ENVIRONMENTAL TECHNOLOGY VERIFICATION

ETV Joint Verification Statement

TECHNOLOGY TYPE:	Passive Groundwater Sampling
APPLICATION:	Sampling and analysis of volatile organic compounds in contaminated groundwater
PRODUCT NAME:	Sorbisense groundwater sampling system with samplers for volatile organic compounds and including sampler analysis
COMPANY:	Sorbisense A/S
ADDRESS:	Niels Pedersens Allé 2 DK-8830 Tjele, Denmark **PHONE:** +45 89 99 25 05
WEB SITE:	www.sorbisense.dk
E-MAIL:	hubert@sorbisense.com

Verification and tests of a passive groundwater sampler were conducted as a joint verification between the Nordic Water Technology Verification Centers (NOWATECH ETV) and the United States Environmental Protection Agency (US EPA) Environmental Technology Verification Program (US ETV). The verification and tests satisfied the requirements of the US ETV program and ETV scheme currently being established by the European Union (EU ETV).

The US ETV Program was established to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of US ETV is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. US ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies. Information and US ETV documents are available at www.epa.gov/etv.

NOWATECH was established and supported by the Nordic Innovation Centre, Nordic Council of Ministers to provide environmental technology verification for Nordic vendors of innovative water technologies. Information and NOWATECH ETV documents are available at www.etvnord.org.

DHI as NOWATECH Water Monitoring ETV Center (NOWATECH WMC) performed the verification and tests in collaboration with the ETV Advanced Monitoring Systems (AMS) Center, managed by Battelle through a cooperative agreement with the US EPA.

VERIFICATION AND TEST DESCRIPTION

The verification and tests of the Sorbisense ground water sampler were conducted from January to April 2009. DHI personnel, with the participation of the vendor, Sorbisense, coordinated and supervised the day-to-day operations of the verification and tests. The testing took place in the DHI laboratories, Hørsholm, Denmark and in the field in the Copenhagen area, Denmark. DHI operated the samplers during the verification. Sorbisense provided the product (sampling systems, the samplers and the analysis of samplers), user manuals, and operation instructions for the tests. Battelle and DHI jointly produced the verification protocol, test and QA plan, process document and report document including this Verification Statement with input from Sorbisense and an expert group.

Four test scales were used as outlined in the Test Plan below. Each scale provided information on specified performance parameters, with the smallest scale possible chosen for each parameter to maintain simplicity and controlled conditions in the tests.

Test Plan

Laboratory		Standpipe	Field
Direct application	**Dispenser**		
Limit of detection: chloroethene, best possible[1]	None	Limit of detection	None
Precision (repeatability): chloroethene, best possible[1]	None	Precision (repeatability and reproducibility)	Precision (reproducibility)
Trueness: chloroethene, best possible[1]	None	Trueness	None
None	None	Range of application	None
None	Robustness, sampling time, groundwater ionic strength, concentration variation and integration	Robustness, sampling depth	General robustness
None	None	None	Robustness, frequency of discrepancy[2]

[1] The determination of performance parameters from the direct application test only included the sorbent.
[2] Positive discrepancy: sampler finds measurable concentration when average of reference samples are below the sampler limit of detection. Negative discrepancy: sampler does not find measurable concentration when average of the reference samples are above sampler limit of detection.

The laboratory tests involved direct application of standard solution to the samplers or exposure of samplers to spiked water from a sample dispenser, without the sampling system. The laboratory tests provided information on the response of the samplers to carefully controlled parameters. For chloroethene, only the laboratory and field tests provided information on the performance of the samplers because this compound could not be included in standpipe tests due to practical and health and safety considerations.

The standpipe tests were intended to simulate groundwater movement through a well. The standpipe was established in the laboratory and allowed full control of solute concentrations. The standpipe tests provided more realistic information than laboratory tests on the performance of the samplers, while minimizing the variability of the test system as compared to field systems.

The field tests provided information on the robustness of the sampling system under real groundwater conditions. In planning the field tests, varying aquifer and well conditions were targeted to consider factors such as groundwater flow, well construction, presence of other contaminants than the target solutes, and the impact of combined variation of robustness parameters.

The operational conditions during sampler testing in the standpipe and in the field included the following.

Sampling temperature ºC	**Sampling depth** meter below water surface	**Sample volume** mL	**Sampling period** days
9-22	0.5-5	80-620	3-9

Water quality operational parameters included the following.

Parameter	**Range** mg/L	**Parameter**	**Range** mg/L (unless otherwise indicated)
Calcium	76-250	Chloride	37-410
Magnesium	7.2-28	Fluoride	0.25-0.91
Potassium	1.6-5.2	Sulfate	10-200
Sodium	17-160	Bicarbonate	295-575
Iron	0.09-7.1	NVOC[1] (DOC)[2]	2.4-9.0
Ammonium	0.016-0.89	Ionic strength	0.011-0.028 moles/L
Nitrate	<0.5-3.8	pH	6.8-7.8 (-)

[1] Non-Volatile Organic Carbon; [2] Dissolved Organic Carbon

The concentrations of volatile organic contaminants tested ranged from below the limits of detection to the stated maximum linear range.

Applications for sampling at waste disposal sites and for groundwater baseline monitoring were not covered by the verification.

Quality Assurance

DHI provided internal review of documents and audit of test performance. Battelle ensured that the verification and tests were planned and conducted to satisfy the requirements of US ETV, including input and concurrence from its stakeholder group. Battelle quality assurance staff conducted a technical systems audit, a performance evaluation audit, and a data quality audit of at least 10% of the test data. Three technical experts provided independent expert review of planning, testing and reporting. The experts additionally reviewed the verification plan and report. This statement reflects the verification results after performing the above quality assurance actions.

TECHNOLOGY AND PRODUCT DESCRIPTION

The following description of the GWS sampling system (the product) is based on information provided by the vendor and does not represent verified information.

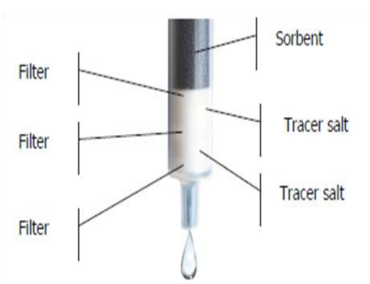
The product combines:

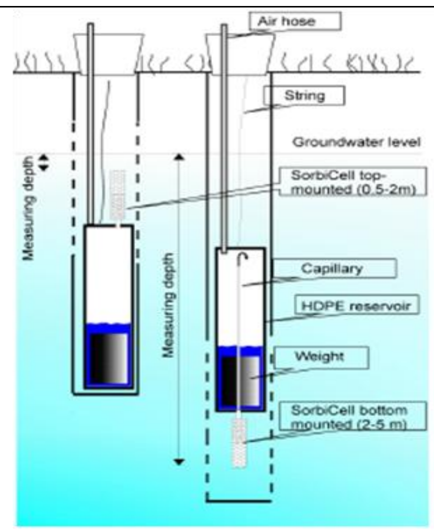
1) Equilibrium based passive sampling;
2) Tracer salt derived calculation of the sampled water volume; and
3) Gas chromatography mass spectrometry (GC-MS) analysis of organic concentrations of concentrations collected on the sample cartridges.

The passive samplers and the subsequent analysis of the cartridges constitute the product. Main features of the product are:

- Sampling of groundwater flowing through a well screen in the aquifer without well purging
- Time integrated sampling over the exposure period
- Transportation of small sample cartridges to the laboratory after completed sampling and
- Laboratory based extraction and analysis of sampled compounds.

The product verified here was the Sorbisense GWS40 sampling system intended for sampling of shallow groundwater (product number 106-012-11) equipped with samplers for volatile organic compounds (products numbers 043-091-12, 043-101-12, 043-102-12). Analysis of the samplers was performed by ALcontrol under their ISO 17025 accreditation. The principles of the Sorbisense sampler and mounting of the GWS40 sampling system are depicted below.





The description of the sampler is based on information provided by the vendor.

VERIFICATION RESULTS

Matrix	Effect	Targets and verified performance summary
Contaminated groundwater	Measurement of concentrations of volatile organic contaminants (mono-, di-, tri- and – tetrachloroethenes, benzene, toluene, ethylbenzene and xylenes (BTEX) and methyl-*tert*-butylether (MTBE)) **Additional parameters:** User manual Product cost Health and safety	Volatile organic compounds performance parameters: Detection limits: 2-70 µg/L Linear maximum: 1,200-1,900 µg/L Accuracy: 65-153% Robustness: 67-121% Precision, repeatability: 8.5-11% relative standard deviation Precision, reproducibility: 38-95% relative standard deviation Positive discrepancies[1]: 0-20% of field samples Negative discrepancies[2]: 0-20% of field samples

[1] Positive discrepancy: sampler finds measurable concentration when average of reference samples are below the sampler limit of detection.
[2] Negative discrepancy: sampler does not find measurable concentration when average of the reference samples are above sampler limit of detection.

Performance Parameters

Compound	Limit of detection	Precision		Trueness	Range of application	Robust-ness	Discre-pancies positive/ negative
	LoD µg/L	Repeatability %	Reproducibility %	%	LoD- µg/L	%	%/%
Chloroethene	<30	>10	<51	65	n.d.[1]	n.d.[1]	0/0
1,1-Dichloroethene	<90	11	51	100	1,900	78-111	0/0
trans-1,2-dichloroethene	4	11	45	101	1,900	94-121	0/0
cis-1,2-Dichloroethenes	4	10.2	60	129	1,500	85-114	0/0
Trichloroethene	70	9.1	42	110	1,700	80-120	0/7
Tetrachloroethene	2	8.5	38	137	1,200	90-106	0/0
Benzene	3	10.0	70	135	1,600	80-108	13/0
Toluene	4	9.5	59	131	1,500	76-107	13/0
Ethylbenzene	5	8.6	46	153	1,600	75-101	20/0
o-Xylene	4	8.8	50	139	1,400	72-101	0/0
m/p-Xylenes	3	8.5	42	138	1,300	78-102	20/20
MTBE	6	10.6	95	147	1,700	67-100	0/0

[1] no data

The user manuals for the product were in general complete, but did not include a description of system limitations, maintenance and storage.

On review of hazardous chemicals or other risks associated with the use of the system, no risk to occupational health and the environment during product operation was identified, compared to conventional groundwater sampling.

The capital investment costs and the operation and maintenance costs were itemized based on a case example for yearly monitoring at one site with five wells over a five year period, totaling 25 samples. It is presumed, that each sampling of the site should include all wells. Equipment for well purging and reference sampling is not included. The required cost items per 25 samples are estimated as follows.

Item type	**Cost item to include with example case design**	**Need**
Capital		
Site preparation	Preparation of wells for access	5 days per 25 samples
Equipment	Sampling systems	5 per 25 samples
Start up/training	Sampling staff training (days/sample)	1 day per 25 samples
Operation and maintenance		
Materials, including chemicals	Samplers (number)	25 per 25 samples
Labor	Sampling without transport (days/sample)	2½ day per 25 samples
	Cleaning of samplers (days/sample)	2½ day per 25 samples

The vendor has stated that as of April 10th 2010, the cost of the sampling system is 218 EURO (one piece, reusable) and the cost of a sampler is 50 EURO (one piece as part of six piece package, disposable).

Original signed by Christian Grøn 5/4/10
Head of NOWATECH Steering Committee, DHI

Original signed by Jørn Rasmussen 5/4/10
Director, Group R&D and Quality Management, DHI

Original signed by Tracy Stenner 6/3/10
Manager Environmental Product Line
Battelle

Original signed by Andy Gillespie for Sally Gutierrez 6/3/10
Director, US EPA National Risk Management Research Office of Research and Development

NOTICE: ETV verifications are based on an evaluation of technology performance under specific, predetermined operational conditions and parameters and the appropriate quality assurance procedures. NOWATECH, DHI, US EPA and Battelle make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable regulatory requirements. Mention of commercial product names does not imply endorsement.