, 0.08	Representative of smaller fractures	16	12	1,100
Aromatics EC5-7	0.01, 0.03	Representative of larger fractures	0.17	7.9	8.1
	0.03, 0.05	**Representative of fracture flow**	**0.19**	**10**	**10**
	0.05, 0.08	Representative of smaller fractures	0.28	12	12
Ammoniacal nitrogen	0.01, 0.03	Representative of larger fractures	0.84	7.9	240
	0.03, 0.05	**Representative of fracture flow**	**0.49**	**10**	**480**
	0.05, 0.08	Representative of smaller fractures	0.49	12	480
Test 2 – hydraulic conductivity in fractures (fracture flow scenario)					
Potassium	**4.9e-6, 2.9e-5, 5.5e-5**	**Values calculated from dewatering test during GI (3-34m²/day transmissivity)**	**15**	**10**	**1,100**
	3.4e-5, 1.1e-4, 1.7e-4	Plausible upper estimate for fracture flow in marly Chalk (20-100m²/day transmissivity)	25	8.5	710
Aromatics EC5-7	**4.9e-6, 2.9e-5, 5.5e-5**	**Values calculated from dewatering test during GI (3-34m²/day transmissivity)**	**0.19**	**10**	**10**
	3.4e-5, 1.1e-4, 1.7e-4	Plausible upper estimate for fracture flow in marly Chalk (20-100m²/day transmissivity)	0.21	8.5	8.7
Ammoniacal nitrogen	**4.9e-6, 2.9e-5, 5.5e-5**	**Values calculated from dewatering test during GI (3-34m²/day transmissivity)**	**0.49**	**10**	**480**
	3.4e-5, 1.1e-4, 1.7e-4	Plausible upper estimate for fracture flow in marly Chalk (20-100m²/day transmissivity)	0.81	8.5	250

Contaminant	Input value	Justification for value	SSTL (mg/l)	Unretarded travel time to CP (years)	Retarded travel time to CP (years)
Test 3 – hydraulic conductivity (m/s) in the saturated and unsaturated matrix (matrix flow scenario)					
Potassium	7e-8	Recorded in 2020 investigation	12	32	1,600
	1e-7	**Price (1989) K in Chalk matrix**	**12**	**32**	**1,600**
	3.4e-5	Low average of 2022 GI	19	22	1,100
Aromatics EC5-7	7e-8	Recorded in 2020 investigation	8.6	32	32
	1e-7	**Price (1989) K in Chalk matrix**	**10**	**32**	**33**
	3.4e-5	Low average of 2022 GI	2.2	22	22
Ammoniacal nitrogen	7e-8	Recorded in 2020 investigation	0.38	32	750
	1e-7	**Price (1989) K in Chalk matrix**	**0.38**	**32**	**800**
	3.4e-5	Low average of 2022 GI	0.62	22	480

Note: Results from the main model run are in bold for comparison.

4.4.3 The interpretation of these results is presented in Section 4.4.1.

4.5 Discussion

4.5.1 The model has been refined from the one presented in the HIA through the use of additional site specific data, namely updated hydraulic conductivity, density and porosity values for the Chalk. As the design of the site has also been progressed, the model has been adapted to represent this by updating the site area and location. From the information presented in Section 3.2, the assessment now includes a vertical unsaturated pathway as the source is assumed to be from a spill to the surface and subsequent infiltration, rather than a leak from underground pipework or tanks.

4.5.2 The results from the updated modelling indicate that once contaminants reach the groundwater in the West Melbury Marly Chalk Formation, downgradient migration of contaminants will likely occur in the fractures which provide preferential pathways in the strata. This is similar to the results of the modelling undertaken for the HIA.

4.5.3 Unretarded travel time to the drain leading to the Black Ditch was modelled to be 32 years for matrix only migration, or between 10 and 22 years when fractures were included in the model. However, these numbers are not fully representative of real conditions as subsurface geochemical and biological processes will cause the contaminants to sorb, degrade or change redox state, which will slow the travel as well as reduce concentrations reaching the receptors. Also, fractures in the model are based on the assumption that preferential flow pathways are linear, continuous and present in the Chalk in the direction of the receptor across the full depth of the aquifer, although this is unlikely as fractures are more likely to be limited in extent, and not all aligned to the north-east/south-west.

4.5.4 The sensitivity test identified that the value for the effective porosity in the fracture flow is not a sensitive parameter for the model, with the SSTL and retarded travel times not varying much from the original model run. Although this parameter has not been taken from site specific information (due to the difficulty in measuring fracture size, orientation and spacing in-situ), the values used are considered to be representative but would not significantly impact the model outputs if different to the actual conditions present.

4.5.5 The sensitivity test also identified that the hydraulic conductivity of the matrix does not vary the outputs much when using a value less than that used in the main model ($1e^{-7}$ m/s). The value used for the main model likely represents a worst case scenario[5], on the basis that the Chalk in the area is marly, and a previous head test (A F Howland Associates, 2020) identified the hydraulic conductivity of the site to be in the region of $7e^{-8}$ m/s (likely purely matrix flow), therefore it is not expected that the matrix flow would be higher than that used in the main model. As the result of the sensitivity test were very similar for the values of $1e^{-7}$ m/s and $7e^{-8}$ m/s, the results of the main model can be considered to be reasonable and conservative.

4.5.6 Overall, the results from the main models (not the sensitivity testing) indicate that for most of the inorganic determinands, the retarded travel time to the receptors is significant (>1,000 years) and therefore no further assessment considered to be required for these contaminants, as indicated in the Environment Agency's Remedial Targets Methodology (Environment Agency, 2006). For the determinands with a retarded travel time <1,000 years (the hydrocarbons, ammoniacal nitrogen and potassium [for the 50m compliance point]), further consideration is needed.

4.5.7 Potassium is not a major contaminant of concern from a WWTP based on the anticipated used and produced substances (it was previously included in the modelling as a known contaminant in groundwater during the site selection process), therefore this determinand is not considered to be a significant risk to the environment from the presence of the site, especially as the time taken to reach the drain was >1000 years.

4.5.8 Ammoniacal nitrogen is a potential contaminant that may be sourced from the WWTP, although the source would be contained and controlled within the WWTP infrastructure, with the only plausible entry to the environment as a result of a leak of the drainage system around the STC or from minimal weeping of the digesters. This compound is unlikely to present a significant issue in the marly Chalk as the aquifer at this location is not used for drinking water. However, it may lead to algal growth if it were to enter the drain leading to the Black Ditch, or the Black Ditch itself. It may also convert to nitrate in favourable oxidising conditions, but the total nitrogen loading would remain the same.

4.5.9 For the hydrocarbons, it is not considered acceptable to allow the discharge of free-phase hydrocarbons into the environment, therefore the availability of these contaminants at the proposed WWTP with the potential to enter the environment will

[5] Taken from literature (Price, 1987) that included more competent Chalk across the south of England.

be limited by site design, management systems and suitable operational and emergency procedures. Any fuel spills would be contained on site by the tank bunds and wider hardstanding, over which the fuel pipelines would be located. Therefore, the likelihood of hydrocarbons reaching ground into which they can infiltrate is very low.

4.5.10 In addition, the ConSim model assumes an infinite source of the contaminants, however any contamination spill incident would be an isolated event with limited volume or mobilisation following rainfall, rather than a prolonged ongoing source. Dilution would occur associated with rainfall events, which would be a further factor, especially if the leak was a result of a failure of the drainage system[6]. The entry of water from the Black Ditch into the SSSI and CWS is also dependent on high flow rates (not connected under normal flow conditions), during which time the dilution capacity of the system would be significantly increased.

4.5.11 The modelling also only considers the migration of the contaminants through the subsurface to the drain that leads into the Black Ditch. If the impacted groundwater migrated vertically beyond the shallow depths that feed into the drain, it could travel beyond the 350m modelled receptor distance, allowing further degradation and sorption of the organics before reaching any environmental receptors. If any impacted groundwater did enter the drain then there would be further dilution (beyond that from the aquifer, which is not included in the model results[7]) and more available organic matter (relative to the Chalk) to which the contaminants would be able to sorb decreasing concentrations that would enter the Black Ditch via surface water flow.

4.5.12 When in the Black Ditch, any contaminants would encounter further dilution; the watercourse was estimated, very approximately, to have a flow rate of the order of 50 l/s during a site reconnaissance visit in December 2020[8], although it is noted that this flow rate is likely in the upper range of values, and the flow will vary seasonally.

4.5.13 Additionally, the Allicky Farm Pond county wildlife site, located adjacent to Black Ditch, is connected with Black Ditch only under high flow conditions. Some grassland areas of Stow Cum Quy Fen SSSI, and waterbodies within these areas, are also connected with Black Ditch but only under high flow conditions. Therefore, further substantial dilution of any residual contaminants would occur in the event that the contaminants were able to discharge to these features. However, any contamination reaching Black Ditch

[6] Met Office data (www.metoffice.gov.uk) for Cambridge Niab, averaged over 1991-2020, indicates an average minimum monthly rainfall of 32.9mm in March, and a maximum monthly value of 58.7mm in October. Assuming a site area of 318,000m^2 and an averaged daily precipitation rate of between 1.06 and 1.89mm/day (conservative as not including evapo(transpi)ration), the site drainage would accept in the region of 340-600m^3 runoff per day.
[7] Based on a Darcy's Law calculation with the maximum recorded flow rate, the groundwater flow rate across the width of the site would be in the region of 3.15 l/s that would act to cause this migration, but would also lead to dilution. (Using a hydraulic gradient of 0.0044, a maximum hydraulic conductivity of 1.7e-4m/s, a saturated thickness of 6.81m, and a site width of 630m).
[8] Indicating that the watercourse is fed by significant volumes of surface water as well as groundwater, based on the calculated groundwater flow rate of approximately 0.005 l/s/m (calculated during the Darcy's Law calculation discussed in footnote 7).

could affect water quality in the sections of Black Ditch located within Stow Cum Quy Fen SSSI. This would include water quality in a pond in the northern corner of the SSSI through which flow in Black Ditch passes.

4.5.14 In lower flow conditions, whilst there is lesser dilution, greater retardation and degradation of contaminants (especially organics) will occur during migration in the drain or Black Ditch.

4.5.15 Based on the multiple lines of evidence presented via the modelling and conceptualisation of the site and receptors, it is considered that the risk of contamination sourced from the proposed WWTP reaching environmental receptors at significant concentrations and causing impacts are low.

5 Summary and conclusions

5.1.1 A ConSim model was run to simulate the fate and transport of dissolved contaminants in groundwater, sourced from the proposed WWTP, with the aim of estimating concentrations that would reach a drain that enters the Black Ditch. The model is inherently a conservative over-simplification of the actual conditions present at a site, and outputs provide an approximate of potential scenarios only. However, it is considered to be appropriate for this assessment, taking into account the availability of data and the nature of the concern.

5.1.2 Although migration of contaminants through the West Melbury Marly Chalk Formation could occur, the retarded travel time exceeds 1,000 years for key inorganics and these are therefore considered insignificant, as indicated in the Environment Agency Remedial Targets Methodology.

5.1.3 Ammoniacal nitrogen and hydrocarbons were the modelled contaminants considered to present the highest risk from the presence of the proposed WWTP. However, even if these were able to enter the subsurface, their concentrations would be reduced through physical, geochemical and biological processes prior to reaching the compliance points, and even further before reaching the ultimate environmental receptors of Stow Cum Quy Fen SSSI and Allicky Farm Pond CWS. This is due to the dilution and greater sorption that would occur in the surface water channel compared to that indicated by the model in the Chalk groundwater, due to the prevalence of organic material, onto which the contaminants could sorb.

5.1.4 Additionally, the CWS and some grassland areas of Stow Cum Quy Fen SSSI, together with waterbodies within these areas, are in connectivity with the Black Ditch under high-flow conditions only. Therefore significant dilution would occur before the contaminants were able to enter these receptors. However, any contamination reaching Black Ditch could affect water quality in the sections of Black Ditch located within Stow Cum Quy Fen SSSI. This would include water quality in a pond in the northern corner of the SSSI through which flow in Black Ditch passes.

5.1.5 The ConSim model also assumes an infinite source of the contaminants. In reality, however, any contaminant spill would comprise an isolated occurrence with limited volume or mobilisation, rather than an ongoing, continuous source.

5.1.6 Despite the modelling results, it should be remembered that the design and construction of the proposed WWTP will include mitigation against major pollution incidents and will include mitigation to minimise the generation and mobilisation of contamination. During construction, these would include a foundation works risk assessment, code of construction practice and operational environmental management plan, which would assess the risks from potential on-site activities and assign appropriate mitigation, in order to reduce the likelihood and impacts of any pollution events to the environment.

5.1.7 The works would be operated in accordance with an Industrial Emissions Directive (IED) permit for the STC which includes the requirement for the operator to develop a written management system with a set of procedures describing actions to minimise the risk of pollution from the activities covered by the permit. The written system would take the form of an Environmental Management System (EMS) accredited to ISO 14001, with associated management plans and procedures. Implementation of the EMS will continue to mitigate against leaks and spills, considered to be the main source of contaminants potentially entering the environment from the proposed WWTP. Through these mitigation measures, the potential for the release of contaminants into the ground is limited

5.1.8 In conclusion, it is unlikely that significant concentrations of potential contaminants will reach Black Ditch within 1,000 years. For some of the hydrocarbons, the retarded travel time has been modelled within 1,000 years, although solubility limits and dilution greatly reduce any impacts that would occur from the release of these determinands. In addition, the ConSim model assumes an infinite source of the contaminants whereas, in reality, any contaminant spill would comprise an isolated occurrence with limited volume or mobilisation.

5.1.9 With appropriate design, construction, management and operational management, including mitigation features, it is unlikely there will be an adverse impact on groundwater quality in the West Melbury Marly Chalk Formation or surface water quality in Black Ditch. Furthermore, as a result, nature conservation sites at Stow Cum Quy Fen SSSI and Allicky Farm Pond CWS should not be affected.

6 References

A F Howland Associates. (2020). *A report on a ground investigation for Cambridge Waste Water Treatment Plant Relocation, Cambridgeshire (Factual) draft Report.*

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Xu and Eckstein. (1995). Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale. *Ground Water*, 33, 905-908.

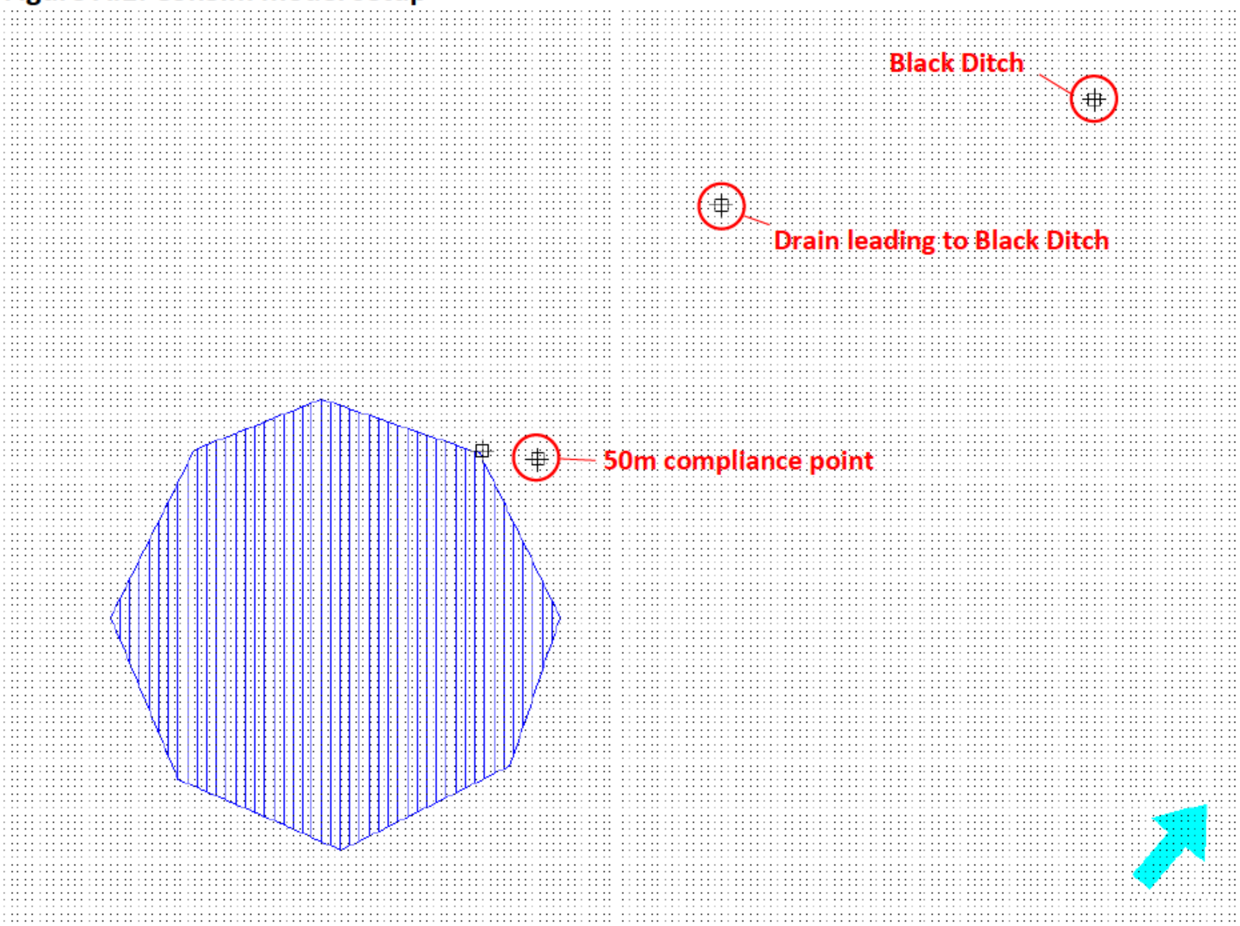
Appendices

A ConSim model results

This appendix contains the outputs of the ConSim modelling (discussed in Section 4) to provide a better understanding of the generation of the site specific target levels (SSTL).

An image of the modelled area is shown in Figure A.1 including the proposed WWTP boundary (blue), groundwater flow direction (arrow), and receptors (black cross-hairs, labelled).

Figure A.1: ConSim model setup



Results are given as 95th percentile for concentration and 50th percentile for travel times.

Table A.1: ConSim model results - CP1 – Drain leading to Black Ditch

Constituent	DWS	EQS	WQS - Minimum	WQC in effluent used to establish SSTL	Retarded travel time (years)			Concentrations at steady state (mg/l)			SSTL (mg/l)		
					Fracture flow	Matrix diffusion	Matrix flow	Fracture flow	Matrix diffusion	Matrix flow	Fracture flow	Matrix diffusion	Matrix flow
Cadmium	0.005	0.00008	0.00008	0.001	19670	19460	28190	7.75E-04	7.77E-04	9.98E-04	0.000103	0.000103	0.000080
Copper	2	0.001	0.001	0.001	6892	6829	9886	7.75E-04	7.77E-04	9.98E-04	0.001290	0.001286	0.001002
Mercury	0.001	0.00005	0.00005	0.001	98320	97190	140800	5.73E-04	5.76E-04	No breakthrough	0.000087	0.000087	---
Nickel	0.02	0.004	0.004	0.001	98320	97190	140800	5.73E-04	5.76E-04	No breakthrough	0.006976	0.006948	---
Potassium	12		12	0.001	1091	1093	1581	7.75E-04	7.77E-04	9.98E-04	15.48	15.44	12.02
Zinc	5	0.0109	0.0109	0.001	7482	7412	10730	7.75E-04	7.77E-04	9.98E-04	0.01406	0.014	0.01092
Aliphatic C5-C6	0.01		0.01	0.001	12.9	25.16	36.28	4.94E-05	4.10E-06	8.51E-07	0.2023	2.439	11.75
Aliphatic C6-C8	0.01		0.01	0.001	23.98	35.88	50.86	4.94E-05	4.10E-06	8.51E-07	0.2023	2.439	11.75
Aromatics EC5-7	0.01	0.01	0.01	0.001	10.38	22.65	32.65	5.24E-05	4.61E-06	1.00E-06	0.1908	2.170	9.990
Aromatics EC7-8	0.01	0.074	0.01	0.001	11.02	23.26	33.56	3.24E-07	1.30E-10	6.39E-13	30.84	76746	15651902
Naphthalene		0.002	0.002	0.001	14.61	26.87	38.69	1.30E-06	2.27E-12	3.56E-11	1.544	883002	56164
Ammoniacal nitrogen	0.38	0.78	0.38	0.001	479.8	489.7	799.4	7.75E-04	7.77E-04	9.98E-04	0.4902	0.4888	0.3807

Note: steady state at 100,000 years.

Table A.2: ConSim model results – CP2 – 50m

Constituent	DWS	EQS	WQS - Minimum	WQC in effluent used to establish SSTL	Retarded travel time (years)			Concentrations at steady state (mg/l)			SSTL (mg/l)		
					Fracture flow	Matrix diffusion	Matrix flow	Fracture flow	Matrix diffusion	Matrix flow	Fracture flow	Matrix diffusion	Matrix flow
Cadmium	0.005	0.00008	0.00008	0.001	12350	12520	16090	7.81E-04	7.85E-04	9.98E-04	0.0001025	0.0001019	0.00008014
Copper	2	0.001	0.001	0.001	4329	4392	5641	7.81E-04	7.85E-04	9.98E-04	0.001281	0.001274	0.001002
Mercury	0.001	0.00005	0.00005	0.001	61720	62560	80360	7.35E-04	7.43E-04	9.91E-04	0.00006799	0.00006731	0.00005046
Nickel	0.02	0.004	0.004	0.001	61720	62560	80360	7.35E-04	7.43E-04	9.91E-04	0.005439	0.005385	0.004037
Potassium	12		12	0.001	687.9	701.7	902.5	7.81E-04	7.85E-04	9.98E-04	15.37	15.29	12.02
Zinc	5	0.0109	0.0109	0.001	4699	4767	6122	7.81E-04	7.85E-04	9.98E-04	0.01397	0.01389	0.01092
Aliphatic C5-C6	0.01		0.01	0.001	10.24	15.91	20.41	9.33E-05	3.56E-05	3.10E-05	0.1072	0.2807	0.3228
Aliphatic C6-C8	0.01		0.01	0.001	17.07	22.64	29.36	9.33E-05	3.56E-05	3.10E-05	0.1072	0.2807	0.3228
Aromatics EC5-7	0.01	0.01	0.01	0.001	8.632	14.29	18.44	9.76E-05	3.81E-05	3.34E-05	0.1025	0.2628	0.2991
Aromatics EC7-8	0.01	0.074	0.01	0.001	9.01	14.68	18.94	2.47E-06	1.37E-07	3.59E-08	4.047	73.15	278.3
Naphthalene		0.002	0.002	0.001	11.31	16.99	21.83	6.94E-06	6.82E-07	2.50E-07	0.2881	2.934	8.003
Ammoniacal nitrogen	0.38	0.78	0.38	0.001	189	217.6	320.8	7.81E-04	7.85E-04	9.98E-04	0.4869	0.4841	0.3807

Note: steady state at 100,000 years.

Get in touch

You can contact us by:

- Emailing at **info@cwwtpr.com**
- Calling our Freephone information line on **0808 196 1661**
- Writing to us at **Freepost: CWWTPR**
- Visiting our website at [redacted]

You can view all our DCO application documents and updates on the application on The Planning Inspectorate website:

https://infrastructure.planninginspectorate.gov.uk/projects/eastern/cambridge-waste-water-treatment-plant-relocation/