BILAG 5 HIMMARK BEACH REMEDIATION
TREATMENT OF CONTAMINATED GROUNDWATER

Project name	**Himmark Strand**
Project no.	**1100040473-002**
Recipient	**Region of Southern Denmark**
Document type	**Technical Memo**
Version	**2.0**
Date	**2026-03-04**
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1. BACKGROUND

Contaminated groundwater from two remediation areas at Himmark Beach in Denmark will be treated in a new groundwater treatment plant (GWTP). The groundwater contains various organic contaminants, including chlorinated and petroleum hydrocarbons that must be removed prior to disposal of the treated water to the sea. The seawater inside the sheet piled area (the treatment area) must also be treated. In addition to groundwater and seawater, contaminated water from other project areas (rainwater from the area, seawater leaking through the joints of the sheet pile etc.) will also be directed to the treatment plant.

This technical memo lists the design data for the best available technology for treating this highly contaminated groundwater and provides an overview of other treatment technologies that could be utilised to treat the contaminated water. Recommendations to consider when preparing a formal Request for Proposal for the new treatment plant is listed as well.

2. DESIGN BASIS

Table 1: Plant capacity: water types, volumes, flows and treatment duration.

Plant Capacity	
Volume of water to be treated	401.000 m^3
1. Groundwater: free phase remediation, treat full volume[1]	4.000 m^3
2. Seawater inside the treatment area	142.000 m^3
3. Groundwater in seabed: treat full volume	72.000 m^3
4. Rainwater and leaking seawater: treat full volume	183.000 m^3
Duration of treatment [2]	480 days
GWTP peak hydraulic capacity	70 m^3/h

[1]Free phase will be removed in a separate process before the treatment plant. The groundwater from this separate process is estimated and will be treated in the water treatment plant.
[2] Includes time when system is offline for maintenance or cleaning.

The GWTP must be able to treat a water flow of 70 m^3/h, which also corresponds to a 20 mm rainfall for one day. Treat total volumes are shown in Table 1. The plant must have a turndown of 30% or less to ensure sufficient groundwater treatment during periods of low pumping activity and include sufficient standby capacity to maintain 50% of operational capacity when servicing or cleaning individual process units. It must also be possible to easily expand the plant if there is a need to increase the treatment capacity or improve efficiency. There should be an emergency power supply system with an alarm.

The average and maximum inlet concentrations of the main contaminants of concern, expected removal rate, environmental quality requirements (MKK) and discharge limits are summarised in in the tables in Annex A (chlorinated solvents, degradation products, hydrocarbons, BTEX, metals and PFAS).

In addition to dissolved organic compounds, free phase oil (C6-C35) and chlorinated hydrocarbons as well as sand or clay particles may be present.

The feed to the plant comes from several sources (groundwater, seawater, rainwater) and will vary significantly in composition over the life of the project. A full list of compounds and associated average concentrations in the groundwater in the seabed and in the seawater are provided in "Oprensning ved Himmark Strand. Ansøgning om midlertidig udledningstilladelse til oppumpet grund- og havvand, bilag 3" and additional information can be found in the Work Description (SAB) [1]. The treated effluent will be mixed with seawater at the discharge point and the combined, diluted flow should comply with environmental quality requirements - EQS (MKK in Danish) that apply to seawater according to BEK 796 of 13/6/2023.

Air emissions from the GWTP must comply with maximum air emission limits permitted at Himmark Strand. The maximum values are shown in Table 2.

Table 2: Maximum air emission values at GWTP (B-values)

		Maximum Air Emission Limit [1]
Tetrachloroethylene, PCE	mg/m^3	0,01
Trichloroethylene, TCE	mg/m^3	0,04
1,1-dichloroethylene, 1,1-DCE	mg/m^3	not determined
Cis-1,2-dichloroethylene, cis-1,2-DCE	mg/m^3	0,4
Trans-1,2-dichloroethylene, trans-1,2-DCE	mg/m^3	0,4
Chloroethylene, VC	mg/m^3	0,002

[1] Average value for 1 hour which may not be exceeded more than 1% of the time. Referred to as B-value in the Danish EPA Air Emission Guideline Nr. 2 2001.

3. TECHNOLOGY EVALUATION

The main contaminants that require removal are petroleum hydrocarbons (C6 – C35), aromatic hydrocarbons (BTEX) and chlorinated hydrocarbons including degradation products. Different treatment technologies will be required to remove the various contaminants, and a typical treatment step will consist of:

1. Pre-treatment to remove particulates and free phase oil and chlorinated hydrocarbons
2. Volatile organics removal
3. Final polishing (depending on the type of heavy hydrocarbons present)

The very low environmental quality requirements (MKK) for especially vinyl chloride requires very high removal percentages which requires a combination of these technologies to treat the contaminated groundwater with the best available technology, as further described below.

In addition to the compounds exceeding the discharge limits, the technology selection will also depend on several inorganic compounds present in the water. High chlorides and total dissolved solids concentrations from seawater ingress could impact process performance and will affect the materials of construction chosen for the system. Bromide could form toxic bromate in some advanced oxidation processes (e.g. ozone) that could potentially be utilised for removal of specifically vinyl chloride.

[1] Reference: DESIGNBASIS, HIMMARK STRAND, AFVÆRGE AF GENERATIONSFORURENING

The described technology, which is based on BAT, can under optimal conditions remove the contaminants to quite low values. After thorough dialog with water treatment experts and suppliers of water treatment plants it is established that the described combination of water treatment units will result in very low concentrations in the discharged water and is considered BAT for the groundwater contamination at Himmark Beach even though the inlet concentrations will vary a lot and the variations will be unpredictable.

A list of suppliers of the below discussed technologies and their contact information is provided in Annex B.

3.1 Pre-treatment

Pre-treatment is required to remove particulate matter and free phase oil and chlorinated hydrocarbons to reduce the fouling potential in downstream equipment. Based on the current available data, it is proposed to install an oil-water separator, followed by media filtration.

An inclined plate interceptor with integrated solids removal section is foreseen for the oil-water separator. The process utilises gravity separation for the removal of sand and heavy clay particles as well as free phase removal in one compact unit. Allowance is made to dose an emulsion breaker upstream of the unit to enhance the coalescence of small oil droplets that may be present in the water.

Finer silt particles may pass through the gravity separation phase and will be removed in a pressure sand filter. The filters will also be used to remove any colloidal iron since the feed to the plant contains elevated concentrations of iron. Groundwater at most places at Himmark Beach is oxygen deficient and the iron could be present as dissolved ferrous ions. An air sparge system should therefore be included to oxidize the dissolved iron and form insoluble iron hydroxide that can be removed through filtration.

3.2 Volatile Organics Removal

BTEX, chlorinated hydrocarbons and possibly some of the petroleum hydrocarbons are volatile and various technologies are available to remove these compounds, including extraction, activated carbon or resin adsorption, steam/air stripping, and advanced oxidation. Removal efficiencies of the compounds do, however, vary significantly for the various processes and vinyl chloride in particular is not removed as efficiently by activated carbon as some other chlorinated compounds such as TCE and will therefore require additional/alternative treatment to limit the amount of carbon used.

Extraction (MPPE, Macro Porous Polymer Extraction) and advanced oxidation (UV and hydrogen peroxide) have been evaluated previously and are relevant techniques because of their expected treatment performance. These techniques however, are not included in this report because of the lack of suitable rental capacity with the respective suppliers. Moreover, both installations are rather complex, and construction of suitably dimensioned treatment plant would require several months' time. Other techniques such as biodegradation and thermal treatment have not been considered for this application based on the water quality (high TDS, variable organic matter for biodegradation) or high energy requirements (thermal treatment).

Multiple-stage air stripping is, in combination with suitable pre-and post-treatment, considered BAT for this case.

Air stripping is a generally accepted method for removal of volatile organics, including vinyl chloride, from water but generates an off-gas stream containing the contaminants that need to be treated to comply with local air emission norms. Due to the poor removal of vinyl chloride on activated carbon in the air phase, treating the full air flow with activated carbon will not be economically feasible (vinyl chloride removal is approximately 20 times lower than benzene). A system with two or three-stage stripping towers is therefore recommended for this application, with thermal air treatment for the first tower and activated carbon air treatment for the subsequent towers, as illustrated in Figure 1. The bulk of the volatile organics are removed in the first tower and the off-gas treated using a catalytic thermal oxidation system, complete with a caustic gas scrubber to neutralise any acid gasses that may form due to the destruction of chlorinated organic compounds. The first stripper will utilise a relatively low/air water ratio which limits the volume of air that has to be treated. A lead-lag activated carbon system is provided to treat the off-gas from the other stripping towers. The lead-lag system uses two carbon filters in series, the second filter providing treatment redundancy in case the first filter is saturated.

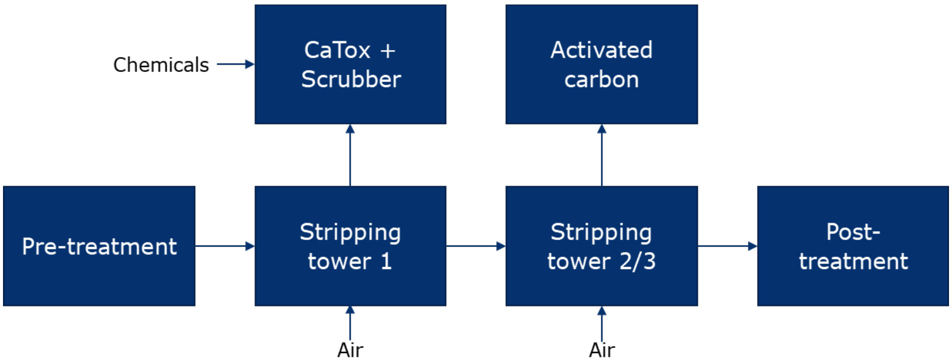

Figure 1: Working layout diagram of multiple-stage stripping treatment for volatile organics removal

3.3 Final Polishing

The exact composition of all petroleum hydrocarbons is not currently known, and it may not be possible to remove all these hydrocarbons in the pre-treatment or volatile organic removal sections of the plant (i.e. some hydrocarbons may not be volatile or be present as a separate phase, and these dissolved compounds will pass through the system). As a final safeguard it is recommended to install lead-lag activated carbon filters to polish the water prior to discharge. Utilising a lead-lag configuration will also maximise the carbon usage (and minimise the associated disposal/replacement costs). A bypass and mixing arrangement could additionally be provided to optimise usage of carbon whilst still achieving the required discharge standards in case of lower feed concentrations over the lifetime of the system.

3.4 Waste Streams

The following waste streams will be generated in the treatment processes and will require off-site disposal:

- Waste oil/free phase of hydrocarbons and/or chlorinated hydrocarbons
- Sludge/solids
- Spent activated carbon (water and/or air phase carbon, depending on process selected)
- Treated off-gas

3.5 Removal effect for other compounds of concern

The above-described treatment technologies for removal of volatile organics are not expected to remove significant amounts of heavy metals from the water phase. During pretreatment, undissolved heavy metals with high affinity to particles may be removed. Possibly a small amount of dissolved heavy metals is precipitated and removed. In the tables in Annex A the removal rates for the different metals are estimated.

The Groundwater Treatment Plant is not designed to remove PFOS. With the current set-up including active carbon filters, maximum 80% PFOS is expected to be absorbed, hence at most reduce the PFOS concentration in the groundwater from 6 ng/l to 1,2 ng/l. This does not comply with the EQS 0,13 ng PFOS/l. It is possible that lower reduction rates than 80% are obtained. Risks for sorption site competition with other organics and PFAS species is high, and insufficient replacement of PFOS-saturated active carbon material will result in desorption due to the aforementioned.

Due to the extremely low PFOS concentrations and presence of other organics, minimum PFOS removal rates from the Himmark contaminated groundwater cannot be guaranteed without testing prior to implementing a full-scale solution. Numbers are based on global experiences from drinking water production, containing less dissolved organics with high affinity to active carbon sorption sites.

3.6 Other Technical Requirements

The system must be able to be monitored, controlled and partly regulated remotely. Equipment is installed to effectively monitor essential operating parameters (especially flow, pressure and leaks) at all critical points in the system. In addition, an automated programme for the sampling of water and effluent air from the system, as well as online measurement, will be established to monitor efficiency and assess when, for example, carbon replacement is needed in the filters. Control of the discharged water follows requirements of the discharge permit (awaiting authorisation).

4. RECOMMENDED TECHNOLOGY SOLUTION

4.1 Plant Description

Based on the above Design Basis and Technology Evaluation, an integrated solution based on multiple-stage stripping is recommended and described in more detail in this section. The integrated solution includes both pre-treatment, volatile organics removal and post-treatment.

A significant part of the water to be treated is not contaminated in the same degree described, e.g. the seawater, the rainwater and the leaking seawater are expected to have low contamination levels. It is also not uncommon for the contaminant concentrations in highly contaminated water types to reduce significantly over the course of the remediation works, and actual inlet concentrations drop to as low as 10 % of the average concentrations measured at the start of the project. Hence, high volumes of lowly contaminated water are expected to be treated during the remediation works, and it is beneficial to implement a dual GWTP capable of treating both averagely and lowly contaminated water to the desired effluent quality. Expected volumes of water with high and low contamination is summarized in Table 3.

Table 3: Level of contamination of the different water types to be treated by the GWTP.

Water type	Volume	Level of contamination
Groundwater: free phase remediation, treat full volume	4.000 m^3	VeryHigh
Seawater inside treatment area	142.000 m^3	Low
Groundwater in seabed: treat full volume	72.000 m^3	High
Rainwater and leaking seawater: treat full volume	183.000 m^3	Low
Total water with high contamination		**76.000 m^3**
Total water with low contamination		**325.000 m^3**

Specifically, a GWTP with a treatment capacity of 70 m^3/h will consist of two equal units capable of treating 35 m^3/h contaminated water each. Both units are stand-alone units, i.e. are designed to operate independently and are illustrated by principle in Figure 2. A monitoring system is essential to control the quality of the treated water.

- Each GWTP unit, dimensioned to treat water of average contamination, consists of an influent buffer and iron removal pre-treatment, 3 stripping towers and 2 active carbon filters as post treatment, as well as a catalytic oxidation for stripping tower 1 and an active carbon filter for air treatment from stripping tower 2 and 3. The units are recommended to be capable of treating 35 m^3/h each during the full treatment period, however this may be reduced when a detailed schedule for the water extraction works is available.

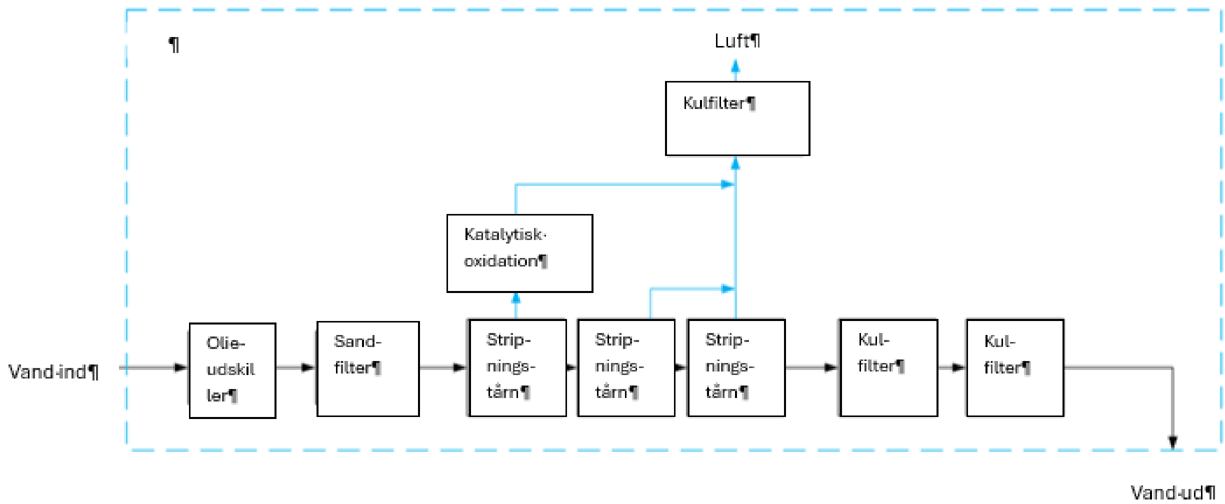

Figure 2: Layout diagram of GWTP Unit 1 and GWTP Unit 2. Air treatment process steps are shown in blue.

4.2 Plant Layout

The required estimated footprint area for the new GWTP is listed per unit and item in Table 4. With a total estimated area of 20 x 26 m for both units, the GTWP will fit in the proposed 30 x 30 m space available. An impermeable lining and containment walls will be installed at the location of the GWTP to avoid contamination of underlying soil by possible leakage from the plant.

Table 4: Footprint estimates for two parallel units of the new GWTP

GWTP Unit 1	GWTP Unit 2
Treatment capacity: 35 m^3/h	Treatment capacity: 35 m^3/h
Water treatment (containment): • 3 12" containers, 6 x 2,5 m • 4 filters, ø 2 – 2,5 m • 3 stripping towers, ca. 2,5 x 2 m • 1 scrubber, ø 1 m • 1 dosing unit, 1 x 1,5 m • Various pumps, pipes, etc. Total ca. 10 x 20 m	Water treatment (containment): • 3 12" containers, 6 x 2,5 m • 4 filters, ø 2 – 2,5 m • 3 stripping towers, ca. 2,5 x 2 m • 1 scrubber, ø 1 m • 1 dosing unit, 1 x 1,5 m • Various pumps, pipes, etc. Total ca. 10 x 20 m
Air treatment: • 1 container 6 x 2 m • 2 or 4 AC filters, ca. 2,5 x 2,5 m Total ca. 8 x 6 m	Air treatment: • 1 container 6 x 2 m • 2 or 4 AC filters, ca. 2,5 x 2,5 m Total ca. 8 x 6 m
Total GWTP ca. 26 x 20 m	

5. ADDITIONAL CONSIDERATIONS

It is recommended that the following items be considered in the permit application and final Request for Proposal document:

1. Expected contaminant concentrations and volumes of water with average and max contamination are recommended to be confirmed by monitoring data before and during the operations.
2. Total suspended solids should be analysed and included in the specification, since this could impact the design of the pre-treatment system (e.g. additional sedimentation capacity).
3. Water temperature, including seasonal variations, should be provided.

4. The cost estimate from suppliers will depend greatly on the actual concentration of pollutants over the course of the project life and the basis for calculations should therefore be clearly specified. The current design basis lists the average and maximum values, which are based on analyses from a number of (test)boreholes.
5. Most suppliers are able to perform basic laboratory or on-site tests to optimise their designs. If water samples are available, suppliers could be engaged at an early stage in the project to perform treatability tests.

ANNEX A – Groundwater quality data, removal rate, environmental quality requirements (MKK) and discharge limits

5-1. Gennemsnits- og maksværdier for havvand og grundvand for chlorerede kulbrinter og nedbrydningsprodukter, med min og max rensegrader, anvendte grænseværdi og udlederkrav for hvert stof. I.a.: ikke analyseret, i.p.: ikke påvist over analysemetodens detektionsgrænse.

	Stof	**Grundvand (µg/l)**		**Havvand (µg/l)**		**Rensegrad (%)**		**MKK/PNEC (µg/l)**	**Forslag til udlederkrav (µg/l)**	**Forslag til maks. udlederkrav (µg/l)**
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
Chlorerede stoffer og nedbrydningsprodukter	1,1,1-trichlorethan	7,7				99,5995	99,9995	2,1	0,031	0,047
	1,1-dichlorethen	25,6	830	0,0	0,0	99,5995	99,9995	0,68	0,10	0,15
	1,2-Dichlorethan-d4	83,2				99,5995	99,9995	10	0,33	0,50
	1,2-Dichlorobenzen	7,7*				99,5995	99,9995	0,37	0,031	0,047
	cis-1,2-dichlorethen	17.018	277.000	7,6	27,0	99,5995	99,9995	0,68	**68,2**	102
	Methylene Chlorid	212,7*				99,5995	99,9995	31	0,85	1,28
	Tetrachlorethen	7.848	330.000	0,3	1,0	99,5995	99,9995	10	**31,4**	46,9
	trans-1,2-dichlorethen	21,4	452	0,0	0,1	99,5995	99,9995	0,68	0,09	0,15
	Trichlorethen	13.682	70.000	1,0	5,2	99,5995	99,9995	10	**54,8**	82,2
	Trichlormethan	3,9	730	i.p.	i.p.	99,5995	99,9995	2,5	0,02	0,03
	Vinylchlorid	1.484	44.000	1,1	4,5	99,5995	99,9995	0,05	**5,9**	8,9

* Baseret på fugacitetsberegning

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
BTEX	Benzen	11,2	1.200	i.p.	i.p.	99,5995	99,9995	8	0,04	0,044
	d8-Toluen	105	111	i.a.	i.a.	99,5995	99,9995	Se Toluen	0,42	0,63
	Ethylbenzen	64,4	660	0,01	0,05	99,5995	99,9995	2	0,26	0,39
	Sum af xylener	186	2.500	0,08	0,11	99,5995	99,9995	1	0,74	1,1
	Toluen	218	5.800	0,01	0,06	99,5995	99,9995	7,4	0,87	1,30
	BTEX (sum)			**0,077**		99,9995	99,9995	Ikke fund af MKK eller andet.	0,001997	

* Baseret på fugacitetsberegning

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
Kulbrinter	1,2,4-trimethylbenzen	734,1[1]				99,9698	99,9996	120	0,2	0,3
	1,3,5-trimethylbenzen	232,7[1]				99,9698	99,9996	101	0,1	0,15
	Sum (C6H6-C35)	19522		10,75		99,9698	99,9996	Ikke fund af MKK eller andet	5,9	8,85

	Stof	**Grundvand (ng/l)**		**Havvand (ng/l)**		**Rensegrad (%)**		**MKK/PNEC (ng/l)**	**Forslag til udlederkrav (ng/l)**	**Forslag til maks. Udlederkrav (ng/l)**
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
PFAS	6:2 FTS (Fluortelomersulfonat)	i.p.	i.p.	i.p.	i.p.	30	80			
	PFBA (Perfluorbutansyre)	3,9	34,0	0,8	3,7	30	80			
	PFBS (Perfluorbutansulfonsyre)	< LOD	1,9	i.p.	i.p.	30	80			
	PFDA (Perfluordekansyre)	< LOD	1,4	i.p.	i.p.	30	80			
	PFDoDA (Perfluordodecansyre)	i.p.	i.p.	i.a.	i.a.	30	80			
	PFDoDS (Perfluordodecansulfonsyre)	i.p.	i.p.	i.a.	i.a.	30	80			
	PFDS (Perfluordecansulfonsyre)	i.p.	i.p.	i.a.	i.a.	30	80			
	PFHpA (Perfluorheptansyre)	0,9	7,2	0,3	2,6	30	80			
	PFHpS (Perfluorheptansulfonsyre)	i.p.	i.p.	i.a.	i.a.	30	80			
	PFHxA (Perfluorhexansyre)	0,4	5,1	0,1	1,1	30	80			
	PFHxS (Perfluorhexansulfonsyre)	0,7	4,1	0,4	4,1	30	80			
	PFNA (Perfluornonansyre)	1,8*	31,0	0,5	4,9	30	80	4,4	**12,6***	
	PFNS (Perfluornonansulfonsyre)	i.p.	i.p.	i.a.	i.a.	30	80			
	PFOA (Perfluoroktansyre)	4,5*	43,0	1,6	12,0	30	80	4,4	3,15	
	PFOS (Perfluoroktansulfonsyre)	12,4	74,0	2,9	18,0	30	80	0,13	**8,68**	13,02
	PFOSA (Perfluoroktansulfonamid)	i.p.	i.p.	i.p.	i.p.	30	80	-		

	PFPeA (Perfluorpentansyre)	0,4	4,8	0,1	1,2	30	80			
	PFPeS (Perfluorpentansulfonsyre)	< LOD	13,0	i.a.	i.a.	30	80			
	PFTrDA (Perfluortridecansyre)	0,3	3,1	i.a.	i.a.	30	80			
	PFTrDS (Perfluortridecansulfonsyre)	i.p.	i.p.	i.a.	i.a.	30	80			
PFAS	PFUnDA (Perfluorundecansyre)	< LOD	1,3	i.a.	i.a.	30	80			
	PFUnDS (Perfluorundecansulfonsyr e)	i.p.	i.p.	i.a.	i.a.	30	80			
	Sum af 4 PFAS (PFHxS, PFNA, PFOA, PFOS)	24,9	150	i.a.	i.a.	30	80	2	**17,43**	26,15
	Sum af påviste PFAS, 22 stoffer	36,5	160	i.a.	i.a.	30	80			
	Sum PFAS-12	23,6	160	13,5	48,0	30	80			
	Sum af påviste 24 stoffer for PFOA-ækvivalenterr							4,4	4,4	6,6

*PFNA indgår i sum af 4 PFAS og indgår i den beregning, derved bliver den ikke behandlet som individuelt stof i videre beregninger.

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til Udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
Metaller	Arsen (As)	3,6	16,0	2,95	5,50	50	70	1,6	**1,8**	2,7
	Arsen (As) feltfiltreret	2,6	9,7	i.a.	i.a.	50	70	1,6	1,3	1,95
	Barium (Ba)	182	1000	183	610	0	0	55,8	**182**	273
	Barium (Ba) feltfiltreret	179,9	460	i.a.	i.a.	0	0	55,8	**179,9**	270
	Bly (Pb) feltfiltreret	0,0	0,1	i.a.	i.a.	0	50	1,3	0,03	0,045
	Cadmium (Cd) feltfiltreret	0,0	0,0	i.a.	i.a.	0	50	0,2	0,01	0,015
	Chrom (Cr) feltfiltreret	0,4	1,0	i.a.	i.a.	0	50	3,4	0,43	0,64
	Kobber (Cu) feltfiltreret	0,4	1,2	i.a.	i.a.	0	50	1,5	0,39	0,59
	Kobolt (Co)	2,4	19,0	1,44	3,30	0	0	1,78	**2,4**	3,6
	Molybdæn (Mo)	1,8	3,0	i.a.	i.a.	0	0	16,7	1,8	2,7
	Molybdæn (Mo) feltfiltreret	1,3	2,8	i.a.	i.a.	0	0	16,7	1,3	1,95
	Nikkel (Ni)	3,5	29,0	2,10	5,40	0	50	8,6	3,5	5,25
	Nikkel (Ni) feltfiltreret	1,2	4,8	i.a.	i.a.	0	50	8,6	1,2	1,8
	Selen (Se) feltfiltreret	0,9	2,0	i.a.	i.a.	0	0	0,58	**0,9**	1,39
	Sølv (Ag)	0,0	0,1	0,02	0,13	0	50	0,21	0,03	0,045
	Zink (Zn) feltfiltreret	2,3	20,0	i.a.	i.a.	0	50	8,8	2,3	3,5

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til Udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
Dioxiner	1,2,3,4,6,7,8-heptaCDD	**2,4E-05**				51	96	1,9E-09	**1,18E-05**	
	1,2,3,4,6,7,8-heptaCDF	**8,1E-05**				51	96	1,9E-09	**3,97E-05**	
	1,2,3,4,7,8,9-heptaCDF	**7,0E-06**				51	96	1,9E-09	**3,43E-06**	
	1,2,3,4,7,8-hexaCDD	**2,0E-06**				51	96	1,9E-09	**9,8E-07**	
	1,2,3,4,7,8-hexaCDF	**2,5E-05**				51	96	1,9E-09	**1,23E-05**	
	1,2,3,6,7,8-hexaCDD	**2,8E-06**				51	96	1,9E-09	**1,37E-06**	
	1,2,3,6,7,8-hexaCDF	**2,0E-05**				51	96	1,9E-09	**9,8E-06**	
	1,2,3,7,8,9-hexaCDD	**2,2E-06**				51	96	1,9E-09	**1,08E-06**	
	1,2,3,7,8-pentaCDD	**1,7E-06**				51	96	1,9E-09	**8,33E-07**	
	1,2,3,7,8-pentaCDF	**6,5E-06**				51	96	1,9E-09	**3,19E-06**	
	2,3,4,6,7,8-hexaCDF	**1,5E-05**				51	96	1,9E-09	**7,35E-06**	
	2,3,4,7,8-pentaCDF	**1,3E-05**				51	96	1,9E-09	**6,37E-06**	
	2,3,7,8-tetraCDD	**3,1E-07**				51	96	1,9E-09	**1,52E-07**	
	OctaCDD	**3,5E-05**				51	96	1,9E-09	**1,72E-05**	
	OctaCDF	**2,1E-05**				51	96	1,9E-09	**1,03E-05**	

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til Udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
PAH		*Gennemsnit*	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
	Naphthalen	**4,4**				30	80	2	**3,08**	4,62
	Sum af 16 PAH'er (EPA)	5,5		**1,7540**		30	80	0,00017	3,85	5,78

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til Udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
Phenoler		*Gennemsnit*	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
	2,3-dimethylphenol	**0,07**				90	99	0,032	0,007	
	2,4-dimethylphenol	**0,16**				90	99	0,032	0,016	
	2,5-dimethylphenol	**0,19**		**0,04**		90	99	0,032	0,019	
	2,6-dimethylphenol	**0,07**				90	99	0,032	0,007	
	3,4-dimethylphenol	**0,07**				90	99	0,032	0,007	
	3,5-dimethylphenol	**0,37**		**0,11**		90	99	0,032	**0,037**	0,056

*PNEC

	Stof	Grundvand (µg/l)		Havvand (µg/l)		Rensegrad (%)		MKK/PNEC (µg/l)	Forslag til Udlederkrav (µg/l)	Forslag til maks. udlederkrav (µg/l)
		Gennemsnit	*Maks*	*Gennemsnit*	*Maks*	*Min*	*Max*			
Andet	Ammonium (NH_4)	**2019**		**2.378**		0	30	Ikke fund af MKK eller andet	2014	
	Cyanid, total	**0,6**				99,96	99,96	2,48	0,00024	
	p-bromofluorobenzen	**88,6**				30	80	0,45	**62,02**	93,03

For grupperne: Chlorerede phenoler og Pesticider var der ingen stoffers gennemsnitsværdi der har overskred grænseværdien. Derfor er der ikke fundet rensegrader for de stoffer.

ANNEX B – Supplier Details

The following suppliers were contacted and contributed to the preparation of this technical memo:

HMVT
www.hmvt.nl

Veolia Water Technologies
https://www.veoliawatertechnologies.com/en/solutions/technologies/macro-porous-polymer-extraction-mppe

Enviolet
www.enviolet.com