SEPTEMBER 2019
REGION OF SOUTHERN DENMARK

CONTRACT UNDER THE THRESHOLDS WITH A CLEAR CROSS-BORDER INTEREST

LAB TESTS OF AOP-METHODS FOR TREATMENT OF CONTAMINATED GROUNDWATER FROM THE POLLUTION PLUME AT GRINDSTEDVÆRKET AS WELL AS ECOTOXICOLOGICAL TESTS

TENDER TERMS INCLUDING APPENDICES, ENGLISH

Region Syddanmark

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TENDER TERMS INCLUDING APPENDICES

PROJECT NO. DOCUMENT NO.

A121940

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
2.0	26-09-2019	Tender terms	AKRA, JAD	LHKL	AKRA

CONTENTS

APPENDICES

1 Information about the tender

1.1 Preliminary description

The Region of Southern Denmark, in the following referred to as the contracting authority, wants to put the following contract out to tender, cf. the Danish Public Procurement Act, chapter 4.

The contract is divided into three sub-agreements. Additional information about the sub-agreements is available in section 1.2 and in the special work descriptions (SAB) included in Appendix A.

The tenderer may bid on one or more sub-agreements.

The nature of the minimum requirements for economic and technical capacities (selection criteria), which must be documented in order to be considered for the project, and related documentation, is described in sections 1.10 and 1.11.

ABRf, abridged general conditions for consultancy services for building and construction works, applies to this project.

Please note the deviation from ABRf § 38, section 4, regarding limitation of the consultant's liability. The limitation of liability is replaced by an amount of DKK 10 million.

Please note the deviation from ABRf § 4, section 4, regarding the order of priority of documents.

1.2 Scope of contract

The contract includes test of treatment of contaminated groundwater using four different advanced oxidation methods (AOP), performed either in the lab or using a mobile plant. Groundwater contaminants include, e.g., pharmaceutical substances (the so-called Grindstedværket substances), chlorinated solvents and degradation products of the solvents, and benzene.

The contract also includes ecotoxicological tests of both untreated and treated groundwater.

SAB in Appendix A provides more details on the project.

The contract is divided into three sub-agreements. Below, each sub-agreement is described.

1.2.1 Description of sub-agreement 1

Sub-agreement 1 involves testing three AOP methods; A-C:

A: Ozone (O_3)
B: O_3 + hydrogen peroxide (H_2O_2)
C: UV+ H_2O_2

For all three methods (A-C), the groundwater must be pre-treated to remove iron and manganese, and after the AOP tests, the water must be post-treated with activated carbon.

Further descriptions of sub-agreement 1 are included in Appendix A.

1.2.2 Description of sub-agreement 2

Sub-agreement 2 includes testing one AOP method; D.

D: H_2O_2+ fixed-bed catalyst (catalytic H_2O_2).

Further descriptions of sub-agreement 2 are included in Appendix A.

1.2.3 Description of sub-agreement 3

Sub-agreement 3 includes ecotoxicological tests of untreated groundwater and groundwater treated using each of the four methods tested under sub-agreements 1 and 2.

Ecotoxicological tests must be performed in accordance with OECD guideline method no. 201 (Rev. 2011) and method no. 202 (2004).

Further descriptions of sub-agreement 3 are included in Appendix A.

1.3 Tender documents

The tender documents include the following documents:

- Draft agreement **(in Danish)**
- Present tender terms in English
- Appendix A - Special work descriptions (SAB)
- Appendix B - Basis for payment and measurement (TAG1-TAG3)
- Appendix C - Bills of quantities (BoQ-BoQ3)
- Appendix D - Solemn declaration in Danish and English
- Appendix E ABR Abridged (Abridged general conditions for consultancy services for building and construction works), applies to this project,.

In case of discrepancies between the Danish and the English versions of the tender terms or special work descriptions, the Danish version prevails.

1.4 Indicative schedule for the tender process

The table below shows the indicative schedule for the tender process.

Schedule for tender process	
Announcement at udbud.dk	26 September 2019
Deadline for submission of questions	10 October 2019
Deadline for answers to questions	14 October 2019
Deadline for submission of tenders	**18 October 2019 at 12:00** (Central European Summer Time, CEST)
Notice of award and contracting	1 November 2019

1.5 Master time schedule for the project

The project is expected to be carried out according to the below master time schedule:

Time schedule for the project, sub-agreement 1	
Supply/pick-up of water	11-12 November 2019
Performance of tests	11 November 2019-12 December Last post-treatment test is performed after receipt of water from winner of sub-agreement 2. Deadline for performance of post-treatment tests is week 50.
Post-treated water must be received by the winner of sub-agreement 3	Not later than 16 December 2019
Deadline for preliminary report	20 December 2019

Deadline for final report	24 January

Time schedule for the project, sub-agreements 2	
Supply/pick-up of water	11-12 November 2019
Performance of tests	11 November 2019-8 December
Post-treated water must be received by the winner of sub-agreement 3	Not later than 9 December 2019
Deadline for preliminary report	20 December 2019
Deadline for final report	24 January

Time schedule for the project, sub-agreement 3	
Receipt of water	11-12 November 2019 (untreated water) 16 December 2019 (treated water)
Performance of ecotoxicological tests	11 November-20 December 2019 (Untreated water, week 46) (treated water, week 50)
Deadline for test report	17 January 2020

As described there is shipping/transport from the laboratory winning sub-agreement 1 to the laboratory winning sub-agreement 3 and from the laboratory winning sub-agreement 2 to the laboratory winning sub-agreement 1. Therefore, compliance with the time schedule is very important.

1.6 Questions regarding tender documents

As soon as possible, the contracting authority should be notified of any discrepancies in the tender documents and/or questions by the below emails.

Anne Krag, COWI, at: akra@cowi.com, and Jarl Dall-Jepsen, COWI, at jad@cowi.com, copy to Hanne Nielsen, the Region of Southern Denmark, at hni@rsyd.dk

Any questions must be submitted in writing not later than **10 October 2019 at 12:00 (CEST).**

Questions will be answered continuously, and the last answers will be uploaded to udbud.dk, not later than **14 October 2019.**

1.7 Deadline for submission of tender

Tenders must be submitted to the emails below:

Anne Krag, COWI, at: akra@cowi.com, and Jarl Dall-Jepsen, COWI, at jad@cowi.com, copy to Hanne Nielsen, the Region of Southern Denmark, at hni@rsyd.dk

Tenders must be received by: **18 October 2019 at 12:00 Central European Summer Time (CEST)**

Tenders received after this deadline will not be considered.

1.8 Opening of tenders

It will not be possible to witness the opening of tenders.

1.9 Notification

All tenderers will be notified in writing simultaneously of the award decision.

1.10 Requirements for submission of tender

All communication must be in Danish or English

The tender must include the following:

- Tenderer's company name, address, email address and telephone
- Annual accounts, approved by auditor, for the tenderers' last two completed accounting periods, which must state the following key figures for each financial year:
  - Net turnover
  - Equity.
- Project description (15 pages maximum) per sub-agreement
- List of references
- CVs for the person(s) responsible for project implementation

- Filled-in Appendix D, solemn declaration
- Filled-in bill of quantities for the sub-agreement(s) tendered for
- A valid liability insurance with limit of cover corresponding to at least DKK 10 million for material and personal injury. Documentation must be included in the tender.

If the tenderer does not meet the above requirements for submission of tender, the tenderer may be declared non-compliant. In that case, the tenderer will not be evaluated any further.

1.11 Requirements for suitability

Below are listed the minimum requirements for economic capability and technical capability in relation to assessing the suitability of tenderers for the project.

The contracting authority carries out this suitability assessment based on an overall assessment of, in particular, the submitted project description, which should convince the contracting authority that the tenderer is able to handle the project.

If the contracting authority assesses that a tenderer is not suited for handling the project, the contracting authority reserves the right to reject the tenderer as being unsuited, due to failure to fulfil the listed minimum requirements, including minimum requirements for economic and technical capabilities. Further details are presented below.

1.11.1 Financial ability

1 The tenderer is to state *key figures*, i.e. *the tenderer's* ***net turnover*** *for the last two completed financial years.*

It is a minimum requirement that turnover in each of the two completed financial years is at least DKK 3 million.

2 The tenderer is to state *key figures*, i.e. the tenderer's ***equity*** for the last two completed financial years.

It is a minimum requirement that equity in each of the two completed financial years is **positive.**

1.11.2 Technical capability

1 The tenderer is to submit a project description of a maximum of 15 pages.

Content:

Based on the special work descriptions for each sub-agreement, the project description must describe the tenderer's approach to the project.

It is a minimum requirement that the project descriptions for sub-agreements 1 and 2 contain the following:

1.1 A description of and arguments for the procedure chosen for testing each method covered by the sub-agreement tendered for, including choice of filtering method for pre-treatment.

1.2 A list of all analyses and measurements that will be carried out during the tests, in addition to the tests that, cf. the special work descriptions, will be sent to Eurofins in Denmark for analysis.

1.3 Information about expected water volume required for carry out all tests under the specific sub-agreement, including all analyses and measurements, including the water volume to be used for all analyses prepared by an external lab (Eurofins).

1.4 Information about expected volume of treated water generated during the tests.

1.5 A description of how the water samples will be handled at the location; how the water will be transported to the lab; and how the water will be stored and handled in the lab or at the mobile plant to minimise the loss as well as degradation of the many volatile compounds such as benzene and chlorinated substances.

1.6 A description of any special requirements or specifications in connection with supply of groundwater.

1.7 A time schedule indicating test sub-activities.

1.8 A preliminary schedule for reporting the results.

1.9 A health and safety plan for the project.

It is a minimum requirement that the project description for sub-agreement 3 contains the following:

1.10 Information about how the water will be stored and handled in the lab to minimise the loss as well as degradation of the many volatile compounds such as benzene and chlorinated substances.

1.11 Information about how results will be reported

1.12 A time schedule for project implementation.

2 The tenderer is to provide a list of references.

It is a minimum requirement that the list of references demonstrates relevant experience from at least three and no more than five comparable references for the past eight years, describing the deliverables/services, project period, contract sum size, and contact person for the specific customer, including telephone and/or email information.

The contracting authority reserves the right to contact the contact persons included in the references in order to verify the information.

3 The tenderer is to submit CVs for the person(s) responsible for project implementation. This includes the CV for the project manager as well as CVs for two technical key staff members. The following minimum requirements apply:

- At least five years of relevant experience (applies to the project manager)
- At least two years of relevant experience (applies to technical key staff members)
- References for at least two projects included in the list of references (applies to the project manager).

1.12 Award criterion

The award criterion for assessing submitted tenders is “lowest price”.

Appendix A Special work descriptions (SAB)

SEPTEMBER 2019
REGION OF SOUTHERN DENMARK

TREATMENT OF CONTAMINATED GROUNDWATER FROM POLLUTION PLUME AT GRINDSTEDVÆRKET

LAB TESTS INVOLVING ADVANCED OXIDATION PROCESSES (AOP)

SPECIAL WORK DESCRIPTION, APPENDIX A

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SEPTEMBER 2019
REGION OF SOUTHERN DENMARK

TREATMENT OF CONTAMINATED GROUNDWATER FROM POLLUTION PLUME AT GRINDSTEDVÆRKET

LAB TESTS INVOLVING ADVANCED OXIDATION PROCESSES (AOP)

SPECIAL WORK DESCRIPTION, APPENDIX A

PROJECT NO.	DOCUMENT NO.
A121940	03

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
2.0			FLDX, AKRA, ND	JAD	

CONTENT

1 Purpose and background

Past activities at the Grindstedværket site in the city of Grindsted in Denmark contaminated the factory site and the groundwater below it. The groundwater contamination is mainly caused by a number of pharmaceutical substances (in the following referred to as Grindstedværket substances), hydro carbons (particularly benzene), chlorinated solvents and degradation products of the solvents, especially vinyl chloride and cis- 1,2- DCE. The contaminated groundwater flows from the source site to Grindsted Stream and much of the contamination flows into the creek at the former Renseanlæg Vest WWTP, which is located at Svinget 12, 7200 Grindsted, Denmark.

The Region of Southern Denmark (RSD) has decided to analyse the possibilities of reducing the impact on Grindsted Stream. Specifically, the idea is to establish a temporary system for protective pumping to provide on-site treatment of groundwater on the Renseanlæg Vest site.

On behalf of the region, COWI carried out a screening of relevant methods for on-site treatment of contaminated groundwater (pump and treat), and in that connection, it was assessed that advanced oxidation processes (AOP) could provide a suitable treatment of the groundwater before it is discharged. Four AOP processes have been selected for testing, either in the lab or in a mobile plant at Svinget 12, 7200 Grindsted Denmark.

The four AOP methods are:

A. Ozone
B. Ozone + H_2O_2
C. H_2O_2 + UV
D. H_2O_2 + fixed-bed catalyst.

Before carrying out AOP tests the groundwater must be pre-treated, and after the AOP tests, it must be post-treated with activated carbon.

The overall purpose of the AOP tests is to examine whether the methods are suited for treating the specific groundwater contamination mix found in Grindsted. The purpose of the AOP tests (sub-agreements 1 and 2) is:

- To test the suitability of the four selected AOP methods for treating groundwater.
- To study the treatment efficiency of all four AOP-processes regarding Grindstedværket substances, total hydrocarbons, BTEXN, chlorinated solvents and degradation products of the solvents, including in particular vinyl chloride and cis-1,2 DCE.
- To study pre-treatment of the polluted groundwater by removing iron and manganese prior to AOP treatment.
- To determine relevant design parameters per m³ water, including dosage and concentration of oxidants and UV-dose, reaction time/contact time for oxidation and for post-treatment with activated carbon as well as any need

for further addition of other chemicals.

Furthermore, the eco-toxicity of both treated and untreated water shall also be tested (sub-agreement 3) to assess the possibilities of discharging the treated water into Grindsted Creek in case a full-scale system is established later on.

Since the AOP tests under sub-agreements 1 and 2 can be carried out in a number of ways, the work descriptions in the tender must contain both suggested test procedures and requirements. The tenderer is free to suggest other test procedures as long as the purpose of the tests, cf. chapter 1, and the documentation requirements are met.

The tenderer may submit quotations for one or more sub-agreements as long as the specific bills of quantities are filled-in.

1.1 Expected contamination in groundwater for testing

Table 1-Table 3 contain selected results from analyses of groundwater from the location.

On several occasions, most recently on 18 July 2019, samples were taken of the groundwater, which is selected for the future tests. On the basis of the analysis results, it was decided that the groundwater to be used for the tests must be taken from filter 2 of well BE6 (DGU no. 114.2567). Table 1 and Table 2 show the analysis results for selected contamination components analysed in 2019 and 2016 as well as information about the highest levels of each parameter found at the location.

These analysis results are expected to provide a solid overview of the composition of the water to be tested, but even significant variations must be expected. Furthermore, it should be stressed that in excess of 1,100 chemical substances and products were used at Grindstedværket, so it is likely that samples will reveal low content of substances not previously analysed for in past studies.

As shown in Table 1, the groundwater contains relatively large concentrations of Grindstedværket substances, especially sulpha substances and barbiturates.

On the basis of a limited amount of data from the location, it is estimated that the substances contributing to the NVOC content are mainly Grindstedværket substances. If we assume that 30 to 60 per cent of the Grindstedværket substances are carbons (depending on the chemical formulas), the NVOC results are consistent with the sum of the Grindstedværket substances.

Table 2 and Table 3 include analysis results for organic and inorganic parameters, respectively.

Table 1 Results of analysis of DGU 114.2567, filter 2, as well as highest level found at the location.

COMPONENT	CAS-NUMBER	UNIT	DGU 114.2567 (BE6)		MAX.VALUE ON THE LOCALITY
			18-07-2019	10-10-2016	
Grindstedværk subbstance					
3-Methoxypropionitril	110-67-8	µg/l	<0.1	<0.1	
5-allyl-5-isobutyl-barbitur acid	77-26-9	µg/l	17	14	17
5-Butylbarbiturat	1953-33-9	µg/l	56	<0.1	56
Acetylsulfaguanidin	19077-97-5	µg/l	<0.1	<0.1	<0.1
Acetylsulfanil acid	121-62-0	µg/l	<0.1	0.18	70
Aethallymal	2373-84-4	µg/l	2	<0.1	2
Allobarbital	52-43-7	µg/l	100	100	270
Allylamine (Dipropenylamin)	107-11-9	µg/l	<0.1	<0.1	8.8
Allyl-n-butylbarbiturat	3146-66-5	µg/l	0.85	2.7	5.4
Amobarbital	57-43-2	µg/l	44	130	130
Barbital	57-44-3	µg/l	13	38	72
Butabarbital	125-40-6	µg/l	14	25	140
Butobarbital	77-28-1	µg/l	9.1	16	58
Ethylcarbamat (Ethylurethan)	51-79-6	µg/l	<0.1	5,700	14,000
Hexobarbital	56-29-1	µg/l	<0.1	0.25	0.25
Isobutylbarbitur acid	42846-91-3	µg/l	72	<0.1	72
Isopropylbarbitur acid	7391-69-7	µg/l	55	0.19	55
Meprobamat	57-53-4	µg/l	170	720	720
Metharbital	50-11-3	µg/l	<0.1	0.16	0.16
Monoethylbarbitur acid	2518-72-1	µg/l	<0.1	<0.1	<0.1
N-N-diethylnicotinamid	59-26-7	µg/l	0.63	2.6	18
Pentobarbital	76-74-4	µg/l	22	160	160
Phtalylsulfathiazol	85-73-4	µg/l	<0.1	<0.1	21
Secobarbital	76-73-3	µg/l	11	26	26
Sulfacetamide	144-80-9	µg/l	<0.1	<0.1	3.8
Sulfadiazin	68-35-9	µg/l	<0.05	<0.05	<0.05
Sulfadimidin (Sulfamethazin)	57-68-1	µg/l	43	85	460
Sulfaguanidine	57-67-0	µg/l	260	5.4	380
Sulfamerazin	127-79-7	µg/l	7.1	6.7	12
Sulfamethizol	144-82-1	µg/l	<0.050	8.0	330
Sulfanilamide	63-74-1	µg/l	180	150	750
Sulfanil acid	121-57-3	µg/l	100	<0.1	9.4
Sulfanilyl urea	547-44-4	µg/l	570	2.5	570
Sulfapyridine	144-83-2	µg/l	<0.10	<0.1	17
Sulfathiazol	72-14-0	µg/l	3.5	2.3	91
Sum of Grindstedværk substances	-	µg/l	1,750	7,196	14,926
NVOC					
NVOC, non-volatile organic carbon		µg/l	1,100	Not analysed	

Table 2 Results of analysis of organic substances in DGU 114.2567 (BE6), filter 2

		DGU 114.2567 (BE6), filter 2	
Component	**Unit**	**18-07-2019**	**10-10-2016**
Organic parameters			
Benzen	µg/l	400	440
Toluen	µg/l	7.9	6.0
Ethylbenzen	µg/l	0.63	0.73
m+p-Xylen	µg/l	0.54	0.70
o-Xylen	µg/l	1.6	2.7
Sum af xylener	µg/l	2.8	4.1
BTEX (sum)	µg/l	410	450
Naphthalen	µg/l	0.02	<0.02
C6H6-C10	µg/l	420	460
C10-C25	µg/l	< 8	11
C25-C35	µg/l	< 9	<0.02
Sum (C6H6-C35)	µg/l	420	480
1,2-dichlorethan	µg/l	< 2	<2
Trichlormethan (Chloroform)	µg/l	< 0.02	<2
1,1,1-trichlorethan	µg/l	< 0.02	<2
Trichlorethen	µg/l	2.1	4.6
Tetrachlormethan	µg/l	< 0.02	<2
Tetrachlorethen	µg/l	4.8	23
Chlorethan	µg/l	< 2	<2
1,1-dichlorethen	µg/l	< 2	<2
trans-1,2-dichlorethen	µg/l	29	47
cis-1,2-dichlorethen	µg/l	350	1,200
1,1-dichlorethan	µg/l	< 2	<2
Vinyl chloride	µg/l	2,700	4,700

Table 2 shows the presence of relatively high concentrations of volatile organic compounds, i.e. hydrocarbons and chlorinated compounds. In particular, high concentrations of benzene, vinyl chloride and cis-1,2-dichlorethene.

The chlorinated solvents and hydrocarbons are volatile, thereby not contributing to NVOC. However, they will form part of the analysis results when analysing for TOC, which is the sum of the volatile organic carbons (VOC) and non-volatile organic carbons (NVOC).

Table 3 shows that the inorganic parameters of the groundwater are typical for groundwater with a relatively low saline concentration. The content of heavy metals is not critical, and water hardness is relatively low. Nevertheless, the groundwater may contain a relatively substantial level of iron and manganese, rendering it necessary to remove iron and manganese before using the groundwater for AOP tests.

Significant bromide concentrations (up to 1500 µg/l) were identified. Bromide concentrations over 35 µg/l are critical, since bromide and ozone may form the hazardous substance bromate, which causes cancer. Therefore, the formation of bromate during AOP tests using ozone must be a key focal point.

Table 3 *Results of analysis of inorganic parameters in DGU 114.2567 (BE6), filter 2*
NA: Not available.
[1]Result from 18 July 2019 for nearby well (sounding well).

Component		DGU 114.2567 (BE6), filter 2	
	Unit	18-07-2019	10-10-2016
pH	pH	5.6	5.7
Temperature at pH-measurement	°C	21	NA
Total dissolved solids	mg/l	350	380
Conductivity20°C	mS/m	60	61
Ammonia (NH4)	mg/l	0.1	0.13
Nitrite	mg/l	< 0.001	0.026
Nitrate, NO_3	mg/l	< 0.3	<0.3
Total Phosphor	mg/l	< 0.01	0.02
Chloride	mg/l	170	130
Fluoride (F)	mg/l	< 0.05	0.065
Sulfate (SO4)	mg/l	29	56
Aggressiv carbon dioxide	mg/l	110	120
Hydrogen carbonat	mg/l	32.3	33.7
Bromide (Br), filtered	mg/l	0.9	1.5[1]
Lead (Pb) filtered in-situ	µg/l	0.028	0.26
Cadmium (Cd) filtered in-situ	µg/l	< 0.003	0.019
Calcium (Ca)	mg/l	3.4	5.3
Chromiu (Cr) filtered in-situ	µg/l	< 0.03	0.81
Iron (Fe)	mg/l	1.1	2.4
Iron (Fe) filtered in-situ	mg/l	0.96	NA
Potassium (K)	mg/l	0.66	1.1
Copper (Cu) filtered in-situ	µg/l	< 0.03	NA
Magnesium (Mg)	mg/l	1.6	2.1
Manganese (Mn)	mg/l	0.047	NA
Manganese (Mn) filtered in-situ	mg/l	0.045	0.18
Sodium (Na)	mg/l	110	120
Nickel (Ni)	µg/l	2.7	4.1
Nickel (Ni) filtered in-situ	µg/l	2	NA
Zinc (Zn) filtered in-situ	µg/l	3.7	10

2 Access conditions and supply of water for tests

As stated earlier, the tests can be carried out using either mobile plants/equipment at the location or in the lab. In either case, the tenderer must use water from filter 2 in well 114.2567 (BE6) on the Grindsted location.

Under supervision of RSD, the tenderer will have access to the well at a specified time within the period mentioned in the tender terms. RSD will pump water from the well to the winning lab(s)'s containers or test bottles etc.

The pump outlet tube dimensions can be agreed with RSD. Any specific requirements for the outlet tube must be included in the tender.

Tenders for sub-agreements 1, 2 and 3 must describe:

- The water volume expected to be required for carrying out all tests under the specific sub-agreement, including the water volume to be used for all analyses at an external lab (Eurofins).
- How the water samples will be handled at the location; how the water will be transported to the lab; and how the water will be stored to minimise the loss of the volatile compounds in the water such as benzene and chlorinated substances.
- Any special requirements or specifications related to the supply of groundwater.

If a mobile system with continuous use of pumped-out water is used, the tenderer must provide pumping equipment and operate it during the tests.

The well from which groundwater will be extracted measures 10", is 16 m deep and is equiped with three ø63 mm screens (inside screen diameter: 51.4 mm). Water will be extracted from screen 2, 8-10 m below ground level. The overview map in Figure 1 shows the location of the well. Any mobile system must be located near the well, to be determined by agreement.

RSD will provide power supply for any mobile system and, if relevant, provide a storage tank for water to be treated on site. If the tenderer wants to discharge water into the sewer system, the tenderer is responsible for obtaining the required permit.

Be aware that the tenderer, cf. BoQ item 1.1, has to pay all costs related to any permits required to transport the water across national borders.

Figure 1 *The location, indicating the location of well 114.2567 (BE6), from which test water samples will be taken.*

3 Overall test description for sub-agreements 1 and 2

All four AOP methods (A-D) must follow the below work procedure:

Pre-treatment → Preliminary screening → Final test → Post-treatment using activated carbon.

Below follows, first, an overall description of the procedures that are identical for sub-agreements 1 and 2. The following chapters provide a more detailed description.

Under both sub-agreements, a number of water samples must be sent for analysis by Eurofins in Denmark, with whom the client has a framework agreement. The client consultant (COWI) will fill in analysis requisition forms and provide contact information for Eurofins Danmark for supply of sample packaging.

Tender terms appendix C includes bills of quantities (BoQs) and the basis for payment and measurement (TAG). All main items and sub-items must be filled in. Deviations from the procedure described in the special work descriptions must be included in the tenderer's project description, and the costs must be included in the BoQ items.

3.1 Pre-treatment

The analyses included in section 1.1 show the content of iron and manganese in the groundwater that is to be treated. Iron and manganese must be removed by pre-treating the groundwater that is to be used for the AOP tests.

In this project, we do not want to use traditional aeration for the pre-treatment since the water contains a lot of volatile organic compounds. Instead, a chemical oxidation of iron and manganese must be carried out. Hydrogen peroxide is not permitted for this oxidation.

With that in mind, the pre-treatment is expected to be carried out as chemical oxidation with sodium hypochlorite following by effective filtering. If a different method is used, arguments must be provided in the project description. After the pre-treatment, the residual concentration of iron and manganese in the water must be checked on site (e.g., by means of a simple colorimetric analysis). The pre-treatment will result in the formation of a maximum of 10 mg sludge solid per litre of treated water, if the sum of iron and manganese is 5 mg/l. It will probably be possible to discharge the sludge-containing water to the sewer system. If not, it must be disposed of in another safe manner.

The US has developed a method for chemical oxidation of iron and manganese in groundwater. It takes place in a so-called Greensand filter. The filter is a kind of sand filter: At the top, there is a granulated mineral (glauconite) with a manganese oxide coating. When treated with a chemical oxidant (chlorine or potassium permanganate), the surface catalyses the oxidation of iron and manganese

in the water. The process either occurs by continuously adding some sodium hypochlorite to the feed water, or by regenerating the manganese coating using potassium permanganate when backwashing the filter. It was considered whether the lab tests should use the Greensand filter for pre-treatment of the water. However, we did not consider it necessary to have this be a requirement, but it is assessed that the method may be used as pre-treatment.

In principle, the proposed pre-treatment method involving sodium hypochlorite is the same as treating the water using a Greensand filter.

As mentioned in sections 4.6 and 5.5, water samples after pre-treatment must be taken for analysis by Eurofins.

3.2 Post-treatment using activated carbon

Post-treatment using activated carbon must be investigated for all four AOP tests since the efficiency of carbon treatment may differ from one AOP-method to another AOP-method, depending on what was degraded and destroyed during the AOP process.

All post-treatment tests must be performed by the company carrying out sub-agreement 1 and will not be further described here, rather under sub-agreement 1. Consequently, the company carrying out sub-agreement 2 must provide AOP-treated water for the carbon tests to the company carrying out sub-agreement 1, cf. section 4.5. The carbon tests will reveal which substances are expected to be removed using activated carbon on both untreated and treated water.

As mentioned in sections 4.6 and 5.5, water samples from the post-treatment tests must be sent to Eurofins in Denmark for analysis.

3.3 Reporting

When the tests are completed, a preliminary report must be submitted, containing a description of how the tests were carried out, as well as all analysis results and measurements taken during the tests. Furthermore, the test results must be commented and assessed. Once the Eurofins analysis results are available, they must be incorporated, and a final report must be prepared, which includes and assesses all analysis results, and a conclusion on the findings from the treatment tests must be provided as well as recommendations stating dosages per m^3 water. This is important since the test results form part of the basis for a possible design of a full-scale system.

3.4 Water volumes

The tenderer must describe how much water is required to carry out the different tests and all described analyses for each sub-agreement that the tenderer bids for. The tenderer is also to state how much water is generated during each process (pre-treated water, AOP-treated water, carbon-treated water).

Reference is made to sections 4.6 and 5.5 regarding information of the water volumes required for analyses by Eurofins.

4 Special work descriptions, sub-agreement 1 (methods A-C)

During the AOP tests, the following parameters must be studied:

- Required dosage and concentration of oxidant
- Reaction time/contact time
- UV dose (test C).

For all methods, the work must include a complete pre-treatment followed by preliminary blank tests and screening tests, final AOP test and, finally, post-treatment of the AOP-treated water using activated carbon.

Prior to commencement of the AOP tests, two to three small preliminary carbon treatment tests must be carried out immediately, using some 200 ml of pre-treated groundwater to which is added varying quantities of activated carbon powder (PAC) to determine how much carbon is required for treating the larger water volumes during the tests. TOC must be measured before and after the treatment. These preliminary tests will reveal how much activated carbon should be used for the final post-treatment tests. This is important to determine since a limited volume of AOP-treated water will be available. Also see section 4.5 for further descriptions of the other carbon tests.

The following sections provide more details on the planned tests. The tenderer is able to change test details if the tenderer believes it to be necessary or advantageously. For that reason, several activities are described as recommendations/suggestions. However, during the tests, you should be able to fulfil the criteria listed under purpose, and the tenderer must describe and provide arguments for the chosen procedure.

A total list of analyses to be performed under sub-agreement 1 is included in Tabel 4.

4.1 Pre-treatment

During the pre-treatment, enough water must be treated to ensure plenty of water for carrying out all the planned tests in the three test-series (A, B and C) and for chemical analyses and ecotoxicological tests.

First, the water must be oxidised by adding sodium hypochlorite, whereby iron and manganese precipitate as ferrihydroxide and manganese oxide (MnO_2), unless arguments are provided for using another relevant pre-treatment method. Depending on the iron and manganese concentration of the water, enough sodium hypochlorite must be dosed to achieve a small excess of chlorine of 1-2 mg/l, which must be checked by measuring the residual concentration of free chlorine. The oxidation process is relatively quick and expected to be completed after 30 minutes. To be on the safe side, you must wait 60 minutes before filtering the water.

For filtering, you can use a fine bag filter (1 µm), a fine cartridge filter (1 µm) or a similar effective filter. When filtering, you should to the extent possible avoid stripping organic solvents when air and water come into contact. After the filtering, you must ensure that iron and manganese have been effectively removed. The tenderer must describe how the filtering is planned. The water must be completely clear, and the residual concentration of iron and manganese must be measured using a good photometer method so you know right away that the water can be used for the subsequent test activities.

During the lab tests, it is recommended to remove excess chlorine using sodium bisulphite or sodium thiosulphate. First, you calculate how much reducing agent is needed to reduce the excess of free chlorine. Then, you may use a small sample (e.g., 50 ml) to check how much reducing agent must be added to reduce all free chlorine without detection of a measurable excess of reducing agent (< 1 mg/l reducing agent). You may monitor the process by measuring the ORP, which changes drastically at the time when all chlorine disappears. The result of the small control test is used to calculate how much reducing agent is needed to treat the entire batch of water with residual chlorine. Following treatment of the large batch, the concentration of residual chlorine must be measured (result to be noted and stated in the test report) and it should be less than 0.1 mg/l, for the water to be acceptable to use in subsequent test activities and analyses.

The pre-treated water must then be stored to minimise stripping of volatile components until it shall be used for AOP-test. Right before commencing an AOP test, samples must be taken of the pre-treated water (in total, 3,090 ml for Eurofins) and the samples sent for analysis along with the treated water from the specific AOP test. The same procedure must be followed for all three AOP test series. As such, there will be a start sample for each of series A, B and C.

As previously mentioned, it is important to focus on pre-treating a sufficient volume of water.

The water samples for Eurofins must be transferred to bottles or containers supplied by Eurofins, cf. section 4.6.

4.2 Test of method A: Ozone (test A)

For instance, the ozone system could be constructed as a high column (a pipe with a base), through which water is pumped at a suitable flow. The water flow can be downstream or upstream, whichever is more practical. The water flow and the pipe volume determine the reaction time (retention time) when water and ozone are in contact. Ozone is blown into the bottom of the pipe, distributing through fritted glass or a similar devise. The water flow is adjusted during the test to achieve the desired retention time in the column (10, 20 or 30 minutes). In practice, a retention time of 10-20 minutes is expected as sufficient. The ozone dosage is expected to be in the range of 30 to 100 mg/l, but a more realistic estimate can be provided when the TOC and COD concentrations are known. Another design of the ozone system can also be used, if such is considered better or more suitable for the task at hand.

4.2.1 Blank test and preliminary screening

It is recommended to initially do two blank tests. In one test, pure oxygen is added instead of a mixture of oxygen and ozone. The purpose is to measure the TOC reduction that is caused by stripping volatile components in the water using the test system. In the second blank test, the ozone absorption in treated water with a realistic ozone dosage is studied.

You can, e.g., determine relevant test conditions by starting with a preliminary screening test with a high ozone dosage (e.g., 100 mg/l) and long retention time (e.g., 30 minutes). Then, you gradually reduce the retention time to 20 and 10 minutes. Furthermore, a low ozone dosage (e.g., 30 mg/l) is tested for retention times of 10, 20 and 30 minutes. For each of the six settings, samples are taken for TOC analysis. The ozone dosage and retention time are just indicative and may be changed during the test, if it is better to use other values. Another strategy for studying dosage volumes and retention time may be applied if considered better.

4.2.2 Final tests

During the three final tests, different ozone dosages and retention times must be studied. These cannot be determined until the TOC results from the screening test are known.

Based on the TOC measurements from the screening tests, you can determine the presumed optimum values for ozone dosage and retention time for the first test (optimum dosage and aeration time). Then, a second test must be made, involving a significantly higher ozone dosage and/or retention time, as well as a third test, where a significantly lower ozone dosage and/or retention time is used. In other words, there are three final test series:

Test A1: Optimum ozone dosage and retention time

Test A2: Higher ozone dosage and/or retention time than in test 1

Test A3: Lower ozone dosage and/or retention time than in test 1.

During the final tests, enough treated water must be generated to cover the subsequent chemical analyses at Eurofins, internal documentation tests and ecotoxicological tests as well as water for testing post-treatment with with activated carbon.

After each of the three final treatment tests, water samples must be extracted and sent to Eurofins for analysis, cf. section 4.6.

4.3 Test of method B: Ozone + H_2O_2 (test B)

This test uses the same test setup as test A, but hydrogen peroxide is dosed before the water is pumped through the ozone column, where ozone is dosed. It may be expected that this process will provide oxidation of some difficult degradable substances which cannot be oxidised completely by pure ozone.

4.3.1 Blank test and preliminary screening

It is recommended that you, like in test A, do a blank test first where you dose a realistic volume of ozone and hydrogen peroxide in treated water. By measuring the hydrogen peroxide concentration at the outlet of the reactor, you can calculate the reduction of hydrogen peroxide in the reactor and this is equal to the generation of hydroxyl radicals in the system. A reduction in the concentration of hydrogen peroxides is caused by the formation of hydroxyl radicals.

The experiences gained from test A are expected to be useful, regarding ozone dosage and retention time in the ozone reactor, allowing you to limit the different settings during the screening test. Details on the screening test are not determined until the ozone test has been carried out. The results from the screening test are used to determine the final retention times and dosages for the three main tests in this series.

4.3.2 Final tests

The main source of oxidation in test B is ozone, and the addition of hydrogen peroxide aims to catalyse the formation of hydroxyl radicals from ozone. The hydrogen peroxide-ozone ratio must be determined during the test, and the decomposition process, and thereby the reaction rate, must be studied. In previous lab tests using water from the Danish megasite Kærgård Plantage (2005), the mole ratio between ozone and hydrogen peroxide was approx. 0.7. It would likely be prudent to use this ratio as starting point, but the optimum ratio should be studied in more detail during the tests. It should be noted that more hydrogen peroxide can reduce the formation of bromate from bromide. If relatively more hydrogen peroxide is dosed, that may, however, inhibit the formation of hydroxyl radicals.

During the three final tests, different dosages of ozone and hydrogen peroxide must be studied as well as retention times. These cannot be determined until the TOC results from the screening test are known. Based on TOC measurements from the screening tests, you can determine the presumed optimum values for dosage and retention time for the first test. Then, a second test must be prepared, involving a significantly higher ozone dosage and/or retention time, as well as a third test, which involves a significantly lower ozone dosage and/or retention time. That presumes that the same optimum ozone-hydrogen peroxide ratio is applied in all final tests. That leads to three final tests:

Test B1: Optimum ozone dosage and hydrogen peroxide as well as optimum retention time

Test B2: Higher dosage and/or retention time than in test 1

Test B3: Lower dosage and/or retention time than in test 1.

After each of the three final treatment tests, water samples must be extracted and sent to Eurofins for analysis, cf. section 4.6.

During the final tests, enough treated water must be generated to cover the subsequent chemical analyses at Eurofins, internal documentation tests and

ecotoxicological tests as well as water for post-treatment tests with activated carbon.

4.4 Test of method C: H_2O_2 + UV (test C)

Tests involving H_2O_2 and UV can be carried out in a number of ways, all of which lead to the desired results.

A commonly used test setup consists of a container with pre-treated water and a circulation pump for pumping the water from the container through the module with UV-lamp and back to the container. To start with, a suitable volume of hydrogen peroxide is dosed into the total water volume. The hydrogen peroxide is consumed as oxidation occurs and hydroxyl radicals are created. Pumping through the module with the UV light takes place at a relatively fast rate, meaning that the water volume in the container passes by the UV light several times an hour. You can choose a low-pressure UV-lamp or a medium-pressure UV-lamp. The UV effect must be adapted to the water volume to be treated, allowing you to operate with realistic reaction times (typically between 5 and 30 minutes).

4.4.1 Blank test and preliminary screening

Initially, a blank test must be carried out involving pre-treated groundwater with hydrogen peroxide, which is passed through the test system. That allows you to measure how fast the concentration of hydrogen peroxide is reduced under the influence of UV-light. A fast reduction of hydrogen peroxide means good, quick formation of hydroxyl radicals. Based on the results from the screening test and blank test, the test conditions for the three final tests must be determined, since you are able to change both the dosage of hydrogen peroxide and reaction time.

As is the case for the ozone test (test A), it is also recommended to carry out a preliminary screening test with contaminated groundwater with two different dosages of hydrogen peroxide. For each dosage, you expect circulation to take 30 minutes, and samples are taken after 10, 20 and 30 minutes. At the same time, the concentration of hydrogen peroxide in the water container is measured, which provides a clear image of the consumption of hydrogen peroxide. In other words, two screening tests are made, which results in six tests, which must subsequently be analysed for TOC.

4.4.2 Final tests

During the three final tests, different dosages of hydrogen peroxide and different reaction times must be studied. These must be determined when the results from the screening test and blank test are available.

Based on TOC measurements from the screening tests, you can determine the presumed optimum values for dosage and reaction time for the first test. Then, a second test must be made, involving a significantly higher dosage and/or

reaction time, as well as a third test, which involves a significantly lower dosage and/or reaction time. That leads to three final tests:

Test C1: Optimum hydrogen peroxide dosage as well as optimum reaction time

Test C2: Higher dosage and/or reaction time than in test 1

Test C3: Lower dosage and/or reaction time than in test 1.

During the final tests, enough treated water must be generated to cover the subsequent chemical analyses at Eurofins, internal documentation tests and eco-toxicological tests as well as water for post-treatment tests with activated carbon.

Following each of the three final treatment tests, water samples must be taken and sent to Eurofins for analysis, cf. section 4.6.

4.5 Post-treatment involving activated carbon

For each test series (A, B, C and D), carbon tests must be carried out for each of the three tested dosages (low, realistic and high). The treatment tests must be carried out using activated carbon powder (PAC).

The company carrying out sub-agreement 2 must send AOP-treated water to the company carrying out sub-agreement 1 for carbon treatment test using water from test series D (test with catalytic H_2O_2). This way, it is ensured that completely identical tests with activated carbon are carried out for all four AOP methods. Therefore, it is crucial that the tender states how much water is expected to be supplied by the company carrying out sub-agreement 2.

The total of 13 water samples (untreated/unprocessed water + three samples from each of the four test series) subjected to treatment with activated carbon must be sent to Eurofins in Denmark for analysis.

Tests with activated carbon must be carried out as batch test on a water sample where the excess oxidant has been removed using thiosulphate or bisulphite. A suitable volume of water sample (to be determined based on what analyses and tests are to be carried out on the treated water) must be treated using activated carbon powder. The water sample with PAC is stirred, until adsorption equilibrium has been achieved (at least two hours). For batch test, activated carbon powder (PAC) must be used, not granulated activated carbon (GAC), which is normally used in a carbon filter. The test must be carried out in a sealed bottle with a magnetic mixer.

The carbon tests will reveal which substances are removed by activated carbon in untreated as well as AOP-treated water. However, you should be aware that fresh carbon may remove quite a lot of organic compounds, but when the carbon reaches saturation, most often, substances with a high affinity to carbon are still absorbed whereas substances with a low affinity are no longer absorbed that well. When a carbon filter is saturated, you may find that substances that are already bound to the carbon are released from the carbon, because of their low

affinity to carbon, and other substances with a high affinity are absorbed instead of the released compounds.

4.5.1 Blank test and preliminary screening

Before commencing the final carbon treatment tests, it is recommended to make a blank test and a few screening tests in small scale (200 ml water samples) to determine the required carbon addition. These tests must be made using pre-treated groundwater. Activated carbon powder, type F400 from Chemviron Carbon or similar carbon quality, may be used.

As a rule of thumb, you can expect activated carbon to absorb organic matter corresponding to 20 per cent of its own weight. Assuming that the contaminated groundwater contains approx. 5 mg/l organic matter (fairly consistent with the analyses in section 1.1), that corresponds to a carbon consumption of 25 mg carbon per litre of water or 5 mg per 200 ml untreated groundwater. For the screening tests, considerably more carbon is desired to achieve as low residual concentration of organic matter as possible. Therefore, dosages of 0, 50, 150 and 500 mg carbon per 200 ml untreated groundwater are suggested as well as stirring for two hours in a sealed glass bottle. Afterwards, the water must be decanted and filtered to remove PAC. TOC must be measured before and after carbon tests for all four samples. The test without carbon dosage will reveal how much organic matter is lost in the test. The three tests involving activated carbon will reveal how much carbon must be added to achieve the highest possible reduction in organic matter.

4.5.2 Final tests

For the final carbon tests, enough water must be treated (probably at least 10 litres per carbon treatment test) to ensure sufficient water for the chemical analyses at Eurofins (3,090 ml) and the ecotoxicological tests (approx. 2,500 ml). These aspects must be clarified in detail with the parties involved before starting AOP tests and carbon treatment tests.

The tests must be carried out in a sealed glass bottle with a mixer to minimise evaporation of volatile compounds. The mixing must be effective and last for at least two hours to ensure optimum absorption of organic matter. Any excess oxidant must be removed immediately after the end of the AOP test. The carbon dosage has to be determined based on the screening test, since you can expect the treated water to contain less organic matter than the untreated water used for the screening test.

13 carbon treatment tests must be prepared as listed below:

1. Untreated groundwater
2. Three samples from treatment involving ozone (test A)
3. Three samples from treatment involving ozone + H_2O_2 (test B)
4. Three samples from treatment involving UV + H_2O_2 (test C)
5. Three samples from treatment involving H_2O_2 + fixed-bed catalyst (test D).

Water for carbon treatment from test D must be provided by the company carrying out sub-agreement 2.

The best sample from each test A-D is send to the laboratory performing ecotoxicological tests (4 samples).

4.6 Chemical analyses, sub-agreement 1

Tabel 4 lists the tests to be carried out under sub-agreement 1 and related analyses. One x per analysis is indicated.

The analyses under packages no. 5-9 will be carried out by Eurofins in Denmark, cf. Table 5, which provides an exhaustive list of analyses.

Table 4 Test matrix for pre-treatment, post-treatment and AOP tests (A-C).

Test	Before adding reduction agent			Analysis of untreated and treated water							
	Ozon, mg/l	H2O2, mg/l	Cl2, mg/l	TOC	COD	Tot-N	Br + BrO3	Metal	Inorganic package	VOC + TPH, BTEXN *	Grindsted phar-ma package
Analysis package no.	1	1	1	2	3	4	5	6	7	8	9
Sample volume, ml	10	10	10	30	10	50	160	100	630	1200	1000
Pre-treatement of raweater											
Rawwater before treatment				x	x	x	x	x	x	x	x
During test			xxx	x							
After pre-treatment				xxx	xxx	xxx	x	x	xxx	xxx	xxx
PAC, 4 screening tests				xxxx							
PAC, final test				x				x		x	x
A: Ozone											
Screening + blank test	x			xxxxxx							
Test 1-O3 dose1- Optimum	x			x	x	x	x	x	x	x	x
Test 2-O3 dose2-High	x			x	x		x		x	x	x
Test 3-O3 dose3-Low	x			x	x		x		x	x	x
3 PAC tests	x			xxx				x		xxx	xxx
B: H2O2 + Ozone											
Screening + blank test	x	x		xxxxxx							
Test 1-O3/H2O2-Optimum	x	x		x	x		x		x	x	x
Test 2-O3/H2O2-High	x	x		x	x		x		x	x	x
Test 3-O3/H2O2-Low	x	x		x	x		x		x	x	x
3 PAC tests	x	x		xxx						xxx	xxx
C: H2O2 + UV											
Screening + blank test		x		xxxxxx							
Test 1-H2O2-Optimum		x		x	x				x	x	x
Test 2-H2O2-High		x		x	x				x	x	x
Test 3-H2O2-Low		x		x	x				x	x	x
3 PAC tests		x		xxx						xxx	xxx
Total number of analyses	10	10	3	46	13	5	8	5	11	23	23

Table 5 provides a comprehensive list of chemical analyses as well as required test volume. The test volumes for internal analyses carried out by the tenderer are estimates, whereas the test volumes for Eurofins are requirements.

The number of internal analyses may change compared to the suggested number stated in the table, if considered necessary or advantageously.

Prices of analyses performed by Eurofins should not be included in the tender since they will be paid for directly by RSD. If the tenderer wants additional analyses from Eurofins than what is proposed in the table, this must be described in

the tender. Please note that the analysis time for Grindstedværket substances is typical one month.

Table 5 Detailed list of analyses.

Package no.	Parameters	ml sample	Laboratorium	Number	Note
1	pH, ORP, conductivity, O3, H2O2, Cl2	50	Internal		During test
2	TOC	30	Internal	46	Test kit photometer
3	COD	10	Internal	13	Test kit photometer
4	total-N	50	Internal	5	Test kit photometer
5	Br + BrO3	160	Eurofins	8	Expensive special analysis
6	As, Pb, Cd, Cr, Cu, Zn	100	Eurofins	5	
7	pH, conductivity, NVOC, Ca, Mg, Na, K, NH4, Fe, Mn, HCO3, Cl-, SO4, NO3, NO2, total-P, F, Ni	630	Eurofins	11	Package (reduced): Main parameters for drinking water control
8	Chlorinated solvents + degradation products + BTEXN + CH	1200	Eurofins	23	
9	Grindstedærket, package A	1000	Eurofins	23	
	Eurofins total	3090	Eurofins		

Package 1 includes typical parameters, which must be measured several times during the AOP tests. The parameters can be measured using transportable equipment. Some of the parameters may even be measured continuously during the tests if the lab is able to do it, but this is not a requirement. Frequent sporadic measurements will be acceptable.

Package 2 (TOC) is a very useful parameter for assessing the content of organic matter in the water samples, but a continuous measurement is not a requirement.

Packages 3 and 4 (COD and total-N) could be useful parameters to know regarding untreated groundwater and a few samples of treated water.

Package 5 (bromide) is only relevant to measure in tests involving ozone, since ozone transforms bromide into bromate, which is unwanted in the treated water. Bromate is only relevant if there is a relatively high level of bromide in the groundwater.

Package 6 (As, Pb, Cd, Cr, Cu and Zn) is probably not an issue with the specific groundwater, but to get a complete picture, these heavy metals must be measured in untreated water and in two selected samples of treated water. In this way, you get a good idea of the level of these substances before and after treatment. In principle, these heavy metals are not removed during the planned treatment tests, but you may obtain removal of some heavy metals along with iron and manganese, which will be removed through filtering in the pre-treatment process.

Package 7 includes inorganic standard parameters for groundwater/drinking water. It covers a reduced programme compared to a standard well control analysis. These parameters provide a good, overall view of the composition of the

water, and allow you to monitor any changes to these parameters during the treatment.

Package 8 (solvents etc.) covers chlorinated solvents and degradation products from the solvents as well as BTEX and hydrocarbons. This analysis package includes, e.g., cis 1,2-DCE, vinyl chloride and benzene, which are the three key organic contamination components in the contaminated groundwater. Removing these three substances is a vital success criterion for the treatment tests.

Package 9 (Grindstedværket substances, package A) covers 35 pharma substances, mainly barbiturates and sulpha compounds. Removing the Grindstedværket substances is also a vital success criterion for the treatment tests.

4.6.1 Sample preservation

Samples from the tests must be sent to Eurofins in Denmark for chemical analysis. It is important that these samples are stored in the recommended bottles and with the prescribed preservation method. Furthermore, the samples must be stored and transported correctly to avoid loss of volatile components. Packaging and bottles for samples to be analysed by Eurofins can be ordered from Eurofins. Table 6 lists the bottles and preservation methods that must be used.

Water samples to be sent to Eurofins for analysis must be stored in a refrigerator at 5 °C until pickup, and they must be transported in thermobags in such manner to prevent loss of volatile components during transport.

As regards preservation and storage of samples for internal measurements and analysis, the preservation method and packaging should be considered as suggestions, but other correct methods may be used. However, it is stressed that you must avoid any excess of reducing agent in samples where COD is analysed, since reducing agents contribute positively to COD. That is especially critical in these samples that have a relatively low concentration of COD.

Table 6 List of packaging and preservation methods for water samples.

Package no.	Parameters	ml sample	Laboratorium	Preservation	Packaging
1	pH, ORP, conductivity, O3, H2O2, Cl2	50	Internal		
2	TOC	30	Internal	Thiosulfat	Glass or plastic
3	COD	10	Internal	Terminox Ultra	Glass or plastic
4	total-N	50	Internal		Glass or plastic
5	Br + BrO3	160	Eurofins	Aftales	2 pc of 80 ml bottles
6	As, Pb, Cd, Cr, Cu, Zn	100	Eurofins	Syre	100 ml plastic bottle
7	pH, conductivity, NVOC, Ca, Mg, Na, K, NH4, Fe, Mn, HCO3, Cl-, SO4, NO3, NO2, total-P, F, Ni	630	Eurofins	No	500 ml bottle with red cap 100 ml bottle with black cap 30 ml plastic tube with acid
8	Chlorinated solvents + degradation products + BTEXN + CH	1200	Eurofins	Thiosulfat for removal of oxidising agents	1000 ml glass bottle, black cap 1 set purge tubes
9	Grindstedværket package A	1000	Eurofins		1000 ml glass bottle, black cap
	Eurofins total	3090	Eurofins		

5 Special work descriptions, sub-agreement 2 (test D)

This chapter describes test D in more details. The tenderer is able to change test details if the tenderer believes it to be necessary or advantageously. For that reason, several activities are described as recommendations. However, during the tests, you should be able to fulfil the criteria listed under purpose, and the tenderer must describe and provide arguments for their choice of procedure.

5.1 Preliminary considerations

The test system can be a small lab system or a mobile pilot plant that can perform the tests on site using pumped-out water from the selected well at the Grindsted location.

Several different types of systems may be capable of performing catalytic oxidation using a fixed-bed catalyst. For instance, it has been documented that a Dutch system can destroy pesticides in drainage water from horticulture to the same extent as other AOP methods based on ozone and UV + hydrogen peroxide. So says a Dutch approval scheme for treatment technologies that remove pesticides from water prior to discharge.

We are aware that literature describes other catalytic methods that use coated activated carbon as a catalyst, possibly combined with iron oxide. These methods may also be used in this project.

The Dutch system is a two-stage system that works as follows:

1 Stage 1 is a ceramic filter coated with a negatively charged surface. It catches small positive particles, leaving the water completely transparent once it passes the filter. The filter is backwashed when it has absorbed a sufficient amount of particles.

2 The filtered water from the first filter is led to the second filter, which is a ceramic filter material coated with a catalytic surface that promotes the formation of hydroxyl radicals based on hydrogen peroxide.

A surplus of hydrogen peroxide must be dosed to achieve the best possible oxidation. The hydrogen peroxide dosage can be estimated in advance when TOC and/or COD in the raw water is known. The Dutch system comes as both a fixed mounted system and a mobile system.

5.2 Pre-treatment

Pre-treatment must be carried out as described in section 4.1, the only difference being that you must pre-treat as much water as necessary to carry out all planned tests in sub-agreement 2. Pre-treatment may be carried out using a mobile system.

5.3 Blank test and preliminary screening test

Initially, a blank test must be carried out where raw water (pre-treated unless pre-treatment is not necessary in the specific system) is treated in the system without the addition of hydrogen peroxide. The purpose is to measure the TOC reduction that occurs by stripping volatile components in the water using the specific test system.

Based on TOC and/or COD in the untreated water, a suitable dosage of hydrogen peroxide is estimated to ensure enough oxidant to destroy all organic matter.

If deemed necessary, a few exploratory tests may be carried out. It will probably be relevant to study two different dosages of hydrogen peroxide as well as two to three different reaction times (retention times). The exploratory tests aim to help determine the optimal dosage and reaction time.

The subsequent screening tests involve treating raw water during a short test where the hydrogen peroxide concentration and water flow are varied to test two to three different concentrations of hydrogen peroxide and two to three different flows. The treated water from each screening test is analysed for TOC. Comparing TOC in the treated water with TOC in the raw water allows you to calculate the treatment effect and determine the optimum operational data to be used for the final test. Hydrogen peroxide values and flow values are determined by the tenderer based on their knowledge of the raw water composition and the test system capacity.

The preliminary screening tests treat a relatively small volume of water. Tests of treated water are collected and excess of oxidant is removed, after which all samples are analysed for TOC, since this parameter can quickly be analysed on site. That provides a good picture of how much organic matter has been destroyed. When the result of the exploratory tests is in, the details regarding dosage and reaction time can be determined for the three 'real' tests to be carried out using method D.

5.4 Final tests

During the three final tests, different dosages of hydrogen peroxide and flows through the system must be studied. The values used for the final tests cannot be determined until the TOC results from the screening test are available. Based on TOC measurements from the screening tests, you can determine the presumed optimum values for flow and dosage of hydrogen peroxide. After the expected optimum test, a second test must be made, involving a significantly higher dosage and/or longer retention time (lower flow), as well as a third test, which involves a significantly lower dosage and/or shorter retention time (higher flow). In other words, there are three final tests:

Test 1: Optimum hydrogen peroxide dosage as well as optimum retention time (flow)

Test 2: Higher dosage and/or longer retention time (lower flow) than in test 1

Test 3: Lower dosage and/or shorter retention time (higher flow) than in test 1.

During the final tests, enough treated water must be generated to ensure plenty of water for carrying out all the subsequent chemical analyses at Eurofins in Denmark, internal documentation tests and ecotoxicological tests, as well as enough water for post-treatment tests with activated carbon.

The retention time is determined based on the results from the screening time.

During each of the three final tests, enough samples of treated water must be extracted to carry out a complete analysis programme, cf. section 5.5 (at least 3090 ml), and to carry out ecotoxicological tests (at least 2500 ml) and carbon treatment tests (at least10 L) pr. sample. A full chemical analysis package must be carried out for all three levels after catalytic oxidation and post-treatment with acivated carbon (in total, six samples). Furthermore, one ecotoxicological test must be carried out on the best sample from AOP and carbon treatment. The best sample is the one where you do not achieve any better treatment effect by increasing the dosage of oxidant and increasing the reaction time. The chemical analyses must be carried out at Eurofins; carbon treatment tests must be carried out by the company that carries out sub-agreement 1; and the ecotoxicological tests must be carried out by the company carrying out sub-agreement 3.

During the tests, you must regularly measure one or several components for detailing the treatment process. For instance, TOC, COD, conductivity, ORP, pH, HCO_3- and H_2O_2 and possibly also SO_4, NO_3 and PO_4. Some of these measurements may be used for finetuning operational data for the process. TOC and COD indicate, e.g., how much organic matter is left in the water after treatment. That offers immediate insight into the achieved result, which is important since the analysis time for Grindstedværket substances is one month, meaning that results on these substances will not be available while these tests are completed.

5.5 Chemical analyses, sub-agreement 2

Table 7 provides a list of the tests to be carried out as well as the related analyses. One x per analysis is indicated.
It is uncertain whether the raw water sample used in the AOP tests under sub-agreement 1 can be used or whether a special sample must be taken for these tests. If the tests are to be carried out in Grindsted using a mobile plant that consumes a lot of water (2-5 m³), it is hardly likely that you can use the raw water sample that was used for the other AOP tests (A, B and C).

Table 7: Test matrix for test involving catalytic oxidation using hydrogen peroxide (test series D)

Test	During test		Analysis of treated and untreated water							
	H2O2, mg/l	Cl2, mg/l	TOC	COD	Tot-N	Br + BrO3	Metals	Inorganic package	VOC + TPH, BTEXN *	Grindsted pharma packet
Package no.	1	1	2	3	4	5	6	7	8	9
Sampling volume, ml	10	10	30	10	50	160	100	630	1200	1000
Pre-treatment										
Before pre-treatment			x	x	x		x	x	x	x
During pre-treatment		xxx	x							
After pre-treatment			x	x				x	x	x
D: H2O2 + fixed-bed catalyst										
Screening + blank test	x		xxxxxx							
Test 1-H2O2 Optimum	x		x	x				x	x	x
Test 2-H2O2 High	x		x	x				x	x	x
Test 3-H2O2 Low	x		x	x				x	x	x
3 PAC tests	x		xxx						xxx	xxx
Total number of analyses	5	3	15	5	1	0	1	5	8	8

The tenderer must handle sampling, storage and transport of water samples for carbon tests, for chemical analysis at Eurofins and for ecotoxicological test. The different sample volumes must be determined in dialogue with the sample recipients.

Table 8 includes an exhaustive list of analyses. The number of internal analyses may change compared to the number suggested in the table, if deemed necessary or expedient.

The sample volume for internal analyses to be carried out by the tenderer is an estimate whereas test volumes for Eurofins are a requirement.

Prices of analyses with Eurofins should not be included in the tender since they will be paid for directly by RSD. If the tenderer wants additional analyses from Eurofins than what is proposed in the table, this must be described in the tender. Please note that the analysis time for Grindstedværket substances is one month.

Table 8: Detailed list of analyses.

Package no	Parameters	ml sample	Laboratorium	Number	Note
1	pH, ORP, conductivity, O3, H2O2, Cl2	50	Internal		During test
2	TOC	30	Internal	15	Test kit photometer
3	COD	10	Internal	5	Test kit photometer
4	total-N	50	Internal	1	Test kit photometer
5	Br + BrO3	160	Eurofins	0	Expensive specia lanalysis
6	As, Pb, Cd, Cr, Cu, Zn	100	Eurofins	1	
7	pH, conductivity, NVOC, Ca, Mg, Na, K, NH4, Fe, Mn, HCO3, Cl-, SO4, NO3, NO2, total-P, F, Ni	630	Eurofins	5	Package (reduced): Main parameters for drinking water control
8	Chlorinated solvents + degradation products + BTEXN + CH	1200	Eurofins	8	
9	Grindstedværket package A	1000	Eurofins	8	
	Eurofins total	3090	Eurofins		

Package 1 includes typical parameters, which must be measured several times during the AOP tests. The parameters can be measured using movable equipment. Some of the parameters may even be measured continuously during the tests if the lab is able to, but this is not a requirement. Frequent sporadic measurements will be acceptable.

Package 2 (TOC) is a very useful parameter for assessing the content of organic matter in the water samples, but a continuous measurement is not a requirement.

Packages 3 and 4 (COD and total-N) could be useful parameters to know regarding untreated groundwater and a few samples of treated water.

Package 7 includes inorganic standard parameters for groundwater/drinking water. It covers a reduced programme compared to a standard well control analysis. These parameters provide a good, overall view of the composition of the water, and allow you to monitor any changes to these parameters during the treatment.

Package 8 (solvents etc.) covers chlorinated solvents and degradation products from the solvents as well as BTEX and hydrocarbons. This analysis package includes, e.g., cis 1,2-DCE, vinyl chloride and benzene, which are the three key organic contamination components in the contaminated groundwater. Removing these three substances is a vital success criterion for the treatment tests.

Package 9 (Grindstedværket substances, package A) covers 35 pharma substances, mainly barbiturates and sulpha compounds. Removing the Grindstedværket substances is also a vital success criterion for the treatment tests.

5.5.1 Sample preservation

Many samples from the treatment tests must be sent to Eurofins in Denmark for chemical analysis. It is important that these samples are stored in the recommended bottles and with the prescribed preservation method, and that they are stored and transported correctly. Bottles and packaging can be ordered from Eurofins, free of charge. Table 9 lists the bottles and preservation methods that must be used. Furthermore, the samples must be stored in a refrigerator at 5 °C until pickup, and they must be transported in thermobags.

As regards preservation and storage of samples that must be measured/analysed internally, the preservation method and packaging should be considered suggestions, and other correct methods may be used. However, it is stressed that you must avoid any excess of reducing agent in samples where COD is analysed, since reducing agents contribute positively to COD. That is especially critical in these samples that have a relatively low concentration of COD.

Table 9: List of packaging and preservation methods for water samples.

Package no.	Parameters	ml sample	Laboratorium	Preservation	Packaging
1	pH, ORP, conductivity, O3, H2O2, Cl2	50	Internal		
2	TOC	30	Internal	Thiosulfat	Glass or plastic
3	COD	10	Internal	Terminox Ultra	Glass or plastic
4	total-N	50	Internal		Glass or plastic
5	Br + BrO3	160	Eurofins	Aftales	2 pc of 80 ml bottles
6	As, Pb, Cd, Cr, Cu, Zn	100	Eurofins	Syre	100 ml plastic bottle
7	pH, conductivity, NVOC, Ca, Mg, Na, K, NH4, Fe, Mn, HCO3, Cl-, SO4, NO3, NO2, total-P, F, Ni	630	Eurofins	No	500 ml bottle with red cap 100 ml bottle with black cap 30 ml plastic tube with acid
8	Chlorinated solvents + degradation products + BTEXN + CH	1200	Eurofins	Thiosulfat for removal of oxidising agents	1000 ml glass bottle, black cap 1 set purge tubes
9	Grindstedværket package A	1000	Eurofins		1000 ml glass bottle, black cap
	Eurofins total	3090	Eurofins		

6 Test descriptions, sub-agreement 3, ecotoxicological tests

Ecotoxicological tests must be carried out with untreated, contaminated groundwater (whole effluent testing) and with treated groundwater from each of the four AOP methods with subsequent carbon treatment. In total, five different tests. The ecotoxicological tests include test of two groups of freshwater organisms: algae and daphnia.

Ecotoxicological tests must be carried out on the following five samples:

- Contaminated, untreated raw water
  (to be delivered by the lab carrying out sub-agreement 1)
- Treated water (after carbon treatment) from the best test from test A
  (to be delivered by the lab carrying out sub-agreement 1)
- Treated water (after carbon treatment) from the best test from test B
  (to be delivered by the lab carrying out sub-agreement 1)
- Treated water (after carbon treatment) from the best test from test C
  (to be delivered by the lab carrying out sub-agreement 1)
- Treated water (after carbon treatment) from the best test from test D
  (to be delivered by the lab carrying out sub-agreement 2)

Ecotoxicological tests on freshwater algae must be carried out in accordance with OECD guideline method no. 201 (Rev. 2011), "Freshwater Alga and Cyanobacteria, Growth Inhibition Test", using one of the recommended species of green algae, e.g. *Pseudokirchneriella subcapitata.* The definitive test must be carried out with a minimum of five (5) concentrations that cover a suitable interval, cf. the guideline.

The test report must include a description of test conditions and parameters as well as documentation of the test system producing valid results, and both must comply with the requirements of OECD Guideline (201). Growth rate-based E_rC_{50} and NOEC must be reported.

Ecotoxicological tests of daphnia must be carried out according to OECD guideline method no. 202 (2004), "*Daphnia* sp., Acute Immobilisation Test", which prefers using *Daphnia magna* as test organism. The test report must include a description of test conditions and parameters as well as documentation of the test system producing valid results, and both must comply with the requirements of OECD Guideline (202). Growth rate-based E_rC_{50} and NOEC must be reported. The definitive test must be carried out with a minimum of five (5) concentrations that cover a suitable interval, cf. the guideline.

It must be expected that treatment tests A-D can supply approx. 2.5 litres of water for the ecotoxicological tests for each method/test. The tenderer's tender must state how much water is required to carry out the tests.

Appendix B Basis for payment and settlement (TAG)

B.1 Basis for payment and settlement, sub-agreement 1 (TAG1)

Present TAG1 covers all work regarding testing of three selected AOP methods for treating contaminated groundwater from the Grindstedværket factory site. Furthermore, the work also includes pick-up of water samples in Grindsted, pre-treatment of water prior to AOP as well as post-treatment of water from AOP treatment using activated carbon. Finally, it is expected that at least one Skype-meeting regarding the work will be held during the project. The work is described in more detail in SAB and BoQ1, which further specify what the test activities include.

As stated in SAB, the tenderer is free to suggest other test procedures than the suggested test procedures, as long as the criteria listed under project purpose are met. Whether the tenderer chooses to do so or not, all main items and sub-items in the bill of quantities must be filled in. Deviations must be included in the tenderer's project description, and the costs must be included in the bill of quantities items.

B.1.1 Bill of quantities items, sub-agreement 1

Numbering refers to the numbers in BoQ1.

1 Pick-up of water samples

1.1 Pick-up, handling and transport

The item must include all costs, including staff, materials, proper storage, safety equipment, any import licenses and transport to the lab in connection with pick-up and handling of groundwater supplied at the described address in Grindsted, Denmark.

2 Pre-treatment tests

2.1 Small-scale test involving chlorine dosing

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described preliminary dosage test.

2.2 Large-scale oxidation test

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described oxidation test.

2.3 Removal of excess chlorine

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described tests for removal of chlorine.

2.4 Decanting and filtering

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described decanting and filtering tests.

2.5 Reporting

The item must include all costs of the test report, which must describe test procedure as well as all results, assessments and conclusions.

3 AOP tests using ozone (A)

3.1 TOC measurements

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described TOC measurements.

3.2 Blank and screening tests

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described blank and screening tests.

3.3 Optimum dosage and reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described determination of dosage and duration of reaction time.

3.4 Over-dosage and long reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described over-dosage tests with long reaction time.

3.5 Under-dosage and short reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described under-dosage tests with short reaction time.

3.6 Sample preservation, storage and transport

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to preserve and store water samples from tests and send the samples to Eurofins and to the winner of sub-agreement 3 for ecotoxicological test. Any import licenses and transport must also be included.

3.7 Reporting

The item must include all costs of preparing a preliminary report including test description and test data as well as results of measurements during the tests.

The item must also include all costs of preparing the final report including assessments and conclusions as well as all analysis results from Eurofins.

4 AOP tests using ozone and H_2O_2 (B)

4.1 Blank and screening tests

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described blank and screening tests.

4.2 Optimum dosage and reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described test with optimum dosage and reaction time.

4.3 Over-dosage and long reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described over-dosage test with long reaction time.

4.4 Under-dosage and short reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described under-dosage tests with short reaction time.

4.5 Sample preservation, storage and transport

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to preserve and store water samples from tests and send the samples to Eurofins and to ecotoxicological tests. Any import licenses and transport must also be included.

4.6 Reporting

The item must include all costs of preparing a preliminary report including test description and test data as well as results of measurements during the tests. The item must also include all costs of preparing the final report including assessments and conclusions as well as all analysis results from Eurofins.

5 AOP tests using UV and H_2O_2 (C)

5.1 Blank and screening tests

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described blank and screening tests.

5.2 Optimum dosage and reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described test with optimum dosage and reaction time.

5.3 Over-dosage and long reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described over-dosage tests with long reaction time.

5.4 Under-dosage and short reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described under-dosage tests with short reaction time.

5.5 Sample preservation, storage and transport

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to preserve and store water samples from tests and send the samples to Eurofins and to ecotoxicological tests. Any import licenses and transport must also be included.

5.6 Reporting

The item must include all costs of preparing a preliminary report including test description and test data as well as results of measurements during the tests. The item must also include all costs of preparing the final report including assessments and conclusions as well as all analysis results from Eurofins.

6 Post-treatment with activated carbon

6.1 TOC measurements of untreated water

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described TOC measurements.

6.2 Screening tests with activated carbon

The item must include all costs, including staff, machinery, chemicals, carbon, analyses and equipment needed to carry out the described screening tests.

6.3 Complete tests with untreated water

The item must include all costs, including staff, machinery, chemicals, carbon, analyses and equipment needed to carry out the described tests on untreated water.

6.4 Tests of water from treatment with ozone

The item must include all costs, including staff, machinery, chemicals, carbon, analyses and equipment needed to carry out the three described treatment tests.

6.5 Tests of water from treatment with ozone + H2O2

The item must include all costs, including staff, machinery, chemicals, carbon, analyses and equipment needed to carry out the three described treatment tests.

6.6 Tests of water from treatment with UV + H2O2

The item must include all costs, including staff, machinery, chemicals, carbon analyses and equipment needed to carry out the three described treatment tests.

6.7 Tests of water from treatment with H2O2 + catalyst

The item must include all costs, including staff, machinery, chemicals, carbon, analyses and equipment needed to carry out the three described treatment tests.

6.8 Sample preservation, storage and transport

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to preserve and store water samples from tests and send the samples to Eurofins and to ecotoxicological tests. Any import licenses and transport must also be included.

6.9 Reporting

The item must include all costs of preparing a preliminary report including test description and test data as well as results of measurements during the tests. The item must also include all costs of preparing the final report including assessments and conclusions as well as all analysis results from Eurofins.

7 General

7.1 Project management

The tenderer is to price hours and resources for general project management beyond the test work.

7.2 Meetings

It is expected that Skype meetings will be held during the project between the region, COWI and the tenderer. The tenderer is to state a price per meeting with a duration of two hours maximum. The price must include preparation and participation.

B.2 Basis for payment and settlement, sub-agreement 2 (TAG2)

Present TAG2 covers all work regarding testing of oxidation method based on hydrogen peroxide and fixed-bed catalyst for treatment of contaminated groundwater from the Grindstedværket factory site. Furthermore, the work also includes pick-up of water samples in Grindsted and pre-treatment of water prior to AOP. After-treatment of treated water with activated carbon will not be a part of sub-agreement 2 but will be prepared by the company winning sub-agreement 1. The AOP-tests may be carried out using a mobile plant on site. Finally, it is expected that some information meetings regarding the work will be held during the project. The work is described in more detail in SAB and BoQ2, which further specify what the test activities involve.

As stated in SAB, the tenderer is free to suggest other test procedures than the suggested test procedures, as long as the criteria listed under project purpose are met. Whether the tenderer chooses to do so or not, all main items and sub-items in the bill of quantities must be filled in. Deviations must be included in the tenderer's project description, and the costs must be included in the bill of quantities items.

B.2.1 Bill of quantities items, sub-agreement 2 (TAG2)

Numbering refers to the numbers in BoQ2.

1 Pick-up of water samples

1.1 Pick-up, handling and transport
The item must include all costs, including staff, materials, proper storage, any import licenses and transport to the lab in connection with pick-up and handling of groundwater supplied at the described address in Grindsted, Denmark.

2 Pre-treatment tests

2.1 Small-scale test involving chlorine dosing
The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described preliminary dosing test.

2.2 Large-scale oxidation test

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described oxidation test.

2.3 Removal of excess of chlorine

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described tests for removal of chlorine.

2.4 Decanting and filtering

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described decantering and filtering tests.

2.5 Reporting

The item must include all costs of the test report, which must describe test procedure as well as all results, assessments and conclusions.

3 AOP tests using H_2O_2 and fixed-bed catalyst (D)

3.1 TOC measurements

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described TOC measurements.

3.2 Blank and screening tests

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described blank and screening tests.

3.3 Optimum dosage and reaction time

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described determination of dosage and duration of reaction time.

3.4 Over-dosage and long reaction time (low flow)

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described over-dosage tests with long reaction time.

3.5 Under-dosage and short reaction time (high flow)

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the described under-dosage tests with short reaction time.

3.6 Sample preservation, storage and transport

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to preserve and store water samples from tests and send the samples to Eurofins and to laboratory performing ecotoxicological tests. Any import licenses and transport must also be included.

3.7 Reporting

The item must include all costs of preparing a preliminary report including test description and test data as well as results of measurements during the tests.

The item must also include all costs of preparing the final report including assessments and conclusions as well as all analysis results from Eurofins.

4 General

4.1 Project management

The tenderer is to price hours and resources for general project management beyond the test work.

4.2 Meetings

It is expected that Skype meetings will be held during the project between the region, COWI and the tenderer. The tenderer is to state a price per meeting with a duration of two hours maximum. The price must include preparation and participation.

B.3 Basis for payment and settlement, sub-agreement 3 (TAG3)

Present TAG3 covers all work related to ecotoxicological tests of untreated, contaminated groundwater and of treated groundwater from the four different AOP-methods.

Treated groundwater will be supplied by the company that wins sub-agreement 1, whereas untreated groundwater will be supplied by the client (possibly via Eurofins in Danmark) upon commencement of the project.

The work is described in more detail in SAB and BoQ3, which further specify what the test activities involve.

B.3.1 Bill of quantities items, sub-agreement 3

Numbering refers to the numbers in BoQ3.

1 Receipt, storage and disposal of water samples

1.1 Receipt, storage and disposal

The item must include all costs, including staff, materials and proper storage and handling of the groundwater samples received. Two rounds of water supplies may be expected: One supply of untreated contaminated groundwater, as well as one supply from the lab performing work under sub-agreement 1.

2 Ecotoxicological tests

2.1 OECD guideline method no. 201 (Rev. 2011)

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the test described in OECD guideline 201 using one of the recommended species of green algae, e.g. Pseudokirchneriella subcapitata. The definitive test must be carried out with a minimum of five (5) concentrations that cover a suitable interval, cf. the guideline.

2.2 OECD Guideline method no. 202

The item must include all costs, including staff, machinery, chemicals, analyses and equipment needed to carry out the tests described in OECD guideline 202 (2004).

2.3 Reporting

The item must include all costs of preparing a test report describing procedures, as well as all results, assessments and conclusions.

Appendix C Bills of quantities

Master Bill of quantities, sub-agreement 1

Lab-tests of AOP methods for treatment of pollution plume at Grindstedværket, sub-agreement 1

Tender The undersigned supplier hereby offers to carry out the above mentioned work for the Region of Southern Denmark in accordance with the tender matarial of september 2019 for a total amount ekskl. VAT

DKK .....

In writing .....

Main Item: Transferred from BoQ

1	Pick op of water samples etc.	DKK
2	Pre-treatment tests	DKK
3	AOP-tests using ozone (A)	DKK
4	AOP tests using ozone and H2O2 (B)	DKK
5	AOP tests using UV and H2O2 (C)	DKK
6	Post-treatment with activated carbon	DKK
7	General	DKK
	Total sum excl. VAT	DKK

Reservations Eventual reservations are listed here

SIGNATURE: The undersigned confirms that no reservations have been made in relation to other appendixes mentioned in the bills of qouatities

SUPPLIERS NAME: _____

ADRESS: _____

PHONE: _____

E-MAIL: _____

_____ Date

_____ Suppliers signature

AUTHORIZED PERSON

_____ Name

_____ Phone number

ALTERNATIVE AND SPECIAL INFORMATION

EVT. SUBCONTRACTOR

Type of work

Name

Adress

Bills of quantities, sub-agreement 1

Main Item	Item	Describtion	Fixed price, DKK	Total excl. VAT
1	**Pick op of water samples etc.**			
	1.1	Pick-up, handeling and transport		
Total main item 1 to transfer to master bills of quantities				
2	**Pre-treatment tests**			
	2.1	Small-scale test involving chlorine dosing		
	2.2	Large-scale oxidation test		
	2.3	Removal of excess chlorine		
	2.4	Decanting and filtering		
	2.5	Reporting		
Total		**Total price for Pre-treatment tests (2.1-2.5), to transfer to master bill of quantities**		
3	**AOP-tests using ozone (A)**			
	3.1	TOC measurements, for calculating comspumption of ozone		
	3.2	Blank and screening tests		
	3.3	Optimum dosage and reaction time		
	3.4	Over-dosage and long reaction time		
	3.5	Under-dosage and short reaction time		
	3.6	Sample preservation, storage and transport		
	3.7	Reporting		
Total		**Total price for AOP-tests using ozone (3.1-3.7), to transfer to master bill of quantities**		
4	**AOP tests using ozone and H2O2 (B)**			
	4.1	Blank and screening tests		
	4.2	Optimum dosage and reaction time		
	4.3	Over-dosage and long reaction time		
	4.4	Under-dosage and short reaction time		
	4.5	Sample preservation, storage and transport		
	4.6	Reporting		
Total		**Total price for AOP-tests using ozone and H2O2 (4.1 til 4.6), to transfer to master bill of quantities**		
5	**AOP tests using UV and H2O2 (C)**			
	5.1	Blank and screening tests		
	5.2	Optimum dosage and reaction time		
	5.3	Over-dosage and long reaction time		
	5.4	Under-dosage and short reaction time		
	5.5	Sample preservation, storage and transport		
	5.6	Reporting		
Total		**Total price AOP test using UV and H2O2 (5.1 til 5.6), to transfer to master bill of quantities**		
6	**Post-treatment with activated carbon**			
	6.1	TOC measurements of untreated water		
	6.2	Screening tests with activated carbon		
	6.3	Complete tests with untreated water		
	6.4	Tests of water from treatment with ozone		
	6.5	Tests of water from treatment with ozone + H2O2		
	6.6	Tests of water from treatment with UV + H2O2		
	6.7	Tests of water from treatment with H2O2 + catalyst		
	6.8	Sample preservation, storage and transport		
	6.9	Reporting		
Total		**Total price Post-treatment with activated carbon (6.1 til 6.9), to transfer to master bill of quantities**		
7	**General**			
	7.1	Project management		
	7.2	Meetings, price for 1 Skype-meeting, 2 hours duration		
		(7.2 attendance at meetings is only honored if the meetings are held)		
Total		**Total price, General, to transfer to Main bill of quantities**		
Total, sub-agreement 1, to transfer to Master Bill of quantities				

Master Bill of quantities, sub-agreement 2

Lab-test of AOP-methods for treatment of pollution plume from Grindstedværket

Tender

The undersigned supplier hereby offers to carry out the above mentioned work for the Region of Southern Denmark in accordance with the tender matarial of september 2019 for a total amount ekskl. VAT

dkk .....

In writing .....

Main Item: Transferred from BoQ

1	Pick op of water samples etc.	DKK
2	Pre-treatment tests	DKK
4	General	DKK
	Total sum excl. VAT	DKK

Reservations Eventual reservations are listed here

SIGNATURE

The undersigned confirms that no reservations have been made in relation to other appendixes mentioned in the bills of quantities

SUPPLIERS NAME: _____

ADRESS: _____

PHONE: _____

E-MAIL: _____

Date _____ Suppliers signature _____

AUTHORIZED PERSON

Name _____ Phone number _____

ALTERNATIVE AND SPECIAL INFORMATION

EVT. SUBCONTRACTOR

Type of work

Name

Adress

Bills of quantities, sub-agreement 2

Main Item	Item	Describtion	Fixed price	Total excl. VAT
1	**Pick op of water samples etc.**			
	1.1	Pick-up, handeling and transport		
Total, main item 1 to transfer to master bill of quantities				
2	**Pre-treatment tests**			
	2.1	Small-scale test involving chlorine dosing		
	2.2	Large-scale oxidation test		
	2.3	Removal of excess of chlorine		
	2.4	Decanting and filtering		
	2.5	Reporting		
Total		**Total price for Pre-treatment tests (2.1 til 2.5), to transfer to Master bill of quantities**		
3	**AOP tests using H2O2 and fixed-bed catalyst (D)**			
	3.1	TOC measurements		
	3.2	Blank and screening tests		
	3.3	Optimum dosage and reaction time		
	3.4	Over-dosage and long reaction time (low flow)		
	3.5	Under-dosage and short reaction time (high flow)		
	3.6	Sample preservation, storage and transport		
	3.7	Reporting		
Total		**Total pricce AOP tests using H2O2 and fixed-bed catalyst (3.1 til 3.7), to transfer to main bill of quantities**		
4	**General**			
	4.1	Project management		
	4.2	Meetings, price for 1 Skype-meeting, 2 hours duration		
		(7.2 attendance at meetings is only honored if meetings are held)		
Total		**Total price, general, to transfer to Main bill of quantities**		
Total, sub-agreement 2, to transfer to Master bill of quantities				

Master Bill of quantities, sub-agreement 3

Ecotoxicological test on water fra polution plume from Grindstedværket, sub-agreement 3

Tender

The undersigned supplier hereby offers to carry out the above mentioned work for the Region of Southern Denmark in accordance with the tender matarial of september 2019 for a total amount ekskl. VAT

DKK .....

In writing .....

Main Item:	Transferred from BoQ	
1	Receipt, storage and disposal of water samples	DKK
2	Ecotoxicological tests	DKK
	Total sum excl. VAT	DKK

Reservations Eventual reservations are listed here

SIGNATURE

The undersigned confirms that no reservations have been made in relation to other appendixes mentioned in the bills of quantities

SUPPLIERS NAME: _____

ADRESS: _____

PHONE: _____

E-MAIL: _____

Date _____ Suppliers signature _____

AUTHORIZED PERSON

Navn Name _____ Phone number _____

ALTERNATIVE AND SPECIAL INFORMATION

EVT. SUBCONTRACTOR

Type of work

Navn Name

Adress

Bills of quantities, sub-agreement 3

Punkt	Post	Beskrivelse	Fixed price	Number	Enhedspris	Total excl. VAT
1	**Receipt, storage and disposal of water samples**					
	1.1	Receipt, storage and disposal				
Total, to transfer to Master Bill of quantities						
2	**Ecotoxicological tests**					
	2.1	OECD Guideline nr. 201 (Rev 2011)		5		
	2.2	OECD Guideline nr. 202		5		
	2.3	Reporting				
Total		**Total price for ecotoxicological tests (2.1-2.3), to transfer to Master Bill of quantities**				
Total, sub-agreement 3, to transfer to Main Bill of quantities						

Do not fill out grey fields

Appendix D Solemn declaration

Solem declaration

The undersigned tenderer hereby solemnly declares that the company does not have unpaid due debt to public bodies which exceeds DKK 100,000 at the time of the tender.

The tenderer declares that the company unpaid due debt to public bodies at time of the tender

amounts to : DKK _____

_____

On behalf of the company (Name, address and CVR no.)

Date _____

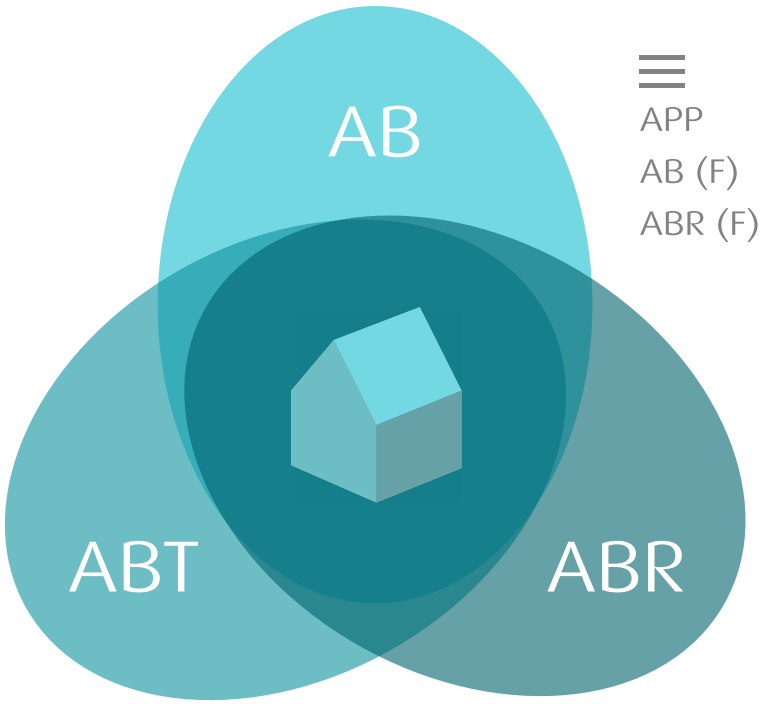
Signature, and company stamp

Region Syddanmark

Appendix E ABR Abridged (Abridged general conditions for consultancy services for building and construction works)

Abridged general conditions

for consultancy services for building and construction works (ABR Abridged)



These 'Abridged general conditions for consultancy services for building and construction works' (ABR Abridged) have been prepared by a committee appointed by the Minister for Climate, Energy and Building in accordance with Report 1570 issued on 21 June 2018, comprising representatives of the following organisations:

- **BL, Danmarks Almene Boliger**
  BL – Danish Social Housing
- **Bygherreforeningen**
  Danish Association of Construction Clients
- **Bygningsstyrelsen**
  Danish Building and Property Agency
- **Danske Arkitektvirksomheder**
  Danish Association of Architectural Firms
- **Dansk Byggeri**
  Danish Construction Association
- **Danske Regioner**
  Danish Regions
- **Dansk Industri**
  Confederation of Danish Industry
- **Foreningen af Rådgivende Ingeniører**
  Danish Association of Consulting Engineers
- **Kommunernes Landsforening**
  Local Government Denmark
- **Kooperationen**
  Danish Cooperative Employers' Association
- **SMVdanmark (tidligere Håndværksrådet)**
  SMEdenmark (formerly the Danish Federation of Small and Mediumsized Enterprises)
- **TEKNIQ**
  TEKNIQ - Danish Mechanical and Electrical Contractors' Association
- **Vejdirektoratet**
  Danish Road Directorate
- **Voldgiftsnævnet for bygge og anlægsvirksomhed**
  Danish Building and Construction Arbitration Board

Prevailing Language
The Danish language version of these general conditions shall be controlling in all respects and shall prevail in case of any inconsistencies with translated versions.

English version published 7 February 2019

Abridged general conditions for consultancy services for building and construction works (ABR Abridged)

A. Contractual basis

Clause 1 Application
Subclause (1) These abridged general conditions are intended for use in relation to contracts on consultancy services for building and construction works when the client is not a consumer and when the assignment involves technical advice without design or with design to a limited extent. The conditions apply once they have been accepted by the parties to the contract.

Subclause (2) Deviation from the conditions is only valid if the points to be deviated from are clearly and explicitly specified in the contract.

Clause 2 Definitions
Subclause (1) All amounts are exclusive of VAT unless otherwise stated.

Subclause (2) 'Working days' are all weekdays from Monday to Friday, with the exception of public holidays, Labour Day (1 May), Constitution Day (5 June), Christmas Eve (24 December) and New Year's Eve (31 December).

Clause 3 Governing law
Subclause (1) The legal relationship in its entirety is to be governed by Danish law.

Clause 4 The consultancy contract
Subclause (1) A consultancy agreement is entered into once a consultancy contract is signed or a tender submitted by the consultant is accepted in writing.

Subclause (2) The contract must include provisions concerning the following:

a) the scope of consultancy services, including the services to be provided by the consultant and any requirements concerning documentation;
b) the consultant's fee, including fee type and rates;
c) the financial framework for the consultancy services and the budgetary assumptions on which it is based;
d) the decisions to be made by the client in connection with the provision of the consultancy services;
e) the form of the consultancy services to be provided; and
f) a time programme specifying the end and start dates for the provision of the services.

Subclause (3) If the contract concerns building and construction works, the client and the consultant must decide in the consultancy contract whether and to what extent the consultant is to provide the following services:

a) design management
b) construction management
c) supervision
d) project follow-up

Subclause (4) If the contract is based on a tender submitted by the consultant following a call for

tenders by the client, the following order of priority will apply in the event of conflict between the provisions of the contract documents unless otherwise provided by general principles of interpretation:

a) the consultancy contract;
b) letters exchanged, minutes of meetings or written material containing agreed changes to, additions to or clarifications of the tender documents or the actual tender, and which are after the tender date;
c) the consultant's tender;
d) letters exchanged, minutes of meetings or other written material containing agreed changes to, additions to or clarifications of the tender documents which are after the date of the tender documents, but before the tender date;
e) the client's tender documents;
f) ABR Abridged.

Clause 5 The client's call for tenders
Subclause (1) The tender documents must contain information about the conditions that will apply to the consultancy contract.

Subclause (2) If the consultant is requested to submit a tender for a fixed fee, a fee based on construction costs or a fee based on hours spent with a maximum amount, the tender documents must provide information about all the matters stated in clause 4, subclause (2).

Subclause (3) If the services involve the design of building or construction works, the tender documents must also contain information about the following:

a) The total financial framework for design and execution if such a framework has been determined;
b) The time limit for the consultant's preparation of a service provision schedule in accordance with clause 11 and the expected end date for the execution of the contract; and
c) the type of organisation in which the contract is to be executed.

Subclause (4) In addition, the tender documents must include information about other matters that are considered to be of significance to the consultant's tender.

Subclause (5) Tenders are submitted on the basis of the information contained in the tender documents. Depending on the level of detail of the documents, the fee type and the services to be provided, the documents must be drafted in such a way that both the services and the terms and conditions are clear.

Clause 6 The consultant's tender
Subclause (1) The tender includes only services that are designated as forming part of the contract according to the tender documents or the tender.

Subclause (2) Any consultant reservations regarding or deviations from the tender conditions must be clearly and collectively stated in the tender.

Subclause (3) The tender acceptance period is twenty working days from the date of the tender.

Clause 7 Subconsulting
Subclause (1) To the extent that it is customary or only of minor importance for services to be provided under a subconsultancy contract, the consultant may entrust the provision of the

services to third parties. The parties may agree, however, that all or specified parts of the services are to be provided by the consultant or by a specific subconsultant, with the effect that the client's approval is required if the consultant desires to subcontract the provision of such services.

Subclause (2) At the client's request, the consultant must submit documentation as soon as possible to prove that a contract has been concluded with a subconsultant and that the subconsultant has acknowledged that the provisions of clause 7 also apply where a subconsultant entrusts others with the services and that the client is entitled to bring a claim for defects directly against the subconsultant in accordance with clause 7, subclauses (3) and (4).

Subclause (3) If it is considered to have been substantiated that the client is not able, or is able only with great difficulty, to pursue a claim for defects against the consultant, the client is entitled to bring the claim directly against the consultant's subconsultants if their services suffer from the same defect.

Subclause (4) Any direct claim is subject to the limitations following from the contracts both between the client and the consultant and between the consultant and the subconsultant, including liability exclusions and limitations set out in both contracts. Such a claim is also subject to the provisions of chapter J on dispute resolution. The client waives any claim for non-contractual damages against subconsultants in respect of matters covered by a direct claim for defects. If the direct claim has been caused by an intentional or grossly negligent act of the subconsultant, the first and third sentences do not apply.

Subclause (5) The provisions of clause 7, subclauses (1) to (4), also apply where a subconsultant entrusts others with the provision of the services.

B. Insurance

Clause 8 Liability insurance
Subclause (1) The consultant and, if applicable, the subconsultants must take out usual professional liability insurance and business liability insurance unless project liability insurance has been taken out to cover the consultant's liability for such errors and omissions.

Subclause (2) On request, the parties must provide documentation proving that the insurance policies are in force.

C. Performance of consultancy services

Clause 9 Services to be provided by the consultant
Subclause (1) The services must be provided in accordance with the contract, good consultancy practices and the client's instructions. The consultant must perform quality assurance of its services.

Subclause (2) If the consultant finds that the completion of the project requires special consultancy services in addition to the consultancy services the consultant agrees to provide, the consultant must notify the client of this before the contract is concluded.

Subclause (3) If the services include the preparation of budgets and the client has defined a financial framework for the provision of services , the consultant must review the client's budget and budget assumptions when the provision of the consultancy services begins.

Subclause (4) In connection with the commencement of the provision of the consultancy services the consultant and the client must also review the assignment with a view to clarifying the provision of the services and their prerequisites.

Clause 10 Consultancy stages
Subclause (1) If the consultancy services are to be provided in stages, the parties must specify the contents of each individual stage in the contract and the scope of the consultant's quality assurance in connection with the completion of the stages.

Subclause (2) The client must as soon as possible after completion of a stage inform the consultant whether the client can approve the services provided in that stage as a basis for the consultant's further work.

Clause 11 Service provision schedule
Subclause (1) The consultant must prepare a time schedule for the services to be provided by the consultant and the client (service provision schedule) if this has been agreed. The service provision schedule must be updated on an ongoing basis.

Clause 12 Design
Subclause (1) The consultant must perform design services to the extent specified in the contract.

Clause 13 Information about methods or materials
Subclause (1) If the consultant is to provide design services and the design involves the use of methods and materials that have not been thoroughly tested, the consultant must inform the client in writing of this as well as of any associated risks.

Clause 14 Client instructions concerning the execution of services
Subclause (1) The client may issue instructions concerning the execution of services.

Subclause (2) The consultant must obtain the client's decision if the contract and the basis for it do not provide sufficient guidance for the execution of services.

Subclause (3) If the consultant finds that the client's instructions under clause 14, subclauses (1) and (2), concerning the execution of the services involve a variation of the services as stated in clause 15, the consultant must notify the client of this as soon as possible.

Clause 15 Variations to services
Subclause (1) The client may order variations in the provision of the services or the basis for it if such variations are naturally linked to the services agreed upon.

Subclause (2) The consultant is entitled to carry out a variation ordered, unless the client shows that there are special reasons for having others perform the services.

Clause 16 Additional payment and cost reductions
Subclause (1) If a variation involves extra work, the consultant is entitled to corresponding adjustment of the consultant's fee based on hours spent unless otherwise agreed.

Subclause (2) If the scope of the consultant's services is reduced, the consultant must credit the expenses that are saved or should have been saved to the client, the maximum amount being the amount at which the work has been calculated in the consultancy contract.

Clause 17 Price and time after variations
Subclause (1) Any claim by the parties concerning amendments to the contract in terms of price and time resulting from a variation to the services or changes in the conditions for executing the services must be submitted in writing as soon as possible.

Clause 18 Obstacles
Subclause (1) If the consultant finds that the services cannot be performed in accordance with the contract entered into, the consultant must notify the client accordingly as soon as possible and then follow the client's instructions.

Clause 19 Client representative
Subclause (1) The client must appoint a person to represent the client in relation to the consultant.

Clause 20 The consultant's authority
Subclause (1) Before commencement of the provision of services, the client must decide whether the consultant is to be authorised to enter into agreements on behalf of the client.

Clause 21 Start-up review
Subclause (1) If the services concern building and construction works, the client, the consultant and the contractor may, before execution of the work, review the contractor's tender and the design the contractor is to execute with a view to achieving a common understanding of the design and execution of the works.

Clause 22 Duty of cooperation and good faith
Subclause (1) The parties have a duty to work together in good faith so that errors, delays and cost increases are avoided.

D. Payment

Clause 23 Fee and indexation
Subclause (1) The consultant's fee must be laid down in the consultancy contract. The fee may be agreed as

a) a fixed fee;
b) a fee based on time spent;
c) a fee based on construction costs; or
d) a combination of different types of fees.

Subclause (2) If the consultancy contract does not specify a type of fee for the provision of services, the consultant is paid on the basis of time spent.

Subclause (3) For the part of the services provided more than twelve months after the date of tender, the fixed fee and agreed hourly rates are adjusted in accordance with an index that has been agreed or which – in the absence of agreement – is considered relevant to the services.

Subclause (4) If the consultant's hourly rates are not set out in the consultancy contract, payment will be based on the consultant's usual hourly rate for similar services, and such rate must not be unreasonable.

Subclause (5) If payment is made on the basis of time spent, the consultant must present an estimate of its fee, reimbursable expenses and costs on request and must notify the client as soon

as possible if there is reason to believe that the estimate will be exceeded.

Subclause (6) In case of a fee based on construction costs, the fee is calculated as a percentage of construction costs. The consultancy contract must specify the expenses falling within the scope of construction costs and the basis on which construction costs are determined, including indexation.

Subclause (7) The fee does not include the cost of manufacturing physical models, expenses for the reproduction of drawings, descriptions, photographs and any other material used to identify the services to be provided, expenses for specialists engaged by agreement with the client, or duties and charges payable for such certificates, etc that are necessary for providing the services under the contract. Invoices for such costs and expenses must be submitted for payment by the consultant. If the consultant pays a third party by agreement with the client, the client must reimburse the consultant for the amount paid plus 5%.

Subclause (8) The fee includes all other expenses the consultant has incurred in providing services, except for expenses the client has agreed to pay in addition to the fee.

Clause 24 Payment and retention
Subclause (1) On written request to the client, the consultant is entitled to receive payment once a month for services provided, etc.

Subclause (2) It may be agreed that payment is to be made in accordance with a payment schedule instead of as set out in clause 24, subclause (1).

Subclause (3) If the date of payment for extra work has not been agreed, the consultant may request payment in accordance with the provision of clause 24, subclause (1). A request for payment must be submitted within a reasonable period of time after the performance of extra work unless special circumstances prevent billing of such work.

Subclause (4) The consultant may demand monthly reimbursement in arrears of reimbursable expenses.

Clause 25 Due date, final date for payment and interest
Subclause (1) The consultant's claims under clause 24 fall due for payment when the client receives a request for payment and are payable no later than 15 working days after receipt.

Subclause (2) Any amount receivable by the consultant carries interest from the due date at the rate of interest provided for in the Danish Interest Act. The time limit set out in clause 25, subclause (1), is the grace period.

Clause 26 The consultant's right to stop work
Subclause (1) If the client fails to pay an amount due by the final date for payment, the consultant may stop providing services after having given written notice of five working days.

E. Intellectual property rights

Clause 27 Intellectual property rights
Subclause (1) The client is entitled to use material prepared for the provision of the services.

Subclause (2) The client is entitled to use other material, including registration of existing conditions, analyses, calculations and any other material which exclusively contains information

necessary for the provision of the services.

Subclause (3) In addition, the consultant retains all rights in ideas developed and material prepared by the consultant.

F. Extension of time and delay

Clause 28 The consultant's right to extension of time
Subclause (1) The consultant is entitled to extension of time if the provision of the services is delayed as a result of

a) variations to the services ordered by the client; see clause 15;
b) the circumstances of the client or delay on the part of another consultant or contractor;
c) war, acts of God, fire, strike, lockout, picketing, vandalism or similar events that are without the fault and beyond the control of the consultant;
d) failure by public authorities to provide approvals, decisions or replies or to provide material or services within the time limits set out in the consultancy contract;
e) public enforcement notices or prohibitions which are not due to the circumstances of the consultant; or
f) any redesign obligations that the consultant may have.

Clause 29 The consultant's liability in case of delay
Subclause (1) Any delay which does not entitle the consultant to extension of time constitutes an actionable wrong.

Subclause (2) If provisions have been made for liquidated damages or other special penalties, no claim for additional damages may be brought as a result of delay.

Subclause (3) Total liquidated damages payable by the consultant cannot exceed 10% of the consultant's fee.

Subclause (4) If no provision has been made for liquidated damages or other special penalties, the client's loss is determined in accordance with the general rules of Danish law, but see also clause 38 on limitation of liability.

Clause 30 The client's right to extension of time
Subclause (1) The client is entitled to extension of time if the client's services or decisions are delayed as a result of

a) war, acts of God, fire, strike, lockout, picketing, vandalism or similar events that are without the fault and beyond the control of the client;
b) failure by public authorities to provide approvals, decisions or replies or to provide services within the time limits set out in the consultancy contract; or
c) public enforcement notices or prohibitions which are not due to circumstances of the client.

Clause 31 The client's liability in case of delay
Subclause (1) A delay which does not entitle the client to extension of time constitutes an actionable wrong.

G. Defects

Clause 32 Definition of defect
Subclause (1) If the services do not comply with clause 9, subclause (1), there is a defect.

Clause 33 Rectification of defects
Subclause (1) The consultant has a duty and a right to rectify defects identified at the delivery of the stages agreed or later.

Clause 34 Lapse of the consultant's right to rectify defects
Subclause (1) The consultant's right to rectify defects lapses if rectification is not effected by the consultant within a reasonable period of time.

Clause 35 Complaints
Subclause (1) The client is entitled to file defects claims or enforce liability against the consultant only if the consultant has been notified in writing within a reasonable period of time after the defects or the consultant's potential liability was or ought to have been discovered. This does not apply if the consultant has been guilty of gross negligence.

Clause 36 Reduction in the consultant's fee
Subclause (1) If the consultant does not rectify defects as set out in clause 33, the client may demand a reduction in the consultant's fee. The client is also entitled to a fee reduction if rectification is impossible.

Clause 37 The consultant's liability
Subclause (1) The consultant is liable under the general law of damages in Denmark for errors and omissions in the provision of the services subject to the limitations set out in clause 38.

Clause 38 Limitation of liability
Subclause (1) The consultant is not liable for any loss of business, loss of profit or other indirect loss.

Subclause (2) If the consultant and one or more other parties are liable towards the client for a loss, the consultant is liable only for the part of the client's loss which corresponds to the part of the total fault committed by the consultant (pro rata liability).

Subclause (3) If project liability insurance has been taken out, the consultant's liability is limited to the cover provided by the project liability insurance policy.

Subclause (4) The consultant's liability is limited to DKK 2.5 million unless otherwise agreed.

Clause 39 Expiry of liability for defects
Subclause (1) The client's claims against the consultant for defects must be submitted no later than five years after the date of completion of the services. However, for consultancy services provided in connection with the execution of building and construction works, any claim by the client must be brought no later than five years after the handover of the building or construction works to which the defect relates.

Subclause (2) Regardless of the provisions of clause 39, subclause (1), the client's claims are retained in relation to parts of the services if

a) the consultant has undertaken to extend the warranty period; or
b) the consultant has been grossly negligent.

H. Postponement and cancellation

Clause 40 Postponement of services
Subclause (1) The client may postpone the provision of the services. If the provision of services is postponed for a period of more than two years, the consultant is entitled to regard the project as cancelled.

Subclause (2) If the client postpones the services after the consultant has started providing the services, and such postponement is not due to circumstances of the consultant, the consultant is entitled to receive both a fee for the work already executed and reimbursement of the expenses incurred by the consultant as a result of the postponement of the services, including wages and salaries for redundant labour and rental payments for redundant leased premises. The consultant must endeavour to keep these costs to a minimum.

Subclause (3) If any postponed provision of services is resumed, the consultant is entitled to receive a fee for any extra work and reimbursement of reasonable additional expenses associated with the resumption of the services

Subclause (4) If the provision of services is resumed, the client may demand that, if possible, the services be provided by staff with the same professional qualifications as the staff members originally assumed.

Clause 41 Cancellation of services
Subclause (1) The client may cancel the provision of the services.

Subclause (2) If the client cancels the services, the consultant is entitled to a fee and reimbursement for expenses as set out in clause 40, subclause (2). The consultant is also entitled to receive reasonable remuneration for the client's use of the material prepared; see clause 42, subclause (1).

Subclause (3) If services are cancelled as a result of circumstances which the client ought to have foreseen or reasonably ought to have avoided, the consultant is entitled, in addition to a fee and reimbursement for expenses in accordance with the first sentence of clause 41, subclause (2), to receive compensation for the profit the consultant has lost by not completing the services.

Clause 42 Use of material after cancellation
Subclause (1) If the client cancels services involving design after design work has started, the client is entitled to use the available design material for the project for which the material has been prepared, once the consultant has received payment in accordance with clause 41, subclauses (2) and (3).

Subclause (2) The client is entitled to use material, including registration of existing conditions, analyses, calculations and any other material which exclusively contains information necessary for the provision of the services, once the consultant has received payment in accordance with the first sentence of clause 41, subclause (2).

Subclause (3) However, the client is not entitled to use any material prepared before the cancellation of services as a basis for manufacture of products intended for sale. This also applies in cases where the services of the consultant comprise development of products intended for manufacture and sale.

Subclause (4) If the client uses any material prepared before the cancellation of services, the consultant is not liable for any defects or errors in uncompleted material.

I. Termination with immediate effect

Clause 43 The client's right to terminate the contract
Subclause (1) After having provided written notice, the client is entitled to terminate the consultancy contract in whole or in part with immediate effect

a) if the consultant commits a material breach of the contract; or
b) if the consultant engages in conduct of such a nature that the consultant cannot reasonably insist on continuing to serve as a consultant to the client.

Subclause (2) In the event that the contract is terminated with immediate effect, the client or the party completing the services on behalf of the client is entitled to use all or any of the material that has been prepared by the consultant and paid for by the client.

Clause 44 The consultant's right to terminate the contract
Subclause (1) After having provided written notice, the consultant is entitled to terminate the consultancy contract in whole or in part with immediate effect

a) if the client commits a material breach of the contract; or
b) if the client engages in conduct of such a nature that it is not reasonable to insist on the consultant continuing with its duties and services.

Clause 45 Common rules on termination with immediate effect
Subclause (1) Notice of termination must be given in writing.

Subclause (2) If either party terminates the contract with immediate effect, the other party is liable for the loss suffered in accordance with the general rules of Danish law.

J. Disputes

Clause 46 Dispute resolution ladder
Subclause (1) Efforts must be made to resolve and settle a dispute between the parties through negotiation as set out in clause 59, subclauses (1) to (3) of ABR 18.

Subclause (2) Mediation, conciliation, speedy resolution and arbitration may not be initiated before the negotiation procedure set out in clause 59 of ABR 18 has been completed. This also applies to expert appraisal unless the purpose of such appraisal is to secure evidence.

Clause 47 Mediation and conciliation
Subclause (1) At the request of either party, the Danish Building and Construction Arbitration Board appoints a mediator to carry out mediation with a view to settling a dispute in accordance with the provisions of clause 60, subclauses (1) and (3) to (9) of ABR 18.

Subclause (2) Mediation cannot be initiated if a party desires speedy resolution of the dispute and files a request to that effect no later than ten working days after the request for mediation was made.

Clause 48 Expert appraisal
Subclause (1) At the request of either party, the Danish Building and Construction Arbitration Board appoints expert appraisers to secure evidence of or assess actual conditions in accordance with the provisions of clause 61, subclauses (2) to (8), of ABR 18.

Subclause (2) If a party has requested speedy resolution, no expert appraisers may be appointed to consider the same matter until the question of speedy resolution has been finally concluded, unless the purpose of expert appraisal is to secure evidence.

Clause 49 Speedy resolution
Subclause (1) At the request of a party, the Danish Building and Construction Arbitration Board appoints an umpire to effect a speedy resolution in accordance with the provisions of clause 62, subclauses (1) and (3) to (12), of ABR 18.

Subclause (2) Speedy resolution proceedings may not be initiated if there is a pending arbitral case about the same dispute.

Clause 50 Arbitration
Subclause (1) Disputes between the parties are finally resolved by arbitration before the Danish Building and Construction Arbitration Board in accordance with the provisions of clause 63, subclauses (3) to (8) of ABR 18.

Subclause (2) Arbitral proceedings may not be initiated until four weeks after the conclusion of negotiations concerning the dispute as set out in clause 59 of ABR 18. Furthermore, arbitral proceedings may not be initiated if mediation, conciliation, speedy resolution or a decision concerning security provided relating to the same dispute is pending.