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By email

Subject: Chelson Meadow Leachate Treatment Plant - Environmental Risk Assessment to Support Permit Amendment

Our ref: 10022842-ARC-LTP-XX-CO-GH-001
Date: 14 September 2021

Dear Phil,

Arcadis Consulting (UK) Ltd (Arcadis) was commissioned by Plymouth City Council (PCC) to provide support in relation to the proposed amendment of an environmental permit associated with the Chelson Meadow Leachate Treatment Plant (LTP), located at Chelson Meadow landfill, Plymouth Devon (the Site). The environmental permit relates to the discharge of treated leachate from the inactive landfill to the tidal River Plym. It is understood that the permit amendment in part relates to a proposed increase in volume of treated leachate to be discharged to the River Plym, from 650,000 to 850,000 tonnes per annum. This letter has been prepared to specifically address the requirement to provide an "*Environmental Risk Assessment*", as stipulated within the Environment Agency's Pre Application Advice – Enhanced Service letter, dated 24 March 2021 (EA reference ENVPAP/CP3731LZ/V005.

Background

A number of previous environmental reports are available in relation to the Site, with the report most pertinent to this assessment comprising an updated Controlled Waters Risk Assessment (CWRA), as detailed below:

- Arcadis, 2020. Chelson Meadow Landfill, Controlled Waters Risk Assessment, Arcadis report ref: 008-UA004894-UP32R-03, September 2020.

This report should be read in conjunction with the 2020 updated CWRA, which provides a detailed overview of the conceptual understanding of the Site, alongside a comprehensive assessment of the risk to controlled water receptors associated with the Site. The 2020 updated CWRA provided an update to previous risk assessment works reported in 2011 and 2015 (by Arcadis), which ultimately indicated no significant risk to controlled water receptors in the vicinity of the Site, including groundwater within the underlying aquifers, and surface water within leated water courses to the north and south and the River Plym (either as a result of discharge of groundwater or discharged treated effluent).

The proposed changes to the discharged volumes of treated leachate is unlikely to affect the previous conclusions in relation to the risk to either groundwater or the surrounding leated water courses. However, further assessment of the tidal River Plym in relation to increased volumes of treated effluent is warranted. As such, the focus of this assessment is on the potential effects of increased discharge volumes of treated effluent to the River Plym (and its associated ecologically protected status) only. It is noted that the River Plym has also been identified by the EA as the primary receptor of concern in relation to the Site, albeit compliance monitoring of measured concentrations of key contaminants in groundwater and leachate is ongoing at the Site.

Objectives

The objective of the works comprised an assessment of the potential effects on the tidal River Plym as a result of an increase in volume of discharged treated leachate from the Site's LTP from the current limit of 650,000 to 850,000 tonnes per annum.

Limitations

This report is concerned with assessing the risk of effluent discharge to the River Plym via the LTP. The assessment relies upon desk-based research, review of previous site investigations, and third-party monitoring data provided to us by Leppitt Associates Ltd, who are employed by PCC to carry out monitoring at the Site.

Methodology

The following methodology essentially mirrors that adopted in the original assessment (Arcadis, 2020) but has been updated in line with current guidance and the proposed amendment to the treated leachate discharged to the River Plym.

The methodology adopted to assess the potential risk to the River Plym was developed in line with guidance presented by the EA[1], which adopts a tiered approach to the assessment of risk. Review of information pertinent to the Site indicates that the River Plym is tidal adjacent to the Site and considered a transitional water, with information provided by the EA indicating that water is brackish. As such, guidance relating to Transitional and Coastal Waters (TraC) has been referred to, alongside guidance associated with estuarine and coastal waters.

The tiered assessment process comprised four tests with an additional test for priority hazardous substances (in relation to significant load), which should be undertaken sequentially. Where failures are not identified at test 1 of the tests, no further consideration is required. However, if a failure is identified as part of test 1, then compounds should be considered for test 2. Compounds that fail at test 2 should be considered through tests 3 and 4, where a failure at either test 3 or 4 may require modelling. A failure of the significant load test may suggest control of the compound is required through a numeric emission limit on the permit. The methodology for the screening tests was as follows:

Test 1:

Comparison of measured concentrations of the potential contaminants measured above the laboratory Method Detection Limit (MDL) in the effluent outfall against Water Quality Standards (WQS), considering data collected from the 1st October 2013 to date (up to and including 25th June 2021) has been included in the comparison. Consideration was also given to Annual Average (AA) Environmental Quality Standards (EQS) or Maximum Acceptable Concentration (MAC) EQS, where available.

While data has been collected since 2000, only the last 9 years of data have been considered given that run off from the southern flank of the southern sector was routed incorrectly prior to this. Instead of discharging into the southern leat, it was being directed into the leachate collection system whilst the southern sector was being capped, and was only rectified in September 2013, hence data from this point onwards is considered most appropriate for the screening.

A list of the WQS adopted within the assessment and their source is presented in Attachment A, while the methodology for the selection of an appropriate WQS is presented in Attachment B.

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[1] https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit
https://www.gov.uk/government/publications/h1-annex-d2-assessment-of-sanitary-and-other-pollutants-in-surface-water-discharges
https://www.gov.uk/government/publications/modelling-surface-water-pollution-risk-assessment

Test 2:

For those compounds which exceeded the WQS, a dilution assessment was undertaken. On the basis that regulated discharge to the River Plym is undertaken at high tide, test 2 comprised calculation of the Process Contribution (PC – the concentration of a discharged chemical in the water after it has been diluted) with subsequent comparison to 4% of the WQS. While previous modelling has shown that the groundwater contribution to the River Plym from the western boundary of the landfill is nominal, this has been included in the calculations to provide a robust assessment. The calculation for the derivation of process contribution is presented below:

$$PC = \frac{(\mathrm{EFR\ x\ RC} + \mathrm{GFR\ x\ GC})}{\mathrm{EFR} + \mathrm{GFR} + \mathrm{RFR}}$$

Where:

PC = Process Contribution

EFR = Effluent Flow Rate

RC = Release concentration of the pollutant in the effluent (annual average paired with AA EQS, where available, and maximum concentrations paired with MAC EQS, where available)

GC = Release concentration of the pollutant in groundwater

GFR = Groundwater flow rate

RFR = River flow rate (of the Plym)

For the purpose of the assessment, and in line with the previous assessment, a high end estimate for release concentration of the pollutant in groundwater was incorporated with both low flow (Q_{95}) and mean flow within the River Plym (albeit acknowledging that the guidance recommends the use of low flow rates).

For full details of the parameters adopted for the calculation of PC, see Attachment B.

Test 3

Where the PC was more than 4% of the WQS, test 3 was conducted. This comprised calculation of the Predicted Environmental Concentration (PEC – which is the summation of the process contribution and Background Concentrations of the compound within the River Plym). If the difference between the PEC and BC is greater than 10% of the WQS, modelling may be required.

Test 4

Test 4 comprised comparison of the PEC with the EQS.

Screening test: "Priority Hazardous Pollutants"

An additional level of screening is required for priority hazardous pollutants for coastal waters and estuaries. This encompasses assessment as to whether the annual limit of priority hazardous pollutants in the discharge is more than the significant load limits, as set out within the guidance[2]. The significant load is calculated by multiplying the average discharge concentration by the average flow, to produce a result in kg/year. Where an exceedance of the significant load limit is identified, the significant load test needs to be re-applied using "cleaned-up data". Data clean-up comprises a check as to whether a minimum number of the samples exceed the Minimum Reporting Value (MRV).

Average daily flow has been calculated based on the proposed increase in leachate discharge to 850,000 tonnes per annum (equating to 2,328,770l/day).

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[2] https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit#screening-test-priority-hazardous-pollutants

Review of the datasets and the significant load limits as set out within the guidance, indicates that this screening is applicable to cadmium, mercury and alpha-hexachlorocyclohexane (HCH) only. The average concentrations adopted within the calculations are presented in Attachment C.

Findings

Test 1

The findings of the Test 1 screening are presented in Attachment D. For completeness, the minimum, maximum, average and 95th percentile concentrations are presented for each contaminant, alongside the number of detections of the compound, total number of samples analysed and standard deviation of each dataset.

Following test 1 screening, total ammonia (NH3 + NH4+), di-n-butylphthalate, selected TPH fractions, alpha-HCH and a number of metals were considered to require further assessment. It should be noted that to date metals analysis for the effluent outfall has been undertaken for total metals only. The WQS (primarily based on estuarine Environmental Quality Standards [EQS]) for the majority of the metals analysed is based on dissolved phase metals. Comparison of total measured metals with an EQS based on dissolved phase is considered highly conservative, as it is unlikely that the dissolved phase metal concentrations will be as high as the total metal concentrations.

Test 2

The findings of the test 2 screening is presented in Attachment E and summarised below. It should be noted that each contaminant is listed twice in Attachment E, with the first row (Scenario 1) reflecting assessment considering AA WQS (and adoption of average effluent concentrations and average effluent flow rates), where available, with the second row (Scenario 2) reflecting assessment considering MAC WQS (and adoption of maximum effluent concentrations and predicted maximum effluent flow rates), where available.

The results of the test 2 screening indicated that the PC exceeded 4% of the WQS for the majority of compounds under low flow conditions. Further, that failures were noted under the mean flow conditions for a number of compounds (primarily metals, but additionally alpha-HCH).

In line with the findings of the previous assessment, the contribution from the groundwater pathway was typically marginal in comparison to the effluent outfall. Predicted contribution from groundwater can also be viewed in Attachment E.

Test 3

The findings of the test 3 screening is presented in Attachment E. Failures under low flow conditions were identified for the majority of compounds analysed, with the exception of manganese and barium. Only copper, lead, cadmium, chromium, nickel and alpha-HCH failed under mean flow conditions.

Test 4

The findings of the test 4 screening is presented in Attachment E and summarised below.

Copper, lead, cadmium, chromium and alpha-HCH failed the test 4 screening for low flow conditions only based on AA EQS. Only lead failed the test 4 screening based on MAC EQS comparison, for both low flow and mean conditions. Failures were not observed for total ammonia, iron, manganese, zinc, nickel, mercury, EH>16-C24, EH>C24-C40 or barium.

Screening test: “Priority Hazardous Pollutants”

The significant annual load for cadmium, mercury and alpha-HCH are presented in Attachment C, alongside the significant annual load limits. The findings of the assessment indicate that none of the three compounds exceed the annual significant load limit. However, the findings should be viewed with caution given that only annual monitoring is available for these compounds, with only limited datasets available for review for the period under consideration.

Evaluation of Findings – Test 1 - 4

A number of compounds failed the test 1 screening, albeit these were primarily associated with metals and additionally total ammonia, alpha-HCH, EH>16-C24 and EH>C24-C40. Further evaluation at test 2 for those compounds that failed test 1 screening indicated that each compound exceeded the criteria considering low flow conditions. Review of the compounds at test 3 and 4 again indicated a number of failures (primarily metals, albeit additionally ammonia, alpha-HCH, EH>16-C24 and EH>C24-C40).

Analytical testing of metals, alpha-HCH, EH>16-C24 and EH>C24-C40 has been undertaken independently of the environmental permit (i.e. there is no requirement for analysis of these compounds based on the current permit), with the analysis of metals based on total metals. Total metals analysis is considered conservative in the context of this assessment given that the EQS for the metals under consideration is based on dissolved phase rather than total metals. The concentration of dissolved phase metals is likely to be lower than that of total metals, with data unavailable for dissolved phase metals.

Presented in the table below is a summary of the compounds that exceed the criteria at test 3 and / or test 4. Additionally presented in the number of samples detected above the laboratory MDL versus the number of samples analysed, alongside the laboratory MDL and the applicable water quality standard.

Compound	**Failure at Test 3**	**Failure at Test 4**	**No of detects above MDL***	**No of samples analysed***	**Laboratory MDL* (µg/l)**	**Estuarine EQS (µg/l)**	
						AA	MAC
Total Ammonia	Yes	No	73	472	200 - 500	1,100	8,000
Total Iron	Yes	No	91	92	1,100	1,000	NA
Total Copper	Yes	Yes	18	92	10 - 85	3.76	NA
Total Zinc	Yes	No	8	92	40 - 100	6.8	NA
Total Lead	Yes	Yes	19	91	20 - 50	1.3	14
Total Cadmium	Yes	Yes	0	91	2 - 5	0.2	NA
Total Chromium	Yes	Yes	0	92	5 - 30	0.6	32 (95th)
Total Nickel	Yes	No	4	92	10 – 70	8.6	34
Total Mercury	Yes	No	1	6	0.1 – 0.2	NA	0.07
Alpha-HCH	Yes	Yes	1	5	0.003 – 0.004	0.0002	0.02
EH>C16-C24	Yes	No	5	6	10	90*	
EH>C24-C40	Yes	No	5	6	10	90*	

* Based on data collected between October 2013 and June 2021

** Drinking water standard in the absence of EQS

Review of the information presented in the table above indicates that for copper, zinc, lead and nickel, relatively few detections are measured, with no detections above the laboratory MDL for cadmium and chromium. Review of the MDL (which has varied over the monitoring period) indicates that in general, for these compounds, the laboratory MDL is at least an order of magnitude higher than the EQS. Given that the average concentrations assume that non detects are equivalent to the MDL, the PEC derived for these compounds is potentially significantly overestimated.

Similar findings are present in relation to mercury and to a lesser extent, alpha-HCH, although it should be noted that while these have only been detected above the laboratory MDL during one sample event, only annual monitoring has been conducted and as such the findings should be viewed with caution.

For total ammonia, a failure is only observed at test 3 considering low flow conditions and maximum effluent concentrations and maximum predicted flow rate (and considering MAC EQS). If the 95th percentile (1,600µg/l) concentration is adopted rather than the maximum (15,000µg/l), no failure for ammonia is observed.

Further consideration of the findings in relation to EH>16-C24 and EH>C24-C40 and the failure at test 3 suggests the PEC for both compounds could be overestimated, with it further noted that a drinking water standard has been used in the absence of an EQS. Review of the concentrations within the untreated effluent for the same sample events indicated significantly lower concentrations, with average concentrations for both compounds an order of magnitude lower than that based on the outfall data. It is plausible that concentrations within the outfall may be elevated due to the presence of entrained fines within the sample rather than the presence of true dissolved phase. It is noted that if the average concentrations from the untreated effluent are incorporated in the assessment, failures are not observed at test 3 or test 4.

Conclusions

While the findings of the assessment suggest a potential impact to the River Plym based on tests 1 – 4, several conservatisms are present within the calculations, including:

- Failures at test 3 and 4, with the exception of a limited number of metals and alpha-HCH are based on low flow conditions only.
- Metals analysis conducted to date (outside of the requirements for the environmental permit) is based on total metals rather than dissolved phase metals, upon which the EQS are based. Dissolved phase metals are likely to be lower than total metal concentrations, and in some instances, may be significantly lower
- The laboratory MDL for the metals which fail screening at tests 3 and 4 is an order of magnitude higher than the EQS adopted for comparison. As such, and given that with the exception of iron, metals were not detected in the majority of samples analysed, the PEC is likely to be significantly overestimated. Similar findings have been identified in relation to alpha-HCH and mercury, albeit only a limited number of samples were available for the assessment of alpha-HCH and mercury.
- Failures considering the MAC at test 3 and 4 are based on maximum predicted effluent flows and the maximum measured concentration of the compound in leachate. For total ammonia, in which a failure is identified at test 3 only, based on consideration of the MAC EQS, adoption of the 95th percentile concentrations results in a pass.

Based on the calculations undertaken, and taking into consideration the large number of conservatisms within the screening assessment (including those relating to assumptions around effluent flow parameters), it is considered unlikely that the proposed increase in treated effluent discharge volumes would result in a significant deterioration in water quality in the River Plym.

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Enc.	Attachment A	Water Quality Standards
	Attachment B	Parameter Inputs: Screening Test 1 – 4
	Attachment C	Assessment of Significant Annual Load
	Attachment D	Test 1 Assessment
	Attachment E	Test 2 – 4 Assessment

Attachment A - Water Quality Standards Adopted within the Assessment

Compound	Water Quality Standard (µg/l) - where this is based on AA, this is stated		Water Quality Standard (µg/l) - maximum acceptable concentration (if available)		Source
	Value	Comment	Value	Comment	
Test 1 - Screening					
Total Organic Carbon	NA		NA		NA
Biological Oxygen Demand	NA		NA		NA
Chemical Oxygen Demand	NA		NA		NA
Suspended Solids	NA		NA		NA
Total Organic Nitrogen	NA		NA		NA
Total Ammonia	1100	AA	8000		8
Nitrate	50000		NA		2
Nitrite	500		NA		2
Chloride	-		-		-
Phosphorus	-		-		-
Sulphate	400000		NA		3
Calcium	-		-		-
Magnesium	-		-		-
Potassium	-		-		-
Sodium	-		-		-
Iron	1000	AA	NA		1
Manganese	123		NA		3
Copper	3.76	AA	NA		1
Zinc	6.8	AA	NA		1
Lead	1.3	AA	14		1
Cadmium	0.2	AA	NA		1
Chromium	0.6	AA	32	95th	1
Nickel	8.6	AA	34		1
Total Mercury	NA		0.07		1
Hexachlorocyclohexane	0.002		0.02		1
Dichlobenil	0.19		NA		4
Bentazone	500		NA		1
Mecoprop	18		187	95th	1
EH >C16 - C24	90		NA		5
EH >C24 - C40	90		NA		5
Dibutyl phthalate	8	AA	40		1
Fluoride	5000	AA	15000		1
Boron	7000	AA	NA		1
Titanium	600		NA		4
Vanadium	100	AA	NA		1
Cobalt	3	AA	100		1
Arsenic	25	AA	NA		1
Molybdenum	2280		NA		4
Tin	10	AA	NA		1
Barium	114.7		NA		6
Thallium	NA		NA		NA
Uranium	30		NA		7
Test 2 - 4 Screening: Derivation of Site Specific Predicted No Effect Concentrations					
Manganese	399		NA		9
Copper	4.5		NA		9
Zinc	13.8		NA		9
Lead	1.56		NA		9
Nickel	5.8		NA		9

Notes

NA	None readily available
-	Water quality standards unavailable for estuarine environment with compounds typically major ions in seawater - see Attachment X for further disucssion
AA	Annual average water quality standard
95th	Maximum acceptable concentration based on 95th percentile
MAC	Maximum acceptable concentration
EQS	Environmental Quality Standard
1	Estuaries and coastal waters specific pollutants and operational environmental quality standards (EQS) or Estuaries and coastal waters priority hazardous substances, priority substances and other pollutants environmental quality standards (EQS)
2	Water Supply (Water Quality) Regulations, 2016
3	Freshwater specific pollutants and operational environmental quality standards (EQS) or Freshwaters priority hazardous substances, priority substances and other pollutants environmental quality standards (EQS)
4	Marine Predicted No Effect Concentration - presented within the European Chemical Agencys Registration, Evaluation, Authorisation and Restriction of Chemicals, accessed online at https://echa.europa.eu/information-on-chemicals/registered-substances
5	WHO 2008/CL:AIRE 2017:Taken from Table 5.4 WHO guide values for TPHCWG fractions in drinking water, Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies. CL:AIRE, 2017. Values for EC>16-21 adopted for the assessment of EH >C16-C24, while criteria for EC>21-35 adopted for the assessment of EH>C24-C40.
6	Freshwater Predicted No Effect Concentration - presented within the European Chemical Agencys Registration, Evaluation, Authorisation and Restriction of Chemicals, accessed online at https://echa.europa.eu/information-on-chemicals/registered-substances
7	World Health Organisation Guidelines for Drinking Water Quality, 2017, 4th edition
8	Based on email correspondance from Maria Walford (17th November 2015)
9	Predicted No Effect Concentration derived using the Metal Bioavailability Assessment Tool (M-BAT) for predicting risk posed by copper, nickel, zinc, manganese in the aquatic environment (typically lakes and rivers). Dissolved organic carbon and calcium adopted from The Importance of Dissolved Organic Carbon in the Assessment of Environmental Quality Standard Compliance for Copper and Zinc by Water Framework Directive - United Kingdom Technical Advisory Group, 2009. Average values adopted for the Lower Plym and Tory Brook (average dissolved organic carbon 1.3 and calcium of 7.35). Two pH were adopted (6.9 and 7.4) based on the 25th and 75th percentile for the Tamar area, and the lower of the Predicted No Effect Concentrations adopted.

Parameter	**Rationale**
Screening Tests 1 – 4	
The methodology for the parameter selection presented below is generally in line with the original assessment (Arcadis, 2020), although has been updated where more recent data or best practice guidance is available. This is emphasised in red in the text below.	
Contaminants selected	Within the original assessment, only total ammonia was considered. Based on the requirement to assess all compounds within the Site effluent, the following approach was undertaken. Potential contaminants that were measured above the laboratory Method Detection Limit (MDL) in the effluent outfall were selected for consideration. These are considered to be most representative of the risk to the River Plym as they represent concentrations at the point of discharge, rather than e.g. pre-treated conditions.
Water Quality Standards	The Water Quality Standards adopted within the original assessment for total ammonia have been retained. The approach for selection of appropriate Water Quality Standards for the remaining compounds is detailed below. Where available, comparison has been made to the estuarine and coastal Environmental Quality Standards (EQS), considering both the annual average and Maximum Acceptable Concentration (MAC). Where estuarine and coastal EQS were unavailable, comparison has been made (in order of preference) to freshwater EQS, Predicted No Effect Concentrations (PNEC) based on the marine environment, and finally Drinking Water Standards (DWS). The Water Quality Standards adopted in the assessment and their source are presented in Attachment A.
Permeability of underlying natural deposits	Within the original assessment, a number of permeabilities were considered (Arcadis, 2020). However, for this assessment, the worst-case literature value has been adopted for simplicity and to reduce the number of potential scenarios considered. Based on Site data for the cohesive silty clays encountered along the western boundary, it is considered that the estuarine silt deposits beneath the landfill are likely to have a permeability in the range of 1x10-8 to 1x10-9 m/s. As worst case however, literature values for higher permeability silt (Freeze & Cherry) have also been considered which results in a higher-end value of up to 1x10-6 m/s.
Head gradient between landfill and estuary	Within the original assessment, a number of head gradients were considered. However, for this assessment, the worst-case gradient (0.05) was adopted to reduce the number of scenarios considered. Several head gradients were considered which were considered to represent the likely gradients between the leachate head in the landfill and the estuary, with 0.05 (worse case based on professional judgement) and 0.02 (based on Site data and considering the average leachate head) selected within the previous assessment (Arcadis, 2020).

Parameter	Rationale
Screening Tests 1 – 4	
The methodology for the parameter selection presented below is generally in line with the original assessment (Arcadis, 2020), although has been updated where more recent data or best practice guidance is available. This is emphasised in red in the text below.	
Groundwater transect area	The groundwater transect area was retained from the original assessment, as detailed below. The transect through which groundwater flows from the Site's western border into the River Plym has been estimated as 900 m in length (the length of the western Site boundary) and assuming a thickness of 7 m in the estuarine silts.
Measured concentrations of contaminants in groundwater	The approach for the selection of an appropriate measured concentration of contaminant in groundwater is in line with the approach from the original assessment, albeit has been updated to reflect more recent data. The exception was the inclusion of data from CMDG100, which was not available at the time the assessment was completed (Arcadis, 2020). Further details are provided below. There are three active groundwater monitoring boreholes along the western boundary (CMDG100, CMDG78, CMDG79). A worst-case concentration has been assumed based on a review of the data for these location, to maximise the input from groundwater. This is based on the maximum measured concentration from all three locations, considering data collected between October 2013 and June 2021 for CMDG78 and CMDG79. For CMDG100, data collected from December 2018 to June 2021 has been included; this is on the basis that the well was re-instated in 2018 due to collapse at depth. As such, data collected prior to December 2018 was not considered to be representative.
River flow	The selection of an appropriate river flow rate is in line with the methodology from the original assessment (Arcadis, 2020), albeit has been updated to reflect more recent river flow rate data, and is detailed below. The Q_{95} and mean flow for the low tide / freshwater component of the Plym were estimated by factoring up the recorded Q_{95} and mean flow at Carn Wood to reflect the increased catchment area (an additional area of approx. 44 km^2) for the Plym adjacent to Chelson Meadow. Estimated Q_{95} flow of 49,000m^3/d and an estimated mean flow of 344,000m^3/d have been derived by this method.
Treated effluent quality	Average and 95th percentile concentrations were adopted within the original assessment for total ammonia. The maximum and average concentrations have been adopted within this assessment based on a review of current best practice, as detailed below. The average concentration for each contaminant was calculated using data measured in the outfall from October 2013 to June 2021. The average concentration was paired with calculations that considered the AA WQS (identified as Scenario 1 within tests 2 – 4), whereas for Scenario 2 the

Parameter	Rationale
Screening Tests 1 – 4	
The methodology for the parameter selection presented below is generally in line with the original assessment (Arcadis, 2020), although has been updated where more recent data or best practice guidance is available. This is emphasised in red in the text below.	
	maximum measured concentration was adopted which was paired with calculations that considered the MAC WQS (identified as Scenario 2 within tests 2 – 4) . The effluent treatment plant is required to achieve a total ammonia, biological oxygen demand and suspended solid limits of 10mg/l, 10mg/l and 75mg/l respectively, for 95% of all measured values of periodic samples taken over one year. Review of the relevant datasets since October 2013 indicates that these have not been exceeded.
Estimated effluent discharge volumes	The effluent discharge volumes have been updated to reflect the proposed changes in discharged leachate, as detailed below. A proposed increase in the annual volume of treated effluent to be discharge to the River Plym from 650,000m^3 to 850,000m^3 is proposed. For the purpose of the calculations, an average and maximum treated effluent flow rate are required, where average flow is paired with AA EQS and maximum flow is paired with MAC EQS, where available. The average daily flow rate was calculated based on the assumption that 850,000m^3 of effluent was discharged evenly across 365 days (i.e. 2,329m^3/day). Monthly effluent meter readings are available from 2008 onwards, which can be used to estimate or predict maximum potential discharge volumes based on the proposed increase in total annual discharge volumes. However, substantial leachate treatment upgrades and capping works mean that the current site conditions have only prevailed since 2012. To compound matters, data collected in the first part of 2013 is influenced by the incorrect diversion of cap run off resulting in additional volumes treated. To estimate the future monthly discharge volumes, the previous monthly effluent meter readings were calculated as a percentage of the annual outflow for that year, and the percentage applied to the proposed new treated effluent volume to provide an estimate of the potential treated discharge volumes for a given month. Only data collected since October 2013, when run off from the cap had been rerouted away from the leachate treatment plant, was included. A maximum estimated monthly outflow of 170,700m^3 (approximately 5,690m^3/day) was calculated based on the review, representing a worst-case effluent discharge volume.
Background concentrations within the River Plym	The method for derivation of an appropriate background concentration have been retained from the original assessment, as detailed below (Arcadis, 2020). These have been assumed to be 50% of the water quality standard, in the absence of site-specific data.

Attachment C
Assessment of Significant Annual Load

Compound*	Leachate Treatment Plant Outfall		Calculated Significant Load (kg per annum)	Significant Load Limit (kg per annum)	Calculated Significant Load Exceeds Significant Load Limit?
	Average Concentration (µg/l)	No of samples analysed***			
Total Cadmium*	3.3	91	2.81	5	No
Total Mercury	0.11	6	0.091	1	No
Hexachlorocyclohexane	0.0036	5	0.003	1	No

Notes

*	All results for cadmium were below the laboratory method detection limit of 2µg/l (91 in total), with the exception of a single value (130,000µg/l) which has been excluded from the dataset as it is considered to be anomalous

Compound*	Water Quality Standard (µg/l) - where this is based on AA, this is stated**		Water Quality Standard (µg/l) - maximum acceptable concentration (if available)**		Leachate Treatment Plant Outfall Data								Consider further for Test 2 assessment?
					Samples collected between October 2013 and June 2021								
	Value	Comment	Value	Comment	Laboratory MDL (lowest recorded over monitoring period)	Minimum Concentration (µg/l)	Maximum Concentration (µg/l)	Average Concentration (µg/l)	95th Percentile (µg/l)	No of detections above MDL	No of samples analysed***	Standard deviation	
List 2 Substances													
Total Organic Carbon	NA		NA		5,000	4,500	29,000	16,780	26,000	50	94	4.93	No[1]
Biological Oxygen Demand	NA		NA		3,000	3,000	46,000	4,619	5,000	9	470	2.15	No[1]
Chemical Oxygen Demand	NA		NA		16,000	16,000	121,000	48,013	78,000	444	465	16.97	No[1]
Suspended Solids	NA		NA		1,500	1,500	203,000	30,664	58,150	476	478	16.98	No[1]
Total Organic Nitrogen	NA		NA		1,300	1,300	122,000	55,015	96,444	474	475	22.65	No[1]
Total Ammonia	1100	AA	8000		200	200	15,000	654	1,600	73	472	1.51	Yes[2]
Nitrate	50000		NA		1,300	1,300	119,140	54,667	96,494	473	474	22.41	No[2]
Nitrite	500		NA		10	10	15,800	286	616	87	473	1.40	No[2]
Chloride	-		-		#	173,000	360,000	221,250	332,850	474	474	92.54	No[3]
Phosphorus	-		-		40	40	588	296	330	18	93	0.09	No[3]
Total Sulphate	400000		NA		11,000	11,000	54,000	20,877	36,800	83	92	8.86	No[5]
Total Calcium	-		-		4,000	4,000	149,000	115,934	138,500	90	91	20.28	No[3]
Total Magnesium	-		-		570	570	49,000	27,209	41,450	91	92	8.15	No[3]
Total Potassium	-		-		#	14,000	82,000	44,022	74,000	92	92	16.40	No[3]
Total Sodium	-		-		#	28,000	312,000	140,681	245,000	91	91	53.75	No[3]
Total Iron	1000	AA	NA		1,100	1,100	54,800	10,503	28,575	91	92	9.70	Yes[4]
Total Manganese	123		NA		122	122	6,050	675	1,580	91	91	0.71	Yes[4]
Total Copper	3.76	AA	NA		10	10	814	104	224	18	92	0.11	Yes[4]
Total Zinc	6.8	AA	NA		40	40	1,110	107	137	8	92	0.11	Yes[4]
Total Lead	1.3	AA	14		20	20	**1,740**	74	143	19	91	0.18	Yes[4]
Total Cadmium	0.2	AA	NA		2.00	2.00	5.0	3.3	5.00	0	91	0.00	Yes[4]
Total Chromium	0.6	AA	32	95th	5.0	5.0	30	26.5	30	0	92	0.007	Yes[4]
Total Nickel	8.6	AA	34		10	10	**213**	18	70	4	92	0.03	Yes[4]
Temperature	No standards readily available for transitional or coastal waters				#	8.1	22.2	14.28	19.4	476	447	3.07	No
pH	No standards readily available for transitional or coastal waters				#	7.3	8.5	8.09	7.8	476	476	0.18	No
List 1 Substances													
Total Mercury	NA		0.07		0.1	0.04	0.2	0.11	0.175	1	6	5.8E-05	Yes[4]
Hexachlorocyclohexane	0.002		0.02		0.003	0.003	0.004	0.0036	0.004	1	5	3.0E+00	Yes[4]
Dichlobenil	0.19		NA		0.004	0.003	0.007	0.0050	0.0066	4	5	1.7E+00	No[5]
Bentazone	500		NA		0.05	0.05	0.13	0.07	0.1225	1	6	3.0E-02	No[5]
Mecoprop	18		187	95th	#	0.06	0.21	0.14	0.1975	6	6	1.5E-01	No[5]
EH >C16 - C24	90		NA		10	20	823	212	655	6	6	2.5E+02	Yes[4]
EH >C24 - C40	90		NA		10	10	1120	253	903	5	6	3.6E+02	Yes[4]
Dibutyl phthalate	8	AA	40		1	1	13.3	4.1	11.4	3	5	4.3E+00	No[5]
Fluoride	5000	AA	15000		#	193	300	248	300	4	4	6.0E-02	No[5]
Total Boron	7000	AA	NA		#	240	870	608	845	4	4	2.7E-01	No[5]
Total Titanium	600		NA		1.1	1.1	2	1.55	2	1	4	5.2E-04	No[5]
Total Vanadium	100	AA	NA		4	0.33	4	2.46	4	2	4	1.8E-03	No[5]
Total Cobalt	3	AA	100		#	2	3	2.63	3	3	4	4.8E-04	No[5]
Total Arsenic	25	AA	NA		#	3.6	9.2	6.8	8.95	4	4	2.3E-03	No[5]
Total Molybdenum	2280		NA		2.7	2.7	14	5.68	12.4	1	4	5.6E-03	No[5]
Total Tin	10	AA	NA		1.5	1.5	7	4.3	7	1	4	3.1E-03	No[5]
Total Barium	114.7		NA		#	160	200	177	197	4	4	1.7E-02	Yes[4]
Total Thallium	NA		NA		0.75	0.75	20	8.4	18.8	1	4	9.4E-03	No[6]
Total Uranium	30		NA		#	0.76	2.72	1.6	2.5	4	4	8.3E-04	No[5]

Notes

Comparison of measured concentrations against the relevant water quality standards has been undertaken in the table above. Where an annual average water quality standard is available, this has been compared to the average measured concentration. Where an annual average WQS is not available, comparison has been made to the maximum measured concentration. Comparison of the maximum measured concentration has also been made to the water quality standard based on maximum acceptable concentration, if available, with the exception of where the maximum acceptable water quality standard is based on the 95th percentile for the datasets considered, in which case comparison has been made to the 95th percentile for that dataset.

*	Includes all compounds measured above the laboratory detection limit between October 2013 and June 2021. For compounds which are analysed under both List 1 and List 2 substances, they have been included within the List 2 substance analysis, given that this is the most comprehensive in terms of numbers of datasets. It is noted that all results for cadmium were below the laboratory method detection limit of 2µg/l (91 in total), with the exception of a single value (130,000µg/l) which has been excluded from the dataset as it is considered to be anomalous
**	The source of the Water Quality Standards adopted is presented in Attachment A.
***	It is acknowledged that for the List 1 substances, the majority of datasets are relatively small, with the preference being a minimum of 12 samples.
#	Data not readily available
NA	None readily available
MDL	Method detection limit
AA	Annual average water quality standard
95th	Maximum acceptable concentration based on 95th percentile
MAC	Maximum acceptable concentration
EQS	Environmental Quality Standard
1	Average concentration exceeds the AA WQS or maximum concentration exceeds the WQS (where AA is unavailable)
1	Maximum concentration excees the MAC WQS
Yes	Compound considered to require further consideration
[1]	No WQS readily available and typically regarded as indicators of water quality. It is noted that biological oxygen demand and suspended solids are considered potential contaminants within the guidance associated with the assessment of sanitary products; however, the guidance does not consider them further in relation to transitional and coastal waters, with the River Plym determined as a transitional water. It is noted that limits for emission of biological oxygen demand and suspended solids not to be exceeded are set within the current environmental permit at 10mg/l and 75mg/l, respectively, for 95% of all measured values of periodic samples taken over a year. These limits have not been exceeded for the monitoring period under consideration (post October 2013).
[2]	For the assessment of nitrogen containing compounds, total ammonia (NH3 + NH4+) has been adopted as an indicator on the basis that the maximum measured concentration exceeds the MAC WQS. Total ammonia (NH3 + NH4+) was considered one of the primary contaminants of concern in relation to effluent discharge previously, with AA and MAC EQS previously agreed with the Environment Agency. It is noted that the water quality standards for both nitrate and nitrite are based on drinking water standards in the absence of EQS.
[3]	Chloride, calcium, magnesium , potassium and sodium (and to a lesser extent phosphorus) are major ions within seawater. Typical concentrations of these ions within seawater are reported as 1.8 x10^{7}µg/l (chloride), 4.0 x 10^{5}µg/l (calcium), 1.3 x 10^{6}µg/l (magnesium), 3.8 x 10^{5}µg/l (potassium), 1.1 x10^{7}µg/l (sodium) and 100µg/l (phosphorus). Review of concentrations of these ions within groundwater samples collected from three boreholes (CMDG79L, CMDG78L and CMBH100) located along the western Site boundary (adjacent to the River Plym indicates that concentrations are generally within this range or lower, with maximum concentrations within the outfall generally an order of magnitude lower than concentrations identified in seawater, with the exception of maximum measured concentrations of phosphorus and potassium, which were in the same order of magnitude as seawater. As such, these have not been considered further in relation to the tidal River Plym.
[4]	Concentration exceeds applicable WQS
[5]	No exceedances identified
[6]	In the absence of a readily available WQS, the remaining metals are considered to represent suitable indicators.

Attachment E
Test 2 - 4 Assessment

Scenario*	Compound**	Groundwater Flow rate (m^3/day)	Groundwater Concentration (mean + 2 x standard deviation) (µg/l)	Predicted Leachate Treatment Plant Discharge Flow Rate (m^3/day) (average for Scenario 1 and maximum flow for Scenario 2)	Leachate Concentration (average for Scenario 1 and maximum for Scenario 2) (µg/l)	Bacground Concentration (BC), i.e. Assumed Background Concentration within the River Plym (µg/l)	Water Quality Standard (µg/l)	Test 2			Test 3						Test 4		Predicted Contribution from Groundwater (µg/l)	
								4% of Water Quality Standard (µg/l)	Predicted Concentration (PC) i.e. Predicted River Concentration (with no assumed background) (µg/l) - to compare with 4% of the WQS		Predicted Environmental Concentration (PEC) i.e. Predicted River Concentration (with assumed background) (µg/l)		Predicted Environmental Concentration - Background concentration / Water Quality Standard (as a percent)		Is the difference between background concentration and predicted environmental concentration greater than 10% of the WQS?		Predicted River Concentration (with assumed background) (µg/l) - to compare with the WQS			
									Mean flow	Low flow	Mean flow	Low flow	Mean flow	Low flow	Mean flow	Low flow	Mean flow	Low flow	Mean flow	Low flow
List 2 Substances																				
1	Total Ammonia	27.22	41,712	2,329	654	500	1100	44	8	44	508	544	0.7%	4.0%	Pass	Pass	508	544	3.30	19.56
2	Total Ammonia	27.22	41,712	5,690	15,000	500	8000	320	247	1581	747	2081	3.1%	19.8%	Pass	Fail	747	2081	3.30	23.15
1	Total Iron	27.22	20,538	2,329	10503	500	1000	40	72	487	572	987	7.2%	48.7%	Pass	Fail	572	987	1.62	11.40
2	Total Iron	27.22	20,538	5,690	54,800	500			893	5709	1393	6209			Pass	Pass	1393	6,209	1.62	11.40
1	Total Manganese	27.22	658	2,329	675	200	399	15.96	4.6	31.0	204	230	1.2%	7.8%	Pass	Pass	204	230	5E-02	4E-01
2	Total Manganese	27.22	658	5,690	6,050	200			98	629	298	829			Pass	Pass	298	829	5E-02	4E-01
1	Total Copper	27.22	61	2,329	104	2.3	4.53	0.1812	0.70	4.7	3.0	7.0	15.5%	104.5%	Fail	Fail	2.97	7.00	5E-03	3E-02
2	Total Copper	27.22	61	5,690	814	2.3			13.2	84.7	15.5	87.0			Pass	Pass	15.55	87	5E-03	3E-02
1	Total Zinc	27.22	91	2,329	107	6.9	13.8	0.552	0.7	4.9	7.6	12	5.2%	35.4%	Pass	Fail	7.62	12	7E-03	5E-02
2	Total Zinc	27.22	91	5,690	1,110	6.9			18.1	115	25.0	122			Pass	Pass	24.97	122	7E-03	5E-02
1	Total Lead	27.22	58	2,329	74	0.78	1.56	0.0624	0.50	3.40	1.3	4.2	32.3%	217.8%	Fail	Fail	1.28	4.18	5E-03	3E-02
2	Total Lead	27.22	58	5,690	1,740	0.78	14	0.56	28.3	181.0	29.1	181.7	202.2%	1292.6%	Fail	Fail	29.09	182	5E-03	3E-02
1	Total Cadmium	27.22	4	2,329	3	0.1	0.2	0.008	0.0225	0.152	0.12	0.25	11.3%	75.9%	Fail	Fail	0.12	0.25	3E-04	2E-03
2	Total Cadmium	27.22	4	5,690	5	0.1			0.082	0.52	0.18	0.62			Pass	Pass	0.18	0.62	3E-04	2E-03
1	Total Chromium	27.22	28	2,329	27	0.3	0.6	0.024	0.181	1.22	0.48	1.52	30.1%	203.0%	Fail	Fail	0.48	1.52	2E-03	2E-02
2	Total Chromium	27.22	28	5,690	30	0.3	32	1.28	0.49	3.13	0.79	3.43	1.5%	9.8%	Pass	Pass	0.79	3.43	2E-03	2E-02
1	Total Nickel	27.22	17	2,329	18	2.9	5.8	0.232	0.13	0.85	3.0	3.7	2.2%	14.6%	Pass	Fail	3.03	3.75	1E-03	9E-03
2	Total Nickel	27.22	17	5,690	213	2.9	34	1.36	3.47	22.2	6.4	25.1	10.2%	65.2%	Fail	Fail	6.37	25	1E-03	9E-03
List 1 Substances																				
1	Total Mercury	27.22	0.11	2,329	0.11	0.35			0.0007	0.005	0.351	0.355			Pass	Pass	0.351	0.355	9E-06	6E-05
2	Total Mercury	27.22	0.11	5,690	0.20	0.035	0.07	0.0028	0.0033	0.021	0.038	0.056	4.7%	29.8%	Pass	Fail	0.038	0.056	9E-06	6E-05
1	Hexachloro-cyclohexane	27.22	6.43	2,329	0.004	0.001	0.002	0.00008	0.00053	0.00357	0.0015	0.0046	26.5%	178.5%	Fail	Fail	0.0015	0.0046	5E-04	4E-03
2	Hexachloro-cyclohexane	27.22	6.43	5,690	0.004	0.001	0.02	0.0008	0.00057	0.00361	0.0016	0.0046	2.8%	18.1%	Pass	Fail	0.0016	0.0046	5E-04	4E-03
1	EH >C16 - C24	27.22	149	2,329	212	45	90	3.6	1.4	9.7	46	55	1.6%	10.8%	Pass	Fail	46	55	1E-02	8E-02
2	EH >C16 - C24	27.22	149	5,690	823	45			13.4	86	58	131			Pass	Pass	58	131	1E-02	8E-02
1	EH >C24 - C40	27.22	149	2,329	253	45	90	3.6	1.71	11.55	47	57	1.9%	12.8%	Pass	Fail	47	57	1E-02	8E-02
2	EH >C24 - C40	27.22	149	5,690	1,120	45			18.2	117	63	162			Pass	Pass	63	162	1E-02	8E-02
1	Total Barium	27.22	740	2,329	177	57.4	114.7	4.6	1.2	8.4	59	66	1.1%	7.3%	Pass	Pass	59	66	6E-02	4E-01
2	Total Barium	27.22	740	5,690	200	57.4			3.3	21.2	61	79			Pass	Pass	61	79	6E-02	4E-01

Notes

*	Scenario 1 assessment considers AA WQS (and adoption of average effluent concentrations and average effluent flow rates), where available, with Scenario 2 reflecting assessment considering MAC WQS (and adoption of maximum effluent concentrations and predicted maximum effluent flow rates), where available
*	Includes those compounds considered to require further consideration following Test 1
▨	Predicted concentration in the River Plym exceeeds 4% of the Water Quality Standard
▨	Difference between background concentration and predicted river concentration greater than 10% of the Water Quality Standard
■	Predicted concentration in the River Plym (including background concentration) exceeeds Water Quality Standard