REPORT

PALDISKI TOWN
CENTRAL BOILER HOUSE

REMEDIATION FEASIBILITY STUDY

FEBRUARY 1997

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FEASIBILITY STUDY OF PALDISKI CENTRAL BOILER HOUSE

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SITE DESCRIPTION

Paldiski Peninsula is located about 50 km westwards from the capital Tallinn. The length of Paldiski Peninsula is 12 km, average width 5 km and area 40 km^2. The upper part of the plateau is formed of limestone with dictyonema shale, sandstones and blue clays openings in the lower part of the geological section. The Paldiski Peninsula has three distinct groundwater aquifers.

The Central Boiler house of Paldiski is situated in the western part of Paldiski Peninsula in the eastern part of Paldiski town. The site of the boiler house covers an area of about 3.5 ha. Before construction of the boiler house, the area was part of a Russian military site. The power generating capacity of the boiler house is 32.5 MW. In 1994, 12 000 tons of black oil was burned, and in 1995, 4 000 tons was burned. The oil loading area, pumps, pipelines and leaks from storage areas require repair. The boiler house is an out-dated facility and in need of thorough reconstruction, repair and remediation.

Due to leakages, lasting for several years, thousands of tons of black oil have been released from the boiler house and the railway cars (during the off-loading of oil) into the soil. Large quantities of black oil are contained in the soil below the boiler house site which is covered with concrete slabs. The greater part of this contaminated soil is surrounded by a subterranean concrete wall, which apparently reaches down to the limestone. The wall is incomplete and contamination at the surface had visibly spread beyond the area surrounded by the wall. Construction of the storm drainage and sewage treatment facilities on the boiler house site have not yet been completed.

For years the black oil has been flowing into the Paldiski Bay and the Baltic Sea from the site of the Paldiski boiler house. Approximately 160 kg of oil flowed daily into the sea in 1992. During the rainy periods this amount reached ca 400 kg per day. A new oil separator was built in 1995 and it was connected with the storm water sewerage system in the spring of 1996.

About 600 tons of black oil, containing about 50% water, was pumped out from the site during 1994. During 1995 about 300 tons of black oil with contaminated water was collected from the site. The soil still contains large quantities of black oil.

REMEDIATION OBJECTIVES

The aims of the remedial actions planned in this study are to prevent leaks in the future, prevent the spreading of the oil in the soil and the water, and to reduce the possible environmental risks caused by the contaminated soil and water. The objects and remediation methods are listed in figure 1.

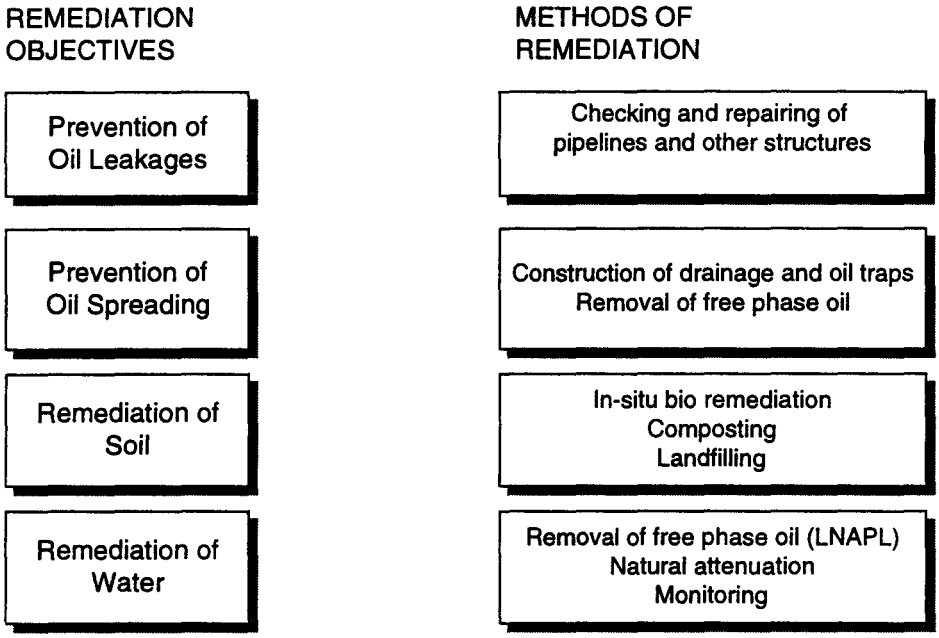


Figure 1. Aims of the remedial objectives.

REQUIRED ACTIONS

There are several required actions that need to be carried out before cleaning up the soil and water. Future leaks will need to be prevented by the following methods:

5.1.1 Repairing of the Pipelines and other Structures;
5.1.2 Construction of the Storm Water Pipes and Oil Separators;
5.1.3 Improvements to the Handling of Oil in the Facility;
5.1.4 Managing the Oil Separator on the Coast.

After these have been carried out, the free phase oil will have to be removed from the drainage pipes and other structures (5.2.1). Free phase oil will also have to be pumped away from the ground and from the surface of the water (5.2.2).

SUGGESTED REMEDIATION METHODS

There are several applicable methods for removing free phase oil and for the remediation of soil and water. The different methods are described in chapter 5 of this report.

Removal of free phase oil

The present approach involving the periodical pumping of free phase oil is not sufficient to remove the oil from the ground. The lack of a working drainage system results in the

spreading of oil from the area of boiler house. Removal of the free phase oil could be improved by following methods:

- Construction of trenches and pumping wells;
- Construction of oil separators;
- Continuous pumping of oil and water through oil separators.

Remediation of contaminated soil

The following methods could be applied to the remediation of contaminated soil:

1. **No remedial action**
   The contaminated soil would be left in the ground to degrade naturally. Degradation would include chemical breakdown, bio-degradation, diffusion and volatilisation. Based on the gross mass estimates of the contamination, the rates for natural attenuation at this site would be measured in terms of decades. There would also need to be some covering of the contaminated surface soils.

2. **In-situ bio-remediation**
   Oxygen, phosphate, nitrogen and potassium would be added to the sub-surface soils to enhance the growth of naturally occurring bacteria. The growth of the naturally occurring bacteria will accelerate the biological decomposition of the oil through the bacteria utilising the hydrocarbons as a food supply. Prior to initiating a bio-remediation program a bio-assay would need to be conducted.

3. **Landfilling**
   Contaminated soil would be removed and landfilled in an approved site suitably constructed for the landfilling of oil contaminated soil. This is the mass transfer alternative.

4. **Above-ground bio-remediation**
   Contaminated soil would be excavated and above ground treatment cells constructed. The treatment cells would be located in an approved place and engineered to provide oxygen, potassium, nitrogen and phosphate to enhance the growth of naturally occurring bacteria. The growth of the naturally occurring bacteria will accelerate the biological decomposition of the oil through the bacteria utilising the hydrocarbons as a food supply. This alternative is more labour intensive than in-situ bio-remediation but the remediation time is shorter. Prior to initiating a bio-remediation program a limited bio-assay should be conducted.

5. **Thermal destruction**
   Contaminated soil would be removed and treated by burning in an approved combustion facility.

6. **Production of asphalt**
   Contaminated soil would be removed and used as a raw material in the production of asphalt.

Remediation of contaminated water

The following methods are suggested for the remediation of the contaminated water:

1. **Free phase oil on the groundwater surface (LNAPL)**
   Removal of free phase oil from the groundwater surface is discussed before in the section "Removal of free phase oil".

2. **Dissolved hydrocarbons**
   Natural attenuation.
   Other methods may need to be considered based on any monitoring results.

ENVIRONMENTAL RISKS

Environmental risks have been evaluated by listing the potential contaminants, exposure pathways and receptors.

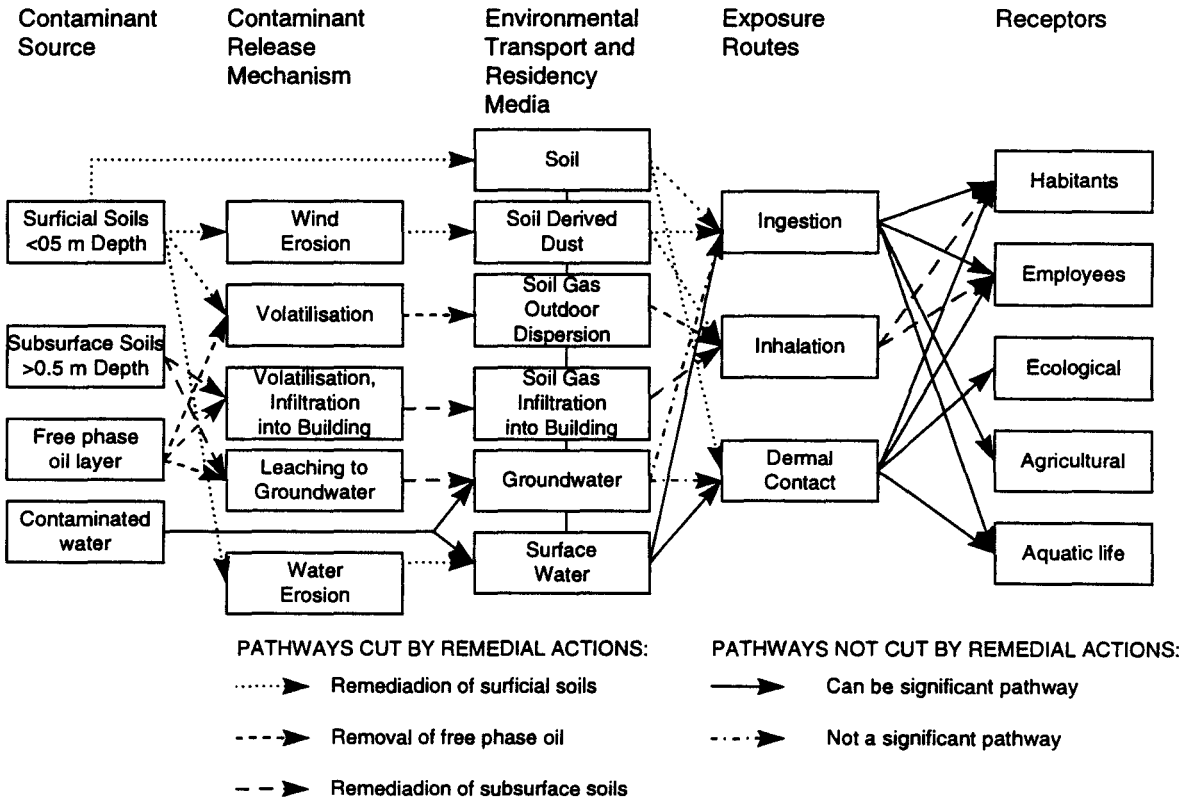


Figure 2. Conceptual model

All the potential exposure pathways are shown in figure 2. The dotted lines represent the pathways which will be removed by the proposed remedial actions for the site. The pathways marked with continuous lines will not be removed by the suggested remedial actions, but the pathways are not regarded as significant.

PRIORITY

The order of priority for the proposed actions at the site will need to be as follows:

1. Cut-off of leaks
2. Removal of free phase oil from open areas/containers
3. Cut-off the spreading of the oil from the area of the boiler house (inside the confining wall)
4. Cleaning of surface soils around the boiler house area (outside the confining wall)
5. Cleaning of soils inside the boiler house area
6. Cleaning of groundwater

COST ESTIMATES

Table 1. Summary of estimated costs.

ACTION	ESTIMATED COST, million EEK		
	Minimum	Average	Maximum
5.1 Testing and repairing	0,8	1,6	2,3
5.2 Removal of free phase oil	0,4	0,8	1,2
5.3 Remediation of soil	0,5	7	10
5.4 Groundwater monitoring	1,2	0,7	0,2
TOTAL	3	10	14

The testing and repairing of the tanks and pipelines will have to be done if it is intended to clean-up the site. The most cost effective clean-up action is the removal of the free phase oil. If it is carried out effectively using the suggested trenches, up to 1 000 tons of oil could be recovered for about one million EEK from the pipelines and from the ground.

It is estimated that after the removal of the free phase oil it would be possible to recover 500 tons of oil, if the contaminated soil was remediated. Above-ground bio-remediation is the suggested remediation method.

No pumping and treating of groundwater is recommended, before the sources of the contamination have been removed. However, the state of the groundwater should be observed by monitoring of the groundwater.

1. INTRODUCTION

1.1 BACKGROUND

The Paldiski Peninsula has been a military base since 1939 and the area has mainly been used for military purposes. In addition to conventional military activities, the area has also housed a nuclear training plant and associated activities. The military activities have resulted in the poor state of the environment. The soil and water pollution are estimated to be severe.

The Paldiski Peninsula is located about 50 km west of the capital Tallinn. The Paldiski Peninsula is situated on the limestone plateau between the Paldiski and Lahepere Bays along the northern coast of Estonia. The area of the Paldiski Peninsula is some 40 km^2.

The Paldiski Town Government has decided to renovate the boiler house at the location. A new DE-25-14GM 6 MW boiler (wood, waste wood, etc.) was operational by March 1996. Paldiski town currently requires 12 MW of heat during the wintertime. Consequently, it will be necessary to still employ one of the existing oil boilers.

The Ministry of the Environment of Estonia has instructed MAVES Ltd. and the Central boiler house of Paldiski to begin the primary treatment of the black oil contamination. The aim is to clean-up the black oil from the surface. About 350 tons of black oil, containing about 50% of water, was pumped from the site by the employees of the boiler house during the summer of 1994. MAVES Ltd. operations during Sept-Nov 1994 recovered about 8 tons of separated black oil from the oil separator near the sea, and 244 tons from the area in the vicinity of the boiler house. During 1995 about 300 tons of black oil with contaminated water was collected from the site by workers of the boiler house. A new oil separator was built near the coast in 1995 and it was connected to the storm water sewerage system in the spring of 1996.

The soil near the boiler house still contains large quantities of black oil. As the scale of the oil contamination is very large, more efficient pumps and separators are required for pumping oil and contaminated water out of the pools and ditches, etc. While pumping may represent a short term remedy to contain the situation, this method alone is inadequate to clean-up and control the situation on the contaminated site. The extent of oil contamination and any future risks must also be assessed.

1.2 OBJECTIVES

The main objective of this Feasibility Study is to provide material (technical and economical) for the authorities in Estonia to choose between the appropriate remediation alternatives, and assess the organisation and financing required for the clean-up activities to be carried out. The aim of the Feasibility study is to propose alternative methods for the actual clean-up works which will need to be executed under a subsequent implementation phase of the Paldiski Environmental Project.

The Feasibility Study has been carried out in three stages:

1. Prevent ongoing leakages or penetration of the black oil. This may be partly addressed by:

   a) Checking and thereafter sealing or renovating the leaking oil storage tanks, pump pipelines, valves etc.

   b) Preventing seepage of the oil into the sea by connecting the new oil separator to the storm water sewerage system at the latest by the spring of 1996.

   These have been carried out via separate ongoing works. Task b) was completed in the spring 1996, but task a) was not carried out during 1996.

2. Localise the black oil contamination to the site and nearby vicinity of the Boiler House.

   This involves the collection of black oil from the surface and ditches, which started in 1994 and continued in 1995 and 1996. Suggestions for improving the collection of oil are presented in this feasibility study.

3. Specify, via a feasibility study, the hydrogeological regime, the nature, extent, rate (quantity), and direction of movement of contaminants from the facility.

The feasibility study shall address the following areas of work:

1. Clean-up the area around Boiler House for free phase oil, and containing the contamination using the drainage systems and oil separators around the contaminated area.
2. Excavation and remediation of contaminated soil that is surrounded by the subsurface concrete walls and covered with concrete slabs.
3. Excavation and remediation of contaminated soil outside the area covered with concrete slabs.
4. Assessment of the groundwater and soil clean-up works that result in the removal of the free oil phase from the groundwater surface.
5. The level of clean-up required to fulfil the criteria values for soil and groundwater as shown in appendix 5.

The Estonian Authorities would determine which alternatives will be used on the basis of the feasibility study and the cost-benefit analysis.

1.3 PHASES OF THE PROJECT

The project has been carried out in three main phases as presented below.

1. Site inspection and preparing detailed work plan

Site inspection and preparation of a detailed work plan was undertaken together with the Estonian consultant Maves Ltd. The site inspection was based on the review of all existing relevant background material. A detailed work plan was prepared based on the site inspection. The work plan is shown in Appendix 1.

2. Field sampling and laboratory work inspection, supervision and support

Health and safety plan

Before undertaking the field work, a health and safety plan was prepared to reduce health and safety risk during the field work. It was discovered during the site visit and from the information presented, that there were no potential hazardous chemicals or other issues requiring special attention in this respect. A health and safety plan is presented in Appendix 2.

Field sampling plan

Field sampling and laboratory analyses were conducted in co-operation with the Estonian firm Maves Ltd. A field sampling plan is presented in Appendix 3.

3. Final report

The Final Report includes technical recommendations and economic analyses (cost benefit and cost-effectiveness) of the various alternatives as well as the time schedule for the works to be carried out and the organisation of the works.

2. DESCRIPTION OF THE SITE

Paldiski Peninsula is located about 50 km westwards from the capital Tallinn. The Paldiski Peninsula is located on the limestone plateau of Estonian northern coast between the Paldiski (Pakri) and Lahepere Bays, and ends in the North at Cape Pakri. The length of Paldiski Peninsula is 12 km, average width 5 km and the area around 40 km^2. Absolute elevation of the ground level on Paldiski Peninsula is 31 m at its highest point. The upper part of the plateau is formed of limestone with dictyonema shale, sandstones and blue clays openings in the lower part of the geological section. An average geological profile is given below(figure 2.1):

1-3 m of moraine and fill;
20 m of limestone;
3 m of dictyonema shale;
30 m of sandstone with intermediate clay layers;
65 m of blue clays;
90 m of sandstone;
Granite rocks at 180-190 m depth and deeper.

The Paldiski Peninsula is dominated by three groundwater aquifers:

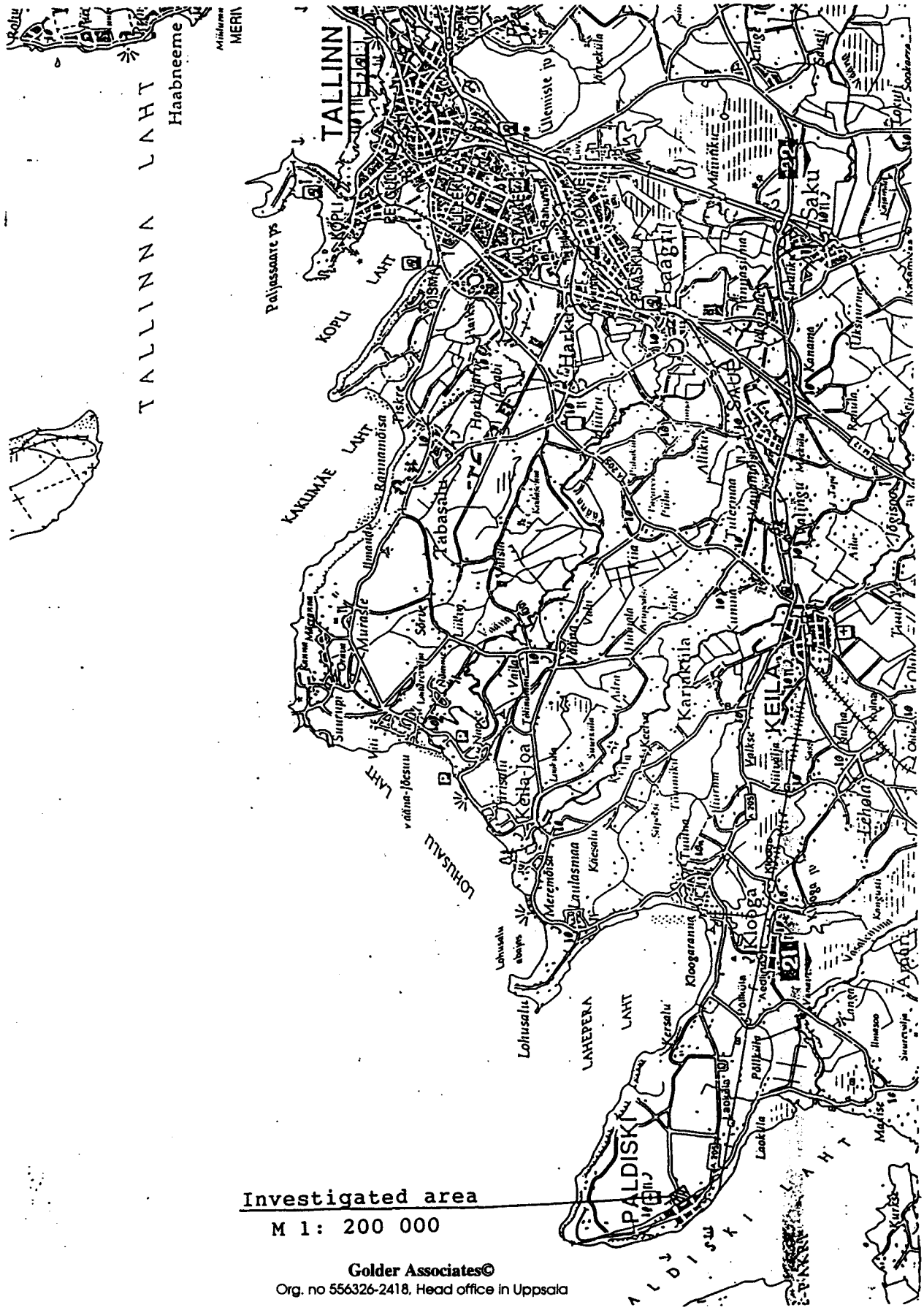
- The uppermost aquifer in the Ordovician limestone (O) is without any natural protection against the penetration of pollution. This aquifer is practically unused
- The second aquifer in the Ordovician-Cambrian (O-Cm)layers is relatively well protected by the overlying shales. This aquifer is used in some places for the local water supply.
- The third aquifer in Cambrian-Vendian (Cm-V) sandstones under the blue clay layer is well protected against the penetration by pollution. Paldiski town is supplied with water from this aquifer.

The central boiler house of Paldiski is situated in the western part of the Paldiski Peninsula in the eastern part of Paldiski town. The site of the boiler house covers an area of about 3.5 ha. The neighbours of the boiler house to the East and north are gardening co-operatives. It is bordered to the West by the city and a military unit, and on the South by empty, unused land. Before construction of the boiler house, the area was part of a Russian military site.

The power generating capacity of the boiler house is 32.5 MW. 12 000 tons of black oil was burned in 1994 and 4 000 tons in 1995. During the winter of 1995-1996, a 2000 m^3 reservoir for storage of heating oil was used. Oil loading pumps, pipelines and storage tanks leaks require repair. The boiler house is an out-dated facility and in need of a thorough reconstruction and renovation. Efficiency of the existing equipment and systems is low and the prime cost of heat is high.

The Paldiski Town Government has decided to renovate the boiler house at the old location. A new 6 MW boiler (wood, waste wood, etc.) was put into operation in March 1996. Paldiski town currently needs 12 MW of heat in the wintertime. Consequently, it is necessary to still employ one existing oil boiler.

Figure 2.1. Location of Paldiski.



Due to gross leakages, lasting for several years, thousands of tons of black oil have been flowing from the boiler house and the railway tanks into the soil. Large amounts of black oil are contained in the soil below the boiler house site which is covered with concrete slabs. The greater part of this contaminated soil is surrounded by a subterranean concrete wall, which should reach down to the limestone. The wall is incomplete and contamination at the surface has spread beyond the area surrounded by the wall. Construction of the storm drainage and sewage treatment facilities on the territory of the boiler house have not yet been completed.

For years the black oil has been flowing into the Paldiski Bay and the Baltic Sea from the site of the Paldiski boiler house. According to data (1992), approximately 160 kg of oil flowed daily into the sea. During the rainy periods this amount reached ca 400 kg per day. A new oil separator was built in 1995 and it was connected to the storm water sewerage system in the spring of 1996.

The Ministry of the Environment of Estonia has instructed Maves Ltd. and the Central boiler house of Paldiski to undertake the primary treatment of the black oil contamination. The aim has been to clean-up the black oil from the surface. About 350 t of black oil, containing about 50% water, was pumped out of the territory by the employees of the boiler house during the summer of 1994. Maves Ltd. Operations during Sept-Nov 1994 collected about 8 tons of separated black oil from the oil separator near the sea, and 244 tons from the site and the area around the boiler house. During 1995 about 300 t of black oil with contaminated water was collected from the territory by workers of the boiler house.

The soil near the boiler house still contains large quantities of black oil. As the scale of oil contamination is very large, more efficient pumps and separators are required for pumping oil and contaminated water out of the pools and ditches, etc. While pumping may represent a short term remedy to contain the situation, this method alone is inadequate to clean-up and control the situation related to the contamination at the site. The extent of oil contamination and future risks need also to be assessed.

The whole town of Paldiski and its environs have a central water supply. There are no boreholes nor pit-type wells near the boiler house thus we have received no information on the quality of groundwater around the boiler house.

3. FIELD AND LABORATORY INVESTIGATIONS

3.1 SITE INSPECTION

Site visits and discussions with the administration staff of the boiler house were carried out in September and October 1996. The main observations made during the site visits and the discussions are summarised below.

Discussions with the boiler house administration staff revealed that the central boiler house has been in use since 1964. In 1985, a new section was added onto the boiler house. The condition of the boiler house was not examined in detail.

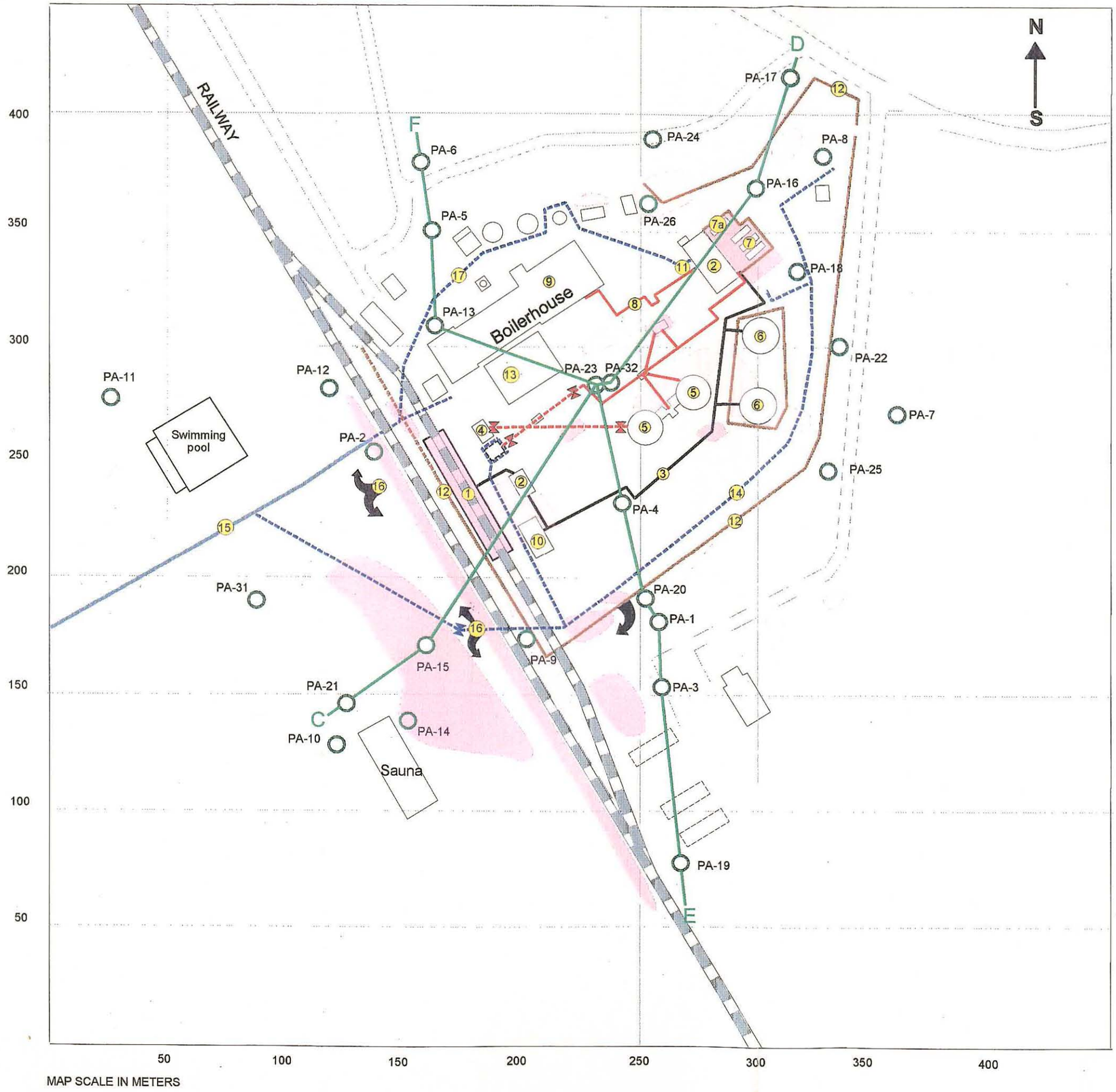
Free phase oil was observed in the concrete canals, drainage pipes, ditches and pits situated in the area of boiler house and to the south and west from the site. It was observed that when the water level rose, oil was spreading from the drainage pipes and the ground.

The subterranean concrete wall is visible in Western and Eastern sides of the area. These walls are connected together on the southern side of the site, but this part of the wall is underground and cannot be seen as the area has been infilled over the top of the subterranean wall. As the area does not have a working drainage system, water and oil flows from time to time over the concrete wall, carrying oil into the ditches near the adjacent railway.

The ground surface is stained with oil near the railway in the southern part of the area. Inside the boiler house area, the ground surface is mainly covered with concrete slabs and oil can be seen only in pits, concrete channels and in other structures. In the northern part of the site, the ground surface is also stained with oil in parts of the area.

Inside the boiler house area, no surface water could be observed, because of the presence of oil. The drainage pipes and wells in the southern and eastern part of the site were partly filled with water and oil. Free phase oil was flowing in the underground concrete channels for pipelines in the middle of the site. The only drainage line where oil was not observed, is located on the north side of the boiler house. The water in the ditches around the railway had an oily layer on the surface, except just after pumping. There was no visible oil in the drainage water, which discharges into the storm water system of Paldiski.

PALDISKI CENTRAL BOILERHOUSE



CONVENTIONAL SIGNS

- Polluted area, according to report of 1993
- Drainage and stormwater runoff pipeline
- Drainage and stormwater runoff pipeline into oil separator
- On-ground black oil pipeline
- Underground black oil pipeline
- Confining wall
- Closed underground black oil pipeline
- Closed drainage and stormwater runoff pipeline
- PA-10 Number of borehole
- Black oil outflow
- ① Railroad receiving junction for black oil
- ② Pump station
- ③ On-ground black oil pipeline
- ④ Underground black oil storage tank (not used)
- ⑤ Black oil storages 1000 m³
- ⑥ Black oil storages 2000 m³
- ⑦ Intermediate black oil storages 3 • 100 m³
- ⑦a Black oil storage tank, used as oil separator (100 m³)
- ⑧ Underground black oil pipeline
- ⑨ Central boiler house
- ⑩ Partically completed new pump station
- ⑪ Tanker unloading bay
- ⑫ Confining wall
- ⑬ Wood chips storage building
- ⑭ Drainage and stormwater runoff system
- ⑮ Drainage and stormwater runoff pipeline into oil separator
- ⑯ Drainage wells which have apparent indications of black oil outflow
- ⑰ Domestic and production (heating steam) wastewater system
- F—E Line of geological section

FIGURE 3.1 LOCATIONS OF INSTALLATIONS, BOREHOLES AND HOT SPOTS

There are four black oil storage tanks on the central boiler house site (locations are shown by number in figure 3.1):

No. 4 an underground intermediate tank of about 150 m^3, next to the railroad terminal

No. 5 an old storage area with two 1000 m^3 tanks, which were completed during the 1970's (photo no 3);

No. 6 a new storage area with two 2000 m^3 tanks, which were completed in the early 1990's (photo no 4);

No. 7 an intermediate black oil storage area with four horizontal 100 m^3 tanks, one of which has been converted into a separator (7a) (photo no 5).

During the current heating season (1996/1997), only one 2000 m^3 tank and the two 100 m^3 tanks are in use; the remaining above-ground tanks are not in use. One 1000 m^3 tank is empty, the other contains about 500 m^3 of a black oil and water mixture, and one 2000 m^3 tank contains about 180 m^3 of marine black oil (a lower viscosity oil used as fuel by the navy). The underground tank is also not in use. It is said to have been emptied, though not cleaned or removed, and contains oily water.

The old black oil storage area (2 x 1000 m^3 tanks) has reached the end of its useful life and is apparently the cause of most of the contamination at the site. As part of a construction project in the end of the 1980's, concrete slabs were placed on the areas of soil that were saturated with black oil.

The pipes in the area of the black oil complex (No. 3) are primarily placed in open, above-ground, reinforced concrete channels and their condition is therefore fairly easily visually observed. The piping would generally be suitable for use, if the leaks were repaired. The channels are partially filled with black oil due to a pipe leakage.

The present boiler house administration staff are aware of at least three larger accidental spills that occurred during the 1980's and 1990's, when a total of about 1500 tons of black oil flowed onto the ground surface and into the soil. According to unconfirmed information, during the time that the area was under Russian military control, there was also intentional and unconditional dumping of black oil onto the ground. No attempt was made to clean up the pollution; instead the contaminated ground surface was covered with new fill and later (in the entire boiler house area) with concrete slabs. The evidence that the soil of the boiler house site is saturated with black oil is demonstrated by the fact that when the foundation for the wood chip storage building (No. 13) was being constructed, a large amount of black oil flowed from the surrounding soil into the foundation excavations.

The Paldiski boiler house drainage system has not yet been completed. On the site there are presently old, unusable pipes, as well as new, incomplete pipes. Black oil which had previously flowed with the water to the city storm water runoff system (No. 15) during periods of high water levels, now collects in the runoff pipeline (No. 14) located to the south of the fuel tanks. Since large quantities of water containing black oil reached the city storm water system, the runoff pipes are presently closed (filled with cement). During the rainy seasons oil can be seen rising from between the concrete slabs and migrating

from the site to the south (photo 7). West of the railroad, near the borehole PA-15, and from there towards borehole PA-2, evidence of previous overflow of oily water and black oil could be seen in the manholes of the storm water runoff pipelines (No. 16) Free phase oil covers the surface of the drainage ditches in the western side of the site (photo 8). Based on the information provided by the administration staff, the only discharges from the boiler house area are domestic and production wastewater (No. 17), and also surface water that flows from shallow drainage ditches bordering the Northwest part of the area, which then discharges into the city storm water runoff system (No. 15) near borehole PA-2. The water that flows into the storm water runoff system occasionally has a film of black oil on its surface.

The city storm water runoff system is constructed from concrete sections, with joints that are not watertight. The runoff system conducts the flow to a new treatment system, constructed in March of 1996, that is located on the coast (photo 9). The nearby old treatment equipment is dilapidated and does not work. Although water flow from the new treatment system was not detected during the investigation, water containing black oil has previously flowed out through the old treatment system, which has resulted in contamination of the shoreline limestone cliffs with a film of black oil (photo 10). In October of this year, a relatively thick (1 - 2 cm) black oil layer was found on the water surface in the new treatment system. There is apparently a significant amount of black oil in the city storm water runoff system that conducts the flow to the treatment system during times of high water levels.

3.2 FIELD WORK

The field work was performed by Maves Ltd. in September and October of 1996, in accordance with the work programme. In all, 28 boreholes were drilled and soil samples were taken from 25 of the boreholes. Later, 11 of those boreholes were drilled to depths of 8.7 to 12.5 m, for the purpose of installing monitoring wells for taking water samples from the Ordovician aquifers of the upper limestone. Two boreholes were drilled to depths of 40 m, so that water samples could be taken from the Ordovician-Cambrian sandstone. The groundwater level was measured in each borehole that was drilled into the limestone or sandstone. The field work was performed during a time of minimum groundwater levels.

A schematic of the site, showing the locations of buildings and boreholes, is given in Figure 3.1. Depicted on the same figure are potential pollution sources and the locations of black oil contamination that have been detected during the earlier studies.

During the drilling of the boreholes and the taking of samples, progression was made from cleaner areas to the more polluted area, and a new split spoon sampler was used for each borehole.

The samples were placed into glass jars and bottles, and filled to the top before being tightly sealed. The wells were thoroughly pumped clean (developed) prior to taking the

water samples. The groundwater pump MP-1 was used for taking water samples, using a new sampling tube for each well.

3.3 LABORATORY ANALYSIS

A total of 28 soil samples were taken, of which 21 were analysed in a laboratory. Twelve water samples were taken. Soil samples that were obviously seen to be contaminated were not analysed. All samples were kept refrigerated until they were shipped to the laboratory. Most of the samples were analysed in the Estonian Environmental Research Centre, but some were also analysed in the Swedish AnalyCen Nordic AB Laboratory.

In addition to the infra-red analysis, some of the analyses in Sweden were also done using a gas chromatograph, to determine the nature of the hydrocarbon contamination.

3.4 RESULTS

3.4.1 Geological and Hydrogeological regime

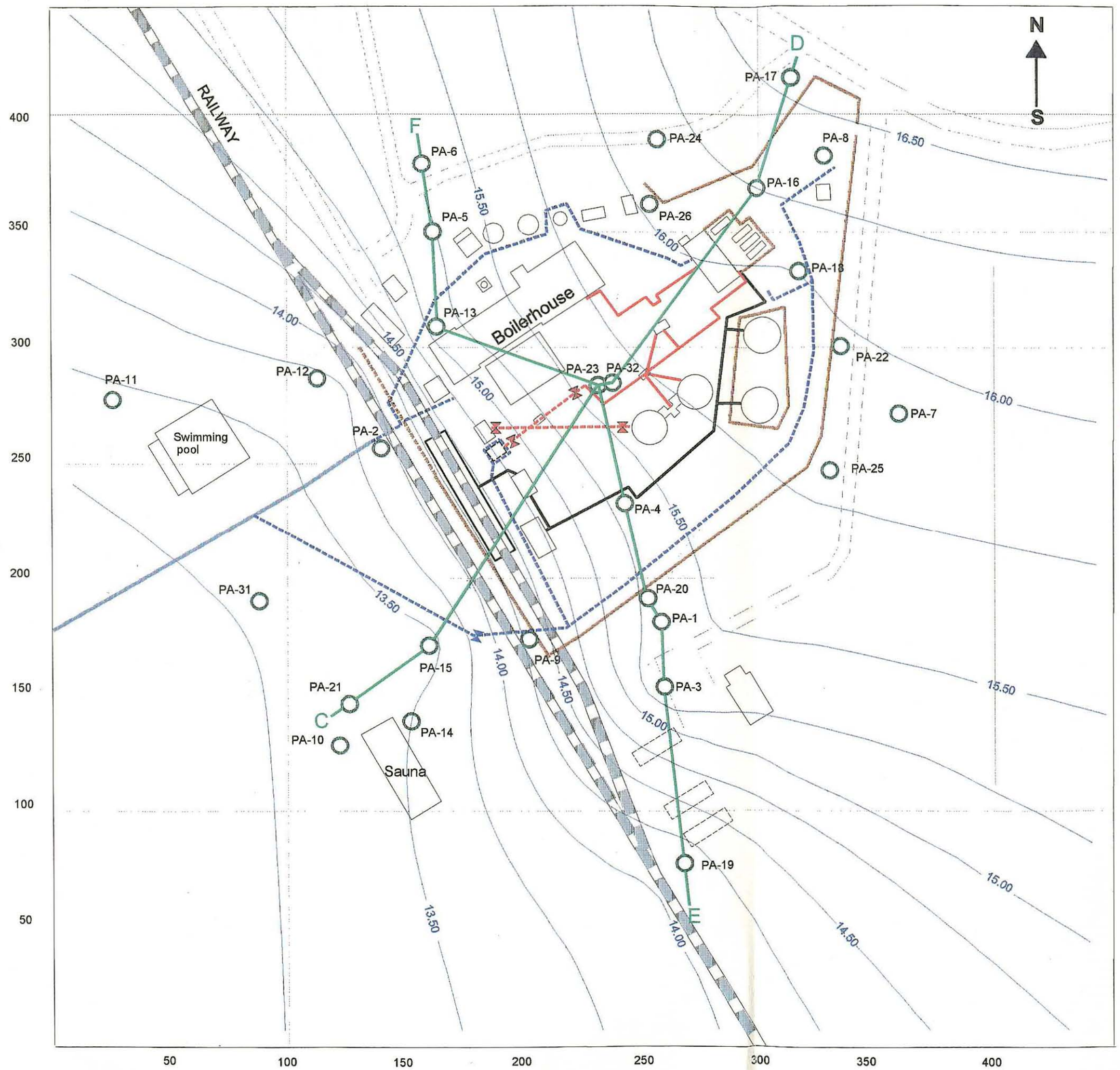
The area investigated as part of this study has a thin ground cover primarily made up of a fill layer (0.4 - 2.2 m). The fill layer is thickest in the boiler house area and near the railroad. Most of the area occupied by the boiler house is covered with concrete slabs that have a thickness of about 0.15 m. The locations of the boreholes and geological profiles are shown in Figure 3.4.1, and the geological cross-sections are presented in Figures 3.4.2 - 4.

Underlying the surface material are middle and lower Ordovician formation limestones and lower Ordovician sandstones, as well as lower Cambrian aleurolites and sandstones.

The surface of the limestone is at a depth of 0.8 - 2.2 m from the ground surface, at an absolute elevation of 13.25 - 16.15 m. The limestone surface is slightly rolling, and slopes to the Southwest. The limestone is clayey and has marl layers, with dolomite in some places. The upper part of the limestone does not have large fissures and is relatively monolithic. The lower part of the Lower Ordovician subsystem, which lies below the limestone, is composed of glauconite clay and dictyonema shale that has a total thickness of 8 m. Below these is sandstone layer containing thin dictyonema and clay intermediate layers, with a total thickness of 2.5 - 3.0 m.

The Lower Cambrian aleurolites and sandstones that lie below the Lower Ordovician sandstone were also drilled into, in the range of 9.5 - 11.5 m.

The layer of glauconite clay and dictyonema shale, which is up to 8 meters thick, acts as a barrier between the two aquifers: the aquifer in the fissured section of the limestone and the sandstone aquifer underlying the glauconite clay and dictyonema shale.



PALDISKI CENTRAL BOILERHOUSE

CONVENTIONAL SIGNS

- 16.50 — Groundwater table isolines
- Drainage and stormwater runoff pipeline
- Drainage and stormwater runoff pipeline into oil separator
- On-ground black oil pipeline
- Underground black oil pipeline
- Confining wall
- Closed underground black oil pipeline
- Closed drainage and stormwater runoff pipeline
- PA-10 — Number of borehole
- F — E — Line of geological sections

FIGURE 3.2 GROUNDWATER TABLE ISOLINES

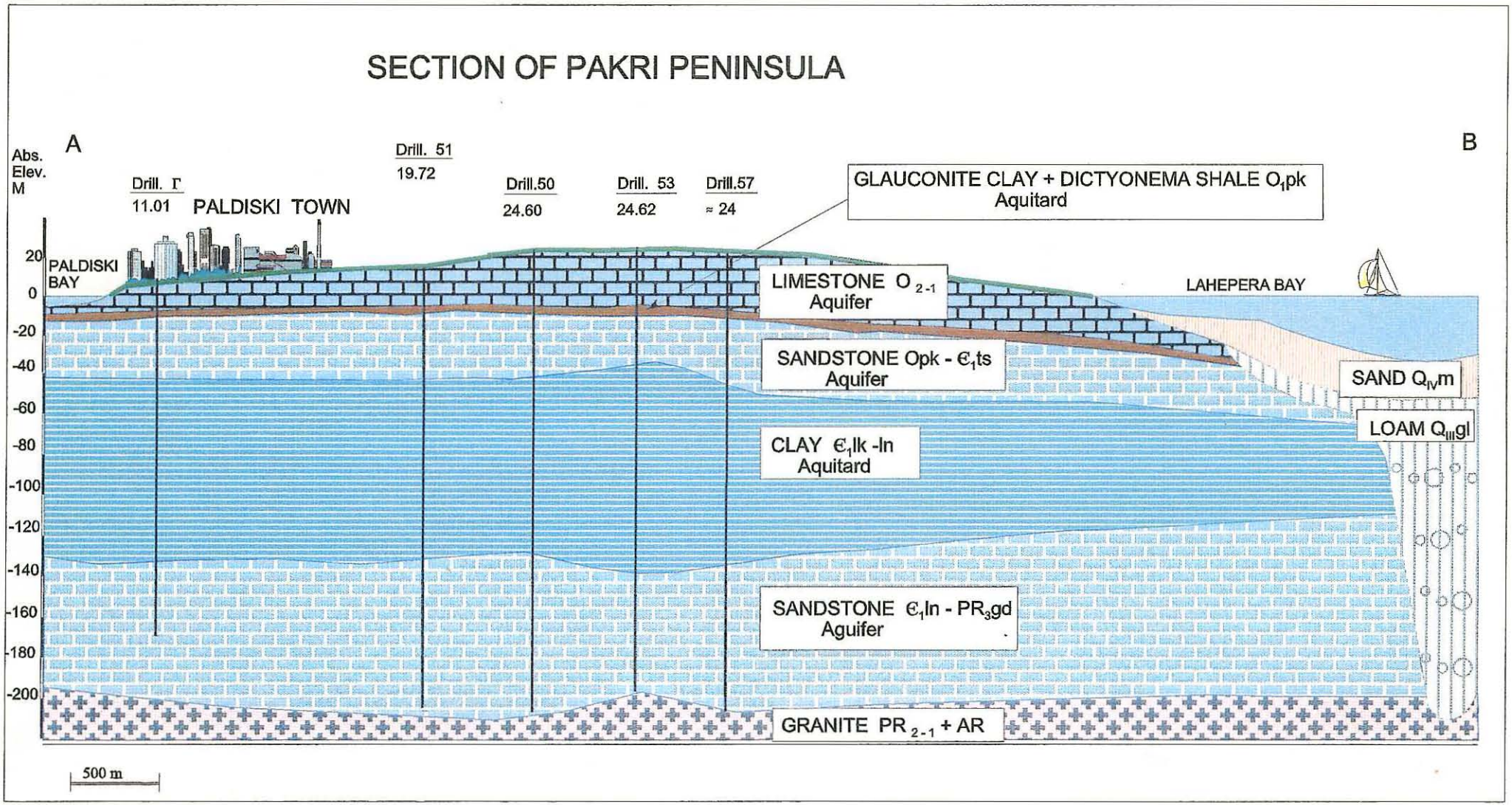


FIGURE 3.3 SECTION OF PAKRI PENINSULA

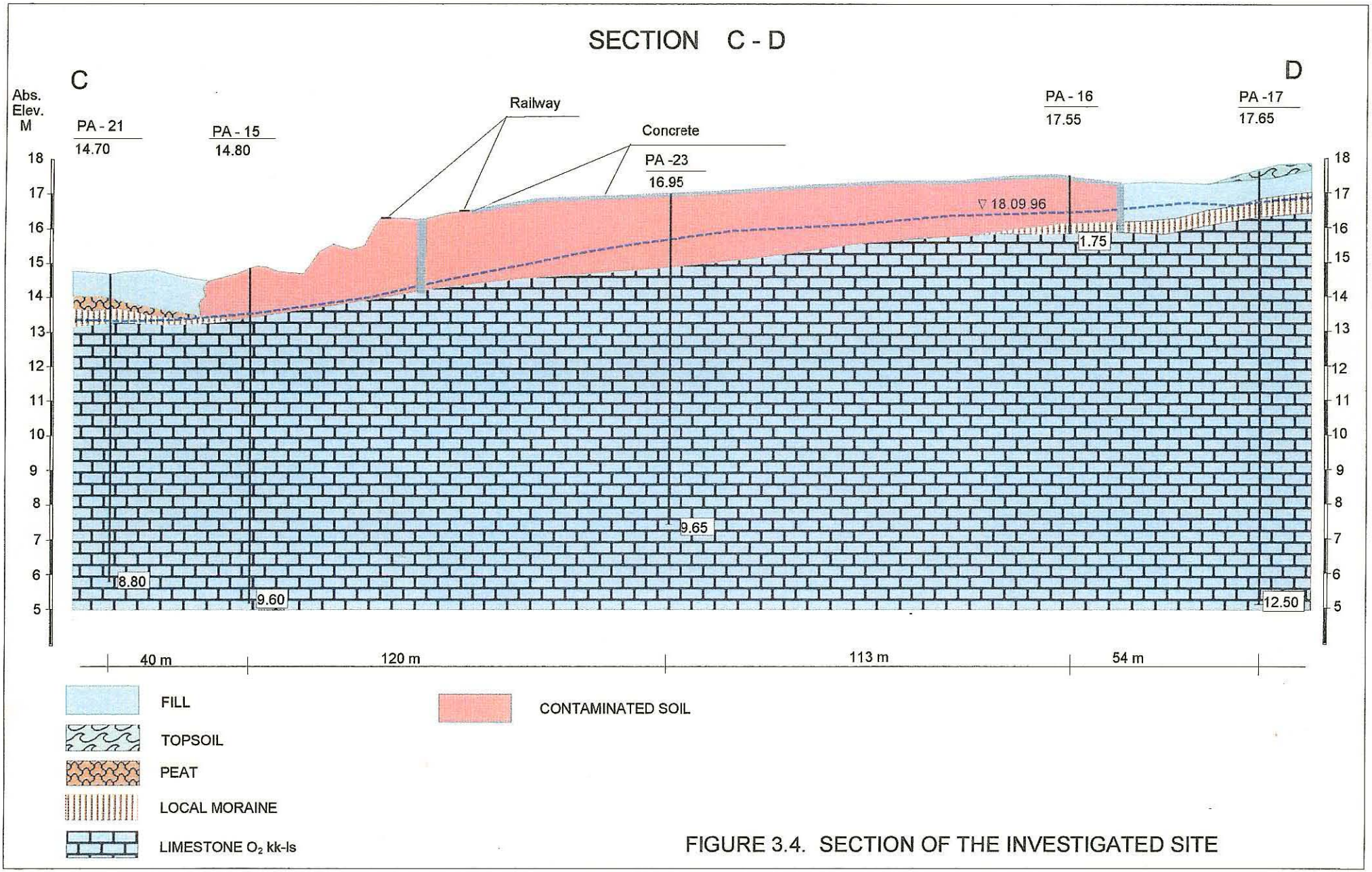


FIGURE 3.4. SECTION OF THE INVESTIGATED SITE

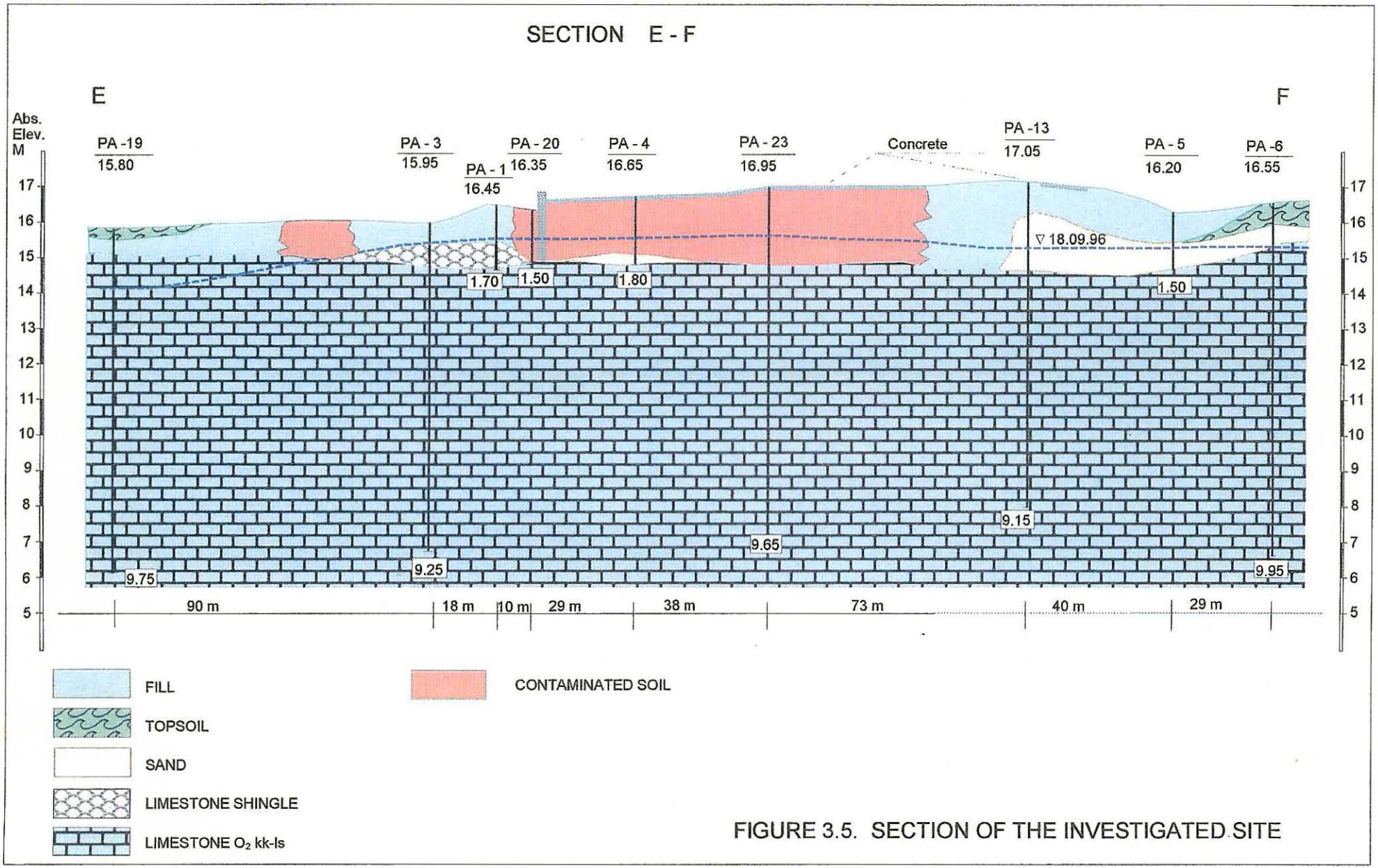


FIGURE 3.5. SECTION OF THE INVESTIGATED SITE

The water level in the limestone aquifer was 0.55 - 1.85 m below ground level at the time of the investigation (18.09.96), with an absolute elevation of 13.4 - 16.6 m. The water level decreases to the Southwest and the water flows towards the sea. The aquifer is recharged by precipitation at that location, and by groundwater flowing from northeast of the boiler house area, that is the central part of the Paldiski peninsula.

The water level in the sandstone and aleurolite aquifer was 14.7 - 16.8 m below the ground surface at the time of the study, at an absolute elevation of 0.25 m. The aquifer is recharged by water from overlying aquifers and drains towards the sea.

The limestone aquifer is unprotected from pollution migrating from the ground surface because of the thin surface cover. The sandstone aquifer is relatively protected from pollution.

3.4.2 Contamination of Soil

The concentration of oil products in the soil was determined both in Estonia and Sweden using infrared analysis. (The methodology of infrared analysis is described in Appendix 4.) The infrared analyses results are presented in Table 3.1.

Table 3.1. Oil Product Concentration in Dry Soil as Determined Using Infrared Analysis (mg/kg)

Borehole No.	Sampling Depth	Oil Products, mg/kg	Borehole No.	Sampling Depth	Oil Products, mg/kg
PA-1	1,7	<10	PA-14	0,8	<10
PA-2	1,0	17,3	PA-15	0,7	**15220**
PA-2*	1,2	45	PA-16	1,2	**6667**
PA-4	1,7	230	PA-16*	1,2	2000
PA-5	0,8	<10	PA-17	1,0	<10
PA-7	0,4	<10	PA-18	1,5	**7515**
PA-7	1,0	<10	PA-21	1,0	<10
PA-8	1,0	206	PA-21	1,3	401
PA-9	1,5	**30659**	PA-22	1,0	**6708**
PA-12*	0,6	5,4	PA-25	1,0	**11178**
PA-13	0,5	1955	PA-32	0,5	309
PA-13	1,6	132	PA-32	1,5	3356
Concentration Limits in Soil, mg/kg	Reference Value	100	Concentration Limits in Soil, mg/kg	Reference Value	100
	Remediation Investigation Value in Industrial Zone	**5000**		Remediation Investigation Value in Industrial Zone	**5000**

*) Samples analysed in Swedish laboratory

The contaminant limits in the tables 3.1 - 4 are based on the Estonian preliminary environmental quality objectives for the contaminants in soil and groundwater. They are presented at two levels:

- The reference value is the environmental contaminant concentration, which is considered as not harmful to humans or the ecosystem;
- The value for a remediation investigation is the contaminant concentration that, if it is exceeded, will require determination of whether the site should either be remediated or isolated from the surrounding area.

The most contaminated sampling points were the boreholes PA-4 and PA-20 in which free phase oil was observed (photos 11 and 12). Soil sample PA-4 was taken from the sand layer at a depth of 1.6 to 1.8 m which was under the oil layer. Pores in the soil samples PA-9 and PA-15 were partly filled with free phase oil.

The gas chromatograph analysis results for soil samples are presented in Table 3.2.

Table 3.2. Oil Product Concentration in Dry Soil as Analysed Using Gas Chromatography in a Swedish Laboratory (mg/kg)

Borehole No.	Sampling Depth	Oil Products, mg/kg	PAH, mg/kg		Type of Contamination
			Benzo(a)pyrene	Total	
PA-9	1,5	**29000**			diesel + black oil
PA-15	0,7	**25000**			Diesel + black oil (lighter fraction)
PA-23	2,0	**11000**	0,2	<5	diesel + black oil
Conc. Limits in Soil, mg/kg	Reference Value	100	0,1	5	
	Remediation Investigation Value in Industrial Zone	**5000**	**10**	**200**	

As can be seen in Table 3.2, the type of contamination is primarily diesel and black oil.

The total PolyAromatic Hydrocarbon (PAH) concentration in borehole PA-23 was below the reference value, although the concentration of benzo(a)pyrene, the only individual component that is limited in Estonia, had exceeded the reference value (0.2 mg/kg). Other results of PAH-analyses are shown in appendix 4.

As a result of field observations and the laboratory analysis, the following conclusions have been reached. The ground in the southern part of the boiler house area inside the confining underground wall is the most contaminated area of the site. There is a free phase oil layer in the ground and the soil pores are filled with oil products. The thickness of the oil layer is about one meter at the sampling point PA-4. Oil is moving towards the

Southwest with the groundwater down the hydraulic gradient. The underground confining wall is limiting the flow (photo 13). Still, when water level is high, oil and water flow over the edge of the wall and spreading onto the ground around the wall.

In the area surrounding the most polluted areas of the site (contains free phase oil), the oil content of soil is around 5 000 - 30 000 mg/kg. The total area, where the oil concentration in the soil exceeds 5000 mg/kg is approximately 3.5 ha.

3.4.3 Contamination of Water

The concentration of oil products in the groundwater was determined in 11 wells and one surface water body (the fire protection pond - see map in Appendix 2). Water samples from wells PA-15 and PA-23 were not analysed, since there was a film of oil on the water surface and it was obvious that contamination was present. The oil product concentration in the water samples is presented in Table 3.3.

As indicated in Table 3.3, the total oil product concentration does not exceed the corresponding remediation investigation value (600 µg/l), although it does exceed the reference value in the water in wells PA-3 and PA-21. Trace levels of oil were also found in wells PA-13, PA-17 and PA-18.

The layer of black oil in the water sample taken from PA-15 was approximately 0.5 cm thick and remained distinctly separate on the surface of the water. Floating under this layer were round drops of black oil, which had apparently aggregated around some particles (mineral particles or bacteria), and which had a specific gravity similar to that of water.

Aromatic, polyaromatic and other mineral oil components were found in the water samples from the boreholes located in the south and Southwest of the site (sampling points PA-3, PA-21). Traces of these components were also found in water samples taken from the northern side of the boiler house (sampling points PA-13, PA-17 and PA-18).

The concentrations of heavy metals were determined in Estonia for Cd, Pb, Hg, and As in boreholes PA-3, PA-12, PA-13 and PA-18, and in Sweden for 19 different heavy metals in boreholes PA-7 and PA-21. The results of the analyses are given in Table 3.4 and in Appendix 4. Barium (Ba) was the only heavy metal for which the concentration exceeded the reference value. The concentration of Barium did not exceed the value for remediation investigation (guidance value).

Table 3.3. Oil Product Concentration in Ground Water from Gas Chromatography Analysis (µg/l)

Bore Hole No.	Depth of Bore Hole,m	Depth to Water,m	Aromatic Hydrocarbons					PAH	Total Oil Products	Phenols	Type of Contamination
			Benzene	Toluene	Xylenes	Indene, Ind. Deriv.	Total				
PA-7	9,30	1,00	<0,1	<0,1	<0,1	<0,1		<0,2	<10 <20*	-	
PA-19	9,75	1,70	<0,1	<0,1	<0,1	<0,1		<0,2	<10	-	
PA-3	9,25	0,55	<0,1	0,2	0,8	43,4		**148,3** 0,7...<2,2*	299,3	no	Degraded Oil Products
PA-21	8,80	1,30	<0,1	0,4	1,0	7,1		**18,2** 1,6...<3,1*	55,1 52*	no	
PA-31	39,0	14,75	<0,1	<0,1	<0,1	<0,1		<0,2	<10	-	
PA-12	8,75	1,45	<0,1	<0,1	0,1	<0,1		<0,2	<10	-	
PA-17	12,5	1,05	<0,1	1,0	1,5	<0,1		traces	traces	trace	Degraded Oil Products
PA-6	9,95	1,20	<0,1	<0,1	0,3	<0,1		<0,2	<10	-	
PA-32	40,4	16,80	<0,1	<0,1	<0,1	<0,1		<0,2	<10	-	
PA-18	9,10	1,40	<0,1	0,2	0,2	<0,1		traces	traces	no	Degraded Oil Products
PA-13	9,15	1,85	<0,1	0,2	0,7	<0,1		traces	traces	no	
Fire Pond			<0,1	<0,1	<0,1	-		-	<10	-	
Concentration Limits in Ground Water, µg/l		Reference Value	0,2	0,5	0,5	-	1	0,2	20	0,5	
		Remedediation Invest. Value	**5**	**50**	**60**	-	**100**	**10**	**600**	**50**	

*) Sample analyzed in Swedish laboratory

To summarise, it may be said that in the vicinity of the boiler house, the groundwater found in the surface material and the upper limestone is contaminated with oil products, as is the ground water in the fissured upper part of the limestone. Contaminated water is flowing from the site to the Southwest. Traces of heavy metals were found in ground water connected with limestone, but none of them exceeded the value for remediation investigation. The aquifer connected with the sandstones lies at a depth of 25 - 40 m and is not contaminated with oil products.

Table 3.4. Heavy Metal Concentrations in Ground Water, µg/l

Borehole No.	Borehole Depth, m	Depth to Water, m	Heavy Metals, µg/l				
			Cd	Pb	Hg	As	Ba
PA-3	9,25	0,55	<0,10	<1,00	<0,05	<1,00	-
PA-7*(34)	9,30	1,00	0,1	<0,2	<0,2	4	104
PA-12	8,75	1,45	-	<1,00	<0,05	-	-
PA-13	9,15	1,85	<0,10	<1,00	<0,05	<1,00	-
PA-18	9,10	1,40	<0,10	<1,00	<0,05	<1,00	-
PA-21*	8,80	1,30	0,67	<0,2	<0,2	3	138
Concentration Limits in Soil, µg/l 1)		Reference Value	1	10	0,4	5	50
		Value for Remed. Invest.	**10**	**200**	**2**	**100**	**700**

*) Sample analysed in Swedish laboratory

1) The meaning of limits are described in section 3.4.2

4. SCREENING LEVEL RISK ASSESSMENT

4.1 CONTAMINANTS

The main contaminants at the site are heavy oil and diesel fuel. Soil and water have been contaminated at the site. The potential risk of the migration of the oil is increased by the following:

- free phase oil on the ground surface (from leaking tanks, pipes, etc.)
- surface soil < 0.5 m depth
- Subsurface oil > 0.5 m depth
- Contaminated water

Contaminant sources are presented in the preliminary conceptual model presented in figure 4.1.1.

4.2 RELEASE MECHANISMS

Wind erosion, volatilisation, leaching and water erosion represent the potential routes for the release of the contamination into the general environment.

Both free phase and dissolved hydrocarbons have been released to the groundwater and surface water. The presence of free phase oil on the surface may also result in the release of hydrocarbons through volatilisation to the air. The soil may also become contaminated when the oil is spread through the movement of water across the area.

Contaminated surface soil can also represent a potential source of material for ingestion and dermal contact without any particular release mechanism. In addition, wind erosion can form dust that can be eaten (ingestion) or breathed in (inhalation). Water erosion may also occur and the surface water may be contaminated.

Contaminated subsurface soils may result in leaching to the groundwater and volatilisation into buildings.

Contaminant release mechanisms are presented in the preliminary conceptual model in figure 4.1.

4.3 ENVIRONMENTAL TRANSPORT AND RESIDENCY MEDIA

The main environmental transport and residency media are the contaminated surface soil, soil derived dust, surface water and groundwater. Soil gas is not regarded as a significant risk as the contaminants (black oil and diesel fuel) are not very volatile.

Surface water and water in the fill materials are heavily contaminated at the site. The uppermost groundwater aquifer in the limestone is contaminated with hydrocarbons (the water is not used for drinking). The second aquifer in upper sandstone layer is not contaminated (the water is used for drinking supply in some parts of Paldiski Peninsula, but not in Paldiski Town). The third aquifer is not contaminated. Paldiski is supplied with water from this aquifer.

Environmental transport and residency media are shown in the preliminary conceptual model in figure 4.1.

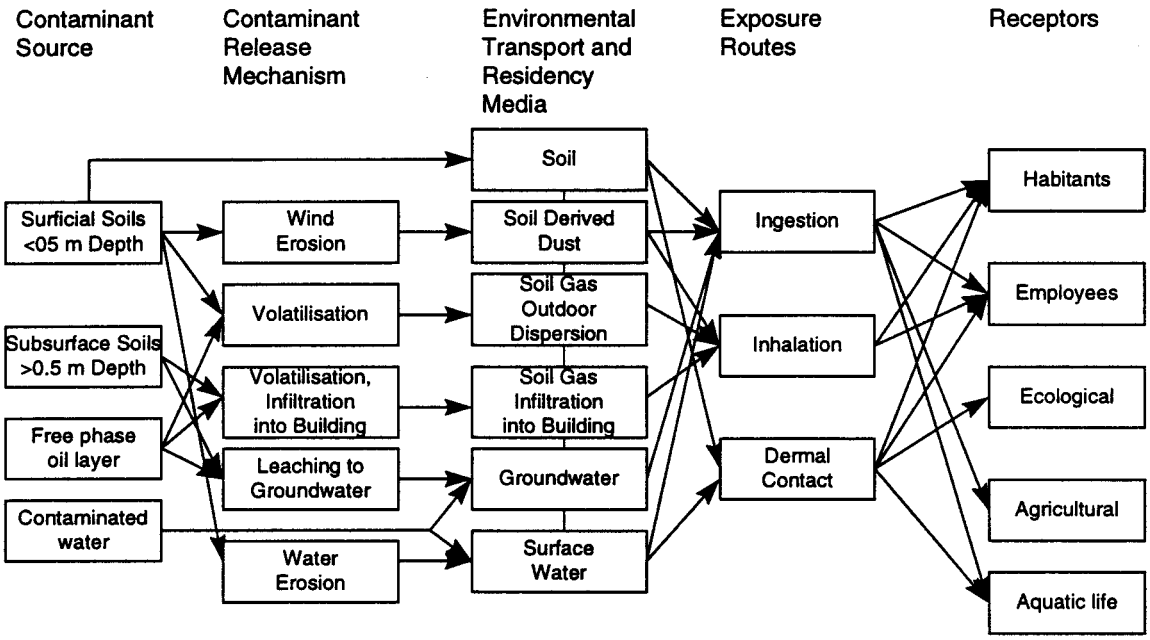


Figure 4.1 Preliminary conceptual model.

4.4 EXPOSURE ROUTES AND RECEPTORS

Exposure routes for biological organisms are ingestion (eating), inhalation (breathing) and dermal contact (touching).

Potential receptors are

- People, who are living near the site and can gain access to the contaminated area (inhabitants)
- People, who are working at the site (employees)
- wild animals and plants which are situated, living or can gain access to the contaminated site (ecological)

- Domesticated animals, which are living near the contaminated site (agricultural)
- Aquatic animals and water plants (aquatic life)

Exposure routes and potential receptors are presented in the preliminary conceptual model in figure 4.1.

Aquatic receptors are potentially affected by the surface water run-off through the storm water system. However, if the oil-water separators are maintained, this exposure route will be controlled. Groundwater does not represent an exposure route to aquatic life, as the natural attenuation degrades the organic contaminants before groundwater migrates through the ground and reaches the sea.

4.5 RISK MANAGEMENT

The possible exposure pathways for every potential receptor are shown in the preliminary conceptual model shown in figure 4.1. Some of these pathways do not pose a significant risk due to the properties of the contaminants and the hydrogeological environment. Other pathways could be controlled by the proposed actions for the site, in other words by managing the risks.
Contaminated surface soils should be remediated, excavated and removed, or covered by at least 0.5 m thick soil layer to prevent volatilisation, wind erosion, water erosion and touching or eating of the contaminated soil. Possible methods are discussed in section 5.3.

Free phase oil must be pumped away from the ground and open pits, drainage lines and other open structures to reduce volatilisation and the spreading of the oil. The contaminated area should also be drained to reduce spread of hydrocarbons by ground and surface water flow.

Remediation of contaminated subsurface soils will reduce possible volatilisation into the buildings and leaching into the water.

Drainage of the contaminated area will reduce the contamination of the water outside the limits of the contaminated soil. There is currently no use of the groundwater in uppermost aquifer which is contaminated. Because water in middle aquifer in the upper sandstone layer is not contaminated and there is currently no use of this groundwater downgradient of the site, there will be no need for remediation of contaminated groundwater whilst the situation remains as it is at present. Furthermore, there is practically no risk of contamination of deepest aquifer in lower sandstone layer. However, monitoring of groundwater should be carried on to observe the hydrocarbon concentrations in groundwater. Surface water should be drained through an oil separator before being discharged to the sea.

After implementing the suggested remedial actions, surface water will remain the main source of potential risk.

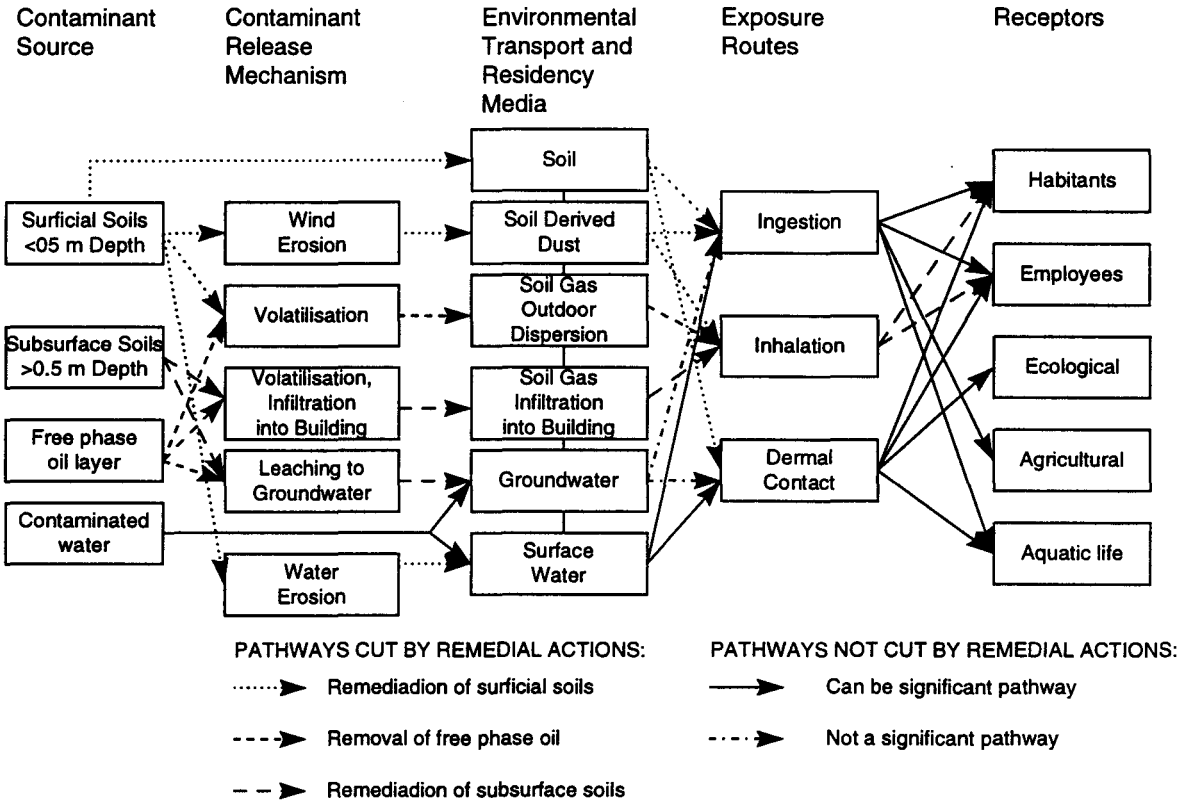


Figure 4.2 Conceptual model after risk management actions

The conceptual model, where risk management actions have been taken into account, is shown in figure 4.2. As shown, most of the potential pathways have been eliminated by the proposed actions, with contaminated surface water being the only remaining pathway that may pose a risk to human health and the environment. After implementing the suggested remedial actions, the risks associated with the contamination of surface water will decrease.

5. SUGGESTED REMEDIAL ACTIONS

5.1 PREVENTING ONGOING AND FUTURE LEAKAGES

5.1.1 Repairing of Pipelines and other Structures

Oil pipes and oil tanks should be pressure tested and repaired if necessary to prevent any future leakages of oil to the ground and groundwater. Other remedial actions should not be implemented until this has been done. Actions should include following:

- emptying and demolition of the two 1000 m^3 oil tanks (no 5), which are out of use. Tests and repairs should be carried out if it is planned to use the tanks again in the future.
- testing and repairing of the two 2000 m^3 oil tanks (no 6), which are in use
- testing and repairing of the four 100 m^3 oil tanks (no 7), which are in use
- testing and repairing of the oil pipes (no 3 and 8), which are in use
- emptying, plugging and demolition of oil pipes, which are not in use
- demolition of the old underground tank (no 4), which is not in use

5.1.2 Construction of Storm Water Pipes and Oil Separators

The storm water system should be completed so that run-off water does not flood onto the neighbouring area and does not cause spreading of oil from the pipelines into the surrounding environment. Drained water should be fed through oil separators and observation pools away from the area. Drains that currently discharge water to the southern corner of the site should be redirected to a new oil separator that should be built at the site. The suggested place for the oil separator and observation pool is the area to the south of the facility and to the east of the railway (the planned area of refinery). The oil separator should be dimensioned so that it will also work during heavy rain and the melting of snow.

All storm water in the southern part of the site should be fed through the oil separator. A new drain should be built from the oil separator to the storm water line (no 15), which leads to the existing oil separator on the coast. The best location of new drain is the place of the present plugged drain to avoid the need for blasting of the limestone.

5.1.3 Handling of Oil in the Facility

The handling of the oil should be carried out so that it does not result in new spillages to the ground and groundwater. Otherwise, the proposed remedial actions will be ineffective.

Unloading of the trains might be one of the most significant reasons for the contamination of the area. According to the information received from the personnel of the boiler house, oil has not been delivered by train since February 1996. The cisterns in the unloading area

are badly contaminated with oil and the free phase oil should be pumped away (a detailed discussion is presented in section 5.2 below).

The oil is transported at present by tanker trucks. A primitive mechanism for unloading the black oil from the trucks (No. 11) has been constructed outside the pump room. Environmental protection equipment that would prevent contamination in the unloading area or the spread of contamination should be constructed. The volume of the protection basin should be at least the volume of the tank of the truck.

The handling of the oil in the area of the four 100 m^3 storage tanks is possibly one reason for the pollution of the area and represents a source of risk of future leakages to the ground. The handling procedures for the oil should be changed so that oil is stored in the tanks and the protection basin be kept clean and empty during normal operations. Only then can the basin work as an emergency basin and the leaks from the tanks be observed. In addition, there is no proof as to the integrity of the basin to ensure that it does not leak oil to the ground and groundwater.

5.1.4 Oil Separator on Shoreline

The new oil separator was constructed in March 1996 near the coast in Paldiski. The separator was constructed so that if the metal plate in the end of system is in the upper position, oil will spread into all sections of the separator. In this case, the system will not operate properly. The metal plate should be locked so it can not be lifted by mistake. When the system is working as it was designed to, oil will be fed to the first section and can be pumped off. This first section should then be emptied of any water to ensure that it will function correctly.

The oil separator should be emptied when needed, based on observations at regular intervals. The first section, in which the oil is collected, should be emptied on a regular basis to ensure that it does not fill up with water. If other sections are found to contain oil, it should be removed. When oil has been removed, the separator should be filled with water, except the first section, which should remain empty.

It is suggested, that oil from the oil separator should be separated from water in the boiler house area where free phase oil will be pumped from the ground.

5.1.5 Proposed Remediation Schedule

Remedial actions that are targeted to reduce future leakages, should be carried out with no delay. Other actions will be useful only after these have been carried out.

The preliminary time schedule is as follows:

- Checking and repairing of the pipelines and other structures: IMMEDIATELY
- Construction of the storm water pipes and oil separators: AS SOON AS POSSIBLE

- Improving the handling of oil in the facility: IMMEDIATELY and continuously
- Improving the management of the oil separator on the coast: IMMEDIATELY and continuously in every month or four times in a year depending, how much oil is entering the separator.

In practice, it is not possible to execute these actions until, at the earliest, spring 1997.

5.1.6 Cost estimates

The testing and repairing of the tanks no 6 and 7 and the pipelines (Section 5.1.1) will cost round 0.6 million EEK. The cost will vary over a large range depending on the extent of the repair required. The cost of demolition of the tanks no 5 and 4 has not been estimated.

The cost of the new oil separator, through which drainage water should be conducted, will depend on the type of construction of the separator (Section 5.1.2). The type of oil separator, that was constructed in March 1996 near the coast in Paldiski, cost around 250 000 EEK. A smaller oil separator would cost about 150 000 EEK. About 200 m of new storm water pipes should be built, this will cost from 100 000 to 200 0000 EEK depending on whether it is the replacement of old pipeline or new pipeline (320 to 720 EEK per meter and including about 5 inspection wells, 6 600 EEK per each). Construction of the drain under the railway will result in extra costs.

The improvement of the handling of the oil in the facility (Section 5.1.3) may demand more labour work and new equipment. The man labour will cost from 700 to 1 000 EEK per day. The total costs of this work has not been estimated.

Inspection of the oil separator near the coast (Section 5.1.4) should be carried out at least once a month and it could be included in the control over the remediation work on the site of the boiler house. In the rainy season and when the snow is melting the oil separator should be controlled once a week. Emptying of the oil separator will cost about 1 000 EEK at a time, which totals around 20 000 EEK per year.

5.2 REMOVING THE SOURCE OF OIL CONTAMINATION

5.2.1 Removal of the oil from pipelines and other structures

Free phase oil should be pumped from the pipelines and other structures through oil traps and observation basins to the sewerage system. This must be carried out before commencing the other remediation work. The cleaning should include all of the oil products from the sewers (no 14), pipeline channels (between tanks no 4- 7 and boilerhouse no 9 and pump stations no 2) and other structures (such as railroad junction no 1). The locations, where oil enters the structures should be checked, repaired and cleaned at the same time.

It is possible that in the southern part of the site, oil enters the structures from the ground. In this case, these structures should be emptied at the same time as free oil is removed from the ground.

5.2.2 Removal of oil from the surface of the groundwater

Free phase oil should be pumped off the ground and from the surface of the groundwater. Oil and water will be pumped through oil traps and observation basins to the sewerage system. This must be carried out before commencing the other remediation work

Periodic pumping is not sufficient, because oil leaks slowly from the ground and replaces removed oil. Pumping of the oil should be executed as a continuous controlled process. The problem to be resolved is how to transfer the oil from ground to the pumping structures. One of the most effective methods can be to use trenches filled with coarse gravel (grain size 30 - 60 mm or the average grain size of the available formation). These feed trenches would be situated across the water flow. If the use of the area and the authorities allow, feed trenches can be connected by open conductor trenches to the collection pond. When the oil is removed from the pond, new oil will be drawn in from the ground through the trenches. The generalised layout of an open trench system is shown in figure 5.1. If the use of open conductor trenches is not permitted, collection ponds should be placed on the end of each feed trench.

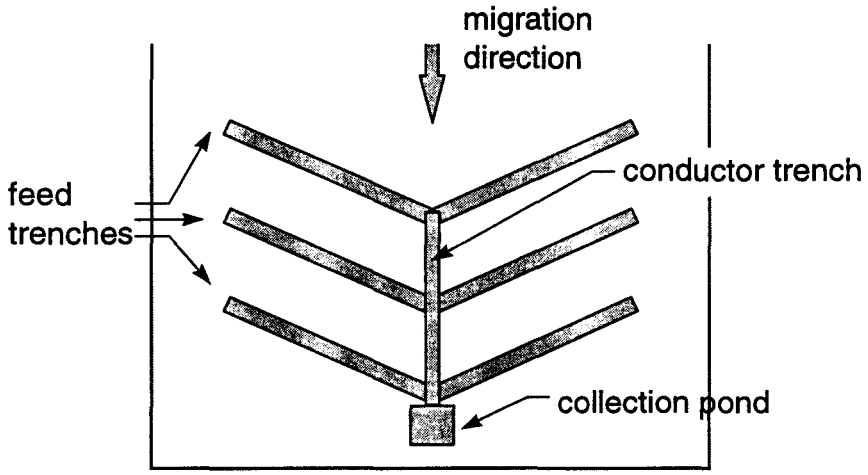
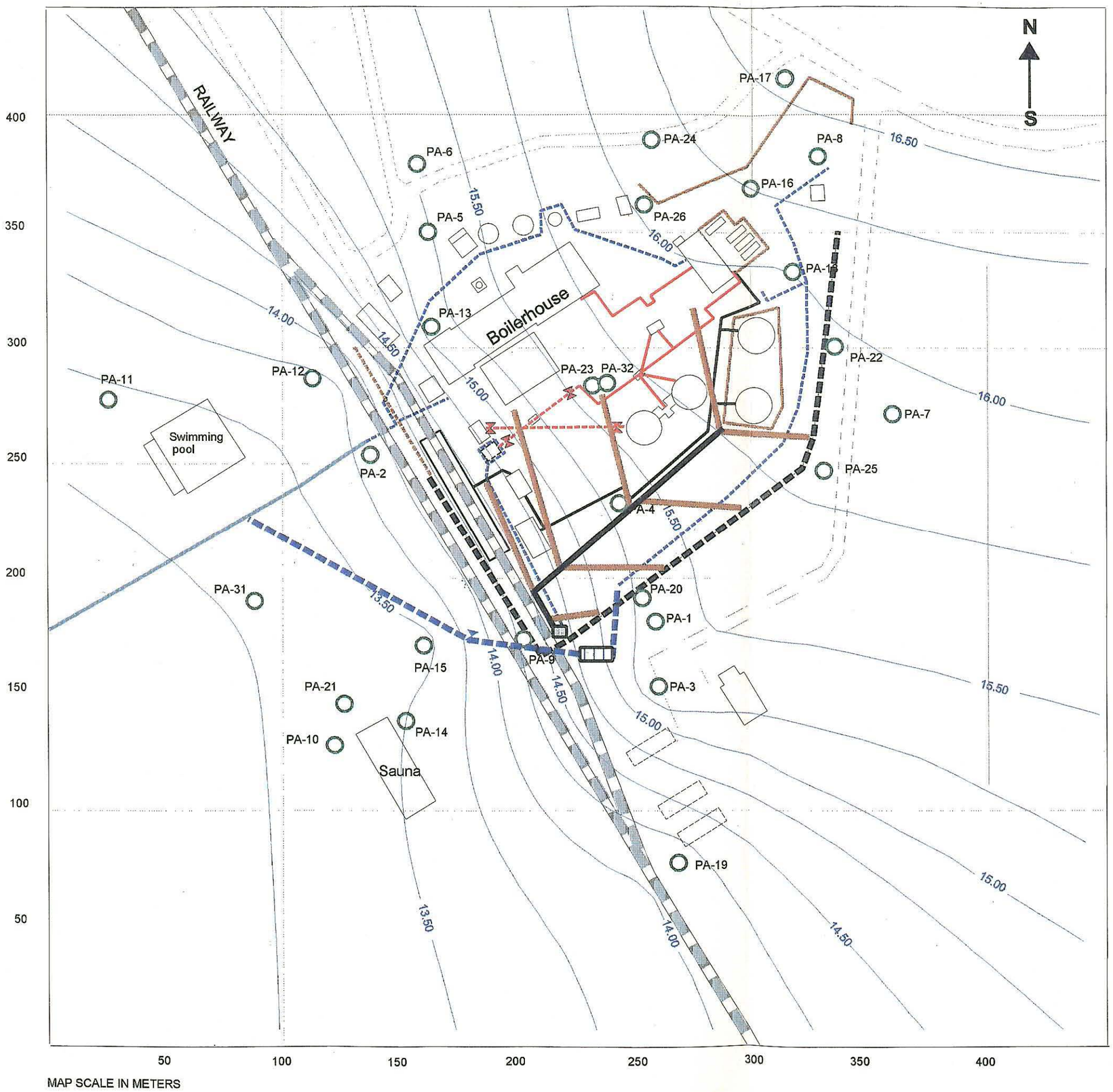


Figure 5.1. Generalised layout of a open-trench system.



PALDISKI CENTRAL BOILERHOUSE

CONVENTIONAL SIGNS

16.50 Groundwater table isolines

Present drainage and stormwater runoff pipeline

Drainage and stormwater runoff pipeline into oil separator

On-ground black oil pipeline

Underground black oil pipeline

Confining wall

Closed underground black oil pipeline

Closed drainage and stormwater runoff pipeline

PA-10 Number of borehole

SUGGESTED NEW STRUCTURES FOR RECOVERY OF FREE PHASE OIL

FEED TRENCHES

CONDUCTOR TRENCH

COLLECTION POND

OBSERVATION TRENCHES AROUND UNDERGROUND WALL

DRAINAGE PIPELINES

OIL SEPARATOR

FIGURE 5.2 SUGGESTED NEW STRUCTURES FOR RECOVERY OF FREE PHASE OIL

Preliminary locations of the trenches and the collection pond are shown in figure 5.2

Observation and pumping trenches should be built on both sides of the underground concrete wall in the southern and western part of the area. The level of oil and water in the trench inside the confining wall must be kept permanently under the top of subterranean concrete wall to prevent the spreading of oil.

The oil separator should be built near the collection pond in the southern part of the site between underground confining wall, building no 10 and sampling point PA-4 (shown in figure 5.2). Oil and water would be pumped from the collection pond through this oil separator and the oil separator in the drainage system to the municipal storm water system.

The total length of the feed trenches is about 300 m which will result in the excavation of soil and a requirement for coarse gravel and sand of about 600 m^3. The length of open ditches (conductor trench and trenches along underground concrete wall) is about 300 m which will result in the excavation of about 600 m^3 soil. In total about 1200 m^3 contaminated soil would have to be treated with an above-ground remediation method.

Oil skimmers and automatic pumps and hoses are also needed. Mobile pumps and a suction tank truck are also required to remove oil from the drainage system and channels.

The concrete well near the sampling point 20 may also be used as a pumping and observation well.

5.2.3 Proposed Schedule

Pumping of the oil from the drainage system and the present excavations and ditches has been carried out periodically for couple of years. The appropriate time for constructing trenches and oil collection ponds is in the spring of 1997. Continuous pumping of oil and oily water should be started immediately, when the pumping wells, oil separators and the drainage system have been completed. The pumping may require some years, because of the slow movements of the oil through the soil. The pumping time could be reduced by building more trenches between the suggested trenches. Once the oil recovery has reached a position such that it is resulting in diminishing returns then a soil remediation program can begin using the methods described in section 5.3.

5.2.4 Cost Estimates

The costs of these tasks can be estimated via the required workloads and materials, which have been evaluated for the proposed remediation actions. Estimated costs of the removal of free phase oil is presented in table 5.1.

Table 5.1 Cost estimates of the removing the source of oil contamination

ACTION	UNIT	QTY units	UNIT COST EEK/unit	COST EEK
Excavation of trenches	m	600	60	36 000
Filling with coarce gravel	m3	600	80	48 000
Breaking of concrete plates	m	600	50	30 000
Oil skimmer and pumps etc.	set	1	150 000	150 000
TOTAL				264 000

The cost of the remediation of the excavated contaminated soil (1200 m^3) is discussed in section 5.3.4. The control of the pumps and oil separators will have to be carried out on a daily or weekly basis, employing one or two persons on a full or half time basis. Pumping of the free oil will periodically require two workers. One working day will cost around 700 to 1000 EEK per person. One full time worker will cost about 200 000 EEK per year.

5.3 REMEDIATION OF CONTAMINATED SOIL

5.3.1 Remediation methods

When the measures for preventing oil leakages to the ground (chapter 5.1)have been carried out and the free phase oil has been removed from the ground and groundwater (chapter 5.2), the contaminated soil should be remediated. The possible methods are set out below:

1. **No remedial actions** (Natural attenuation and degradation, cover of surface soils)
   Contaminated soil will be left in the ground to degrade naturally. Degradation would include chemical breakdown, bio-degradation, diffusion and volatilisation. Based on the gross mass estimates, the rates for natural attenuation at this site would be measured in decades. There may be a need for some covering of the contaminated surface soils.

2. **In-situ bio remediation**
   Oxygen, phosphate, nitrogen and potassium are added to the subsurface to enhance the growth of naturally occurring bacteria. The growth of the naturally occurring bacteria will accelerate the biological decomposition of the oil when they utilise the hydrocarbons as a food supply. Prior to initiating a bio-remediation program a bio-assay should be conducted.

3. **Landfilling**
   Contaminated soil will be removed and landfilled in an approved place constructed for the landfilling of oil contaminated soil. This is the mass transfer alternative.

4. **Above-ground bio remediation**
Contaminated soil will be excavated and above ground treatment cells constructed. The treatment cells would be located in an approved place and engineered to provide oxygen, potassium, nitrogen and phosphate to enhance the growth of naturally occurring bacteria. The growth of naturally occurring bacteria will accelerate the biological decomposition of the oil when they utilise the hydrocarbons as a food supply. This alternative is more labour intensive than in-situ bio-remediation but the remediation time is shorter. Prior to initiating a bio-remediation program a limited bio-assay should be conducted.

5. **Thermal treatment**
Contaminated soil will be removed and treated by burning in an approved combustion facility.

6. **Production of asphalt**
Contaminated soil will be removed and used as a raw material in the production of asphalt.

The total contaminated area that requires remediation (oil content >5000 mg/kg), is about 3.5 hectares and it contains about 55 000 m^3 contaminated soil.

The advantages and disadvantages for each remediation method are as follows:

1. No remedial actions

Advantages: This would be the cheapest way of "handling" the situation, no digging would be required, no additional traffic would result.
Disadvantages: The cleaning of the site would be a very slow process and there is still the risk of the spreading of hydrocarbons via the water flow through the site. Drainage of the site will need to be continued for a long time due to the high concentrations that are present in the soil. This option will also require a long-term monitoring programme over a considerable number of years.

2. In-situ bio-remediation

Advantages: The problem is not being merely moved to an other place. The amount of excavation can be minimised and the drainage trenches can be used as air supply structures.
Disadvantages: The speed of the biological processes depends on the micro organisms and the nutrients present, as a result the remediation can take from half a year to several years. In certain cases, an excess of micro-organisms and nutrients are needed to achieve a sufficient degree of remediation. When air is blown into these kinds of shallow contaminated soil layers, air may leak to the ground surface instead of penetrating through the soil. Degradation of the heavy oil components may be very slow. The costs are higher than in methods 1, 3 and 4.

3. Landfilling

Advantages: Remediation of the site will not take as much time as the in-situ methods (1 and 2). Contaminated soil will be removed from the site.
Disadvantages: The problem is moved to another place which needs to be approved and constructed for this purpose. Earth moving will result in heavy truck traffic between the boiler house and the landfill site. Decomposition of the oil may take years without any composting procedures. The costs will be more or less the same as method 4 depending on the distance to the landfill site.

4. Above-ground bio remediation

Advantages: Contaminated soil will be removed from the site. The degree of the remediation of the soil will be better than in methods 1 to 3. Soil may be used as a filling material after composting.
Disadvantages: Remediation will take several years, as the composting will need to be carried out in phases, for example 5 000 m^3 at one time. Composting will also require a location which will need to be approved and constructed for this purpose. Earth moving will result in heavy truck traffic between the boiler house and the composting site. The costs are larger than in method 3.

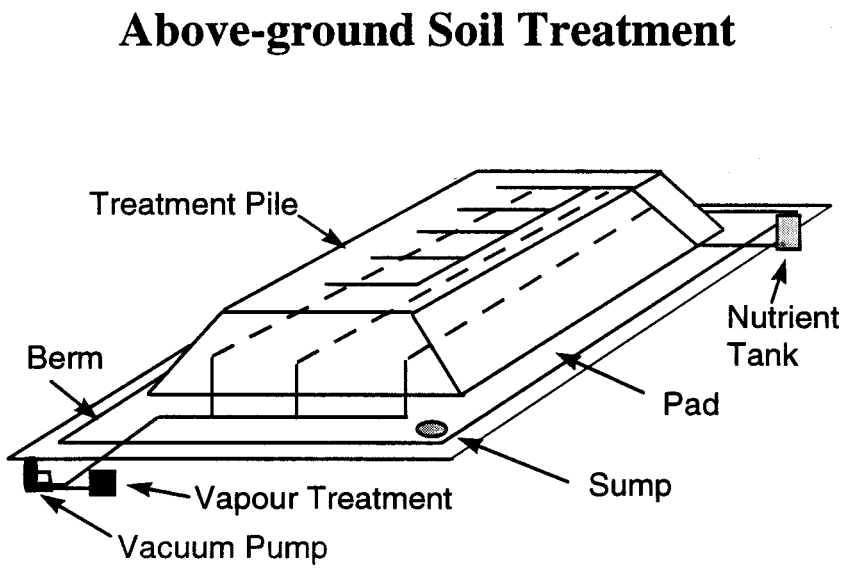


Figure 5.3. Generalised design of an above-ground bio remediation pile.

5. Thermal destruction

Advantages: Remediation of the site will not take as long as in-situ methods (1 and 2). Contaminated soil will be removed from the site.

Disadvantages: There will need to be a combustion facility that has been approved and constructed for this purpose. Earth moving will result in heavy truck traffic between the boiler house and the combustion site. The heavier components of the oil may breakdown to more toxic substances, if the temperature of the treatment is not high enough. Burning at high temperatures is very expensive.

6. Production of asphalt

Advantages: Remediation of the site will not take as long as in-situ methods (1 and 2). Contaminated soil will be removed from the site and reused.
Disadvantages: There will need to be an asphalt plant available and the demand for asphalt production.

5.3.2 Suggestion of Applied Methods

There are two strategies, that may be applied in the remediation of the contaminated site:

1. Minimal remediation resulting in minimal costs being incurred. This will lead to an increase in time required for the remediation and will affect the final result of the clean-up. There will be a continuous need for monitoring of the drainage system and oil separators

2. The optimal clean-up strategy which will require less time but more resources. This will require the removal of contaminated soil from the site and additional funding.

The contaminated soil can be divided into the following classes, which will require different remediation methods:

A. Soil inside the underground concrete wall (inside the site of the facility)
B1. Surface soils (<0.5 m depth) outside the underground wall (outside the facility)
B2. Subsurface soils (>0.5 m depth) outside the underground wall

As presented in table 5.2, different remediation methods can be applied depending on the remediation strategy, the location and extent of the contamination of the soil.

If remediation strategy 1 is chosen, contaminated soil inside the confining underground wall will be left on site (No actions) providing that the oil is covered by the concrete slabs or clean soil. The areas where the concentrations exceed 30 000 mg/kg will be slowly reduced by pumping-off of free phase oil. Covering of the contaminated soil is regarded as the minimum remedial action that is required outside of the area of the facility to prevent inhabitants being exposed to oil products.

Table 5.2. Suggested remediation methods for different remediation strategies and sections of contaminated soils

REM. STRA-TEGY	SECTION OF CONTAMI-NATED SOIL	REMEDIATION METHODS				
		Concentration in soil, mg/kg				
		> 30 000	> 5 000	< 5000	< 500	
1	A. Inside the wall	Removal of free phase oil	Bio (excavated soil) [1)]	No action	No action	
	B1. Surface soils outside the wall	Cover Removal of..	Cover Natural bio.	Cover Nat. bio.	No action	
	B2. Subsurface soils	Removal of free phase oil	Natural biodegrad.	No action	No action	
2	A. Inside the wall	Above-ground Bio	Above-ground Bio	No action	No action	
	B1. Surface soils	Above-ground Bio	Above-ground Bio	A-g Bio Cover	No action	
	B2. Subsurface	Above-ground Bio	Above-ground Bio	No action	No action	

1) Contaminated soil from the oil recovery trenches (cf. section 5.2.2)

Prior to initiating a bio-remediation program a limited bio-assay should be conducted.

5.3.3 Time Schedule

The remediation of the contaminated soil can be commenced as soon as the potential for future leaks of oil has been stopped (section 5.1), the free phase oil has been removed and the spreading of oil has been controlled (section 5.2). Oil could be recovered from the excavated soil if it is removed simultaneously with the pumping of oil from the site. Remediation of the soil may take some years depending on the chosen remediation method. If natural bio-remediation is relied upon, continued monitoring of the site would be required for some decades.

5.3.4 Cost estimates

The costs of remediation of the soil depends on the chosen remediation methods.

The relative cost ranking of different remediation methods for contaminated soil are as follows:

$ No remedial action
$$ Landfilling or Above-ground bio remediation
$$$ In-situ bio remediation or asphalt incorporation
$$$$ Thermal destruction

If the total amount of 55 000 m^3 of contaminated soil is remediated with one of the above methods, then the total cost will range from about 5 to more than 100 million EEK. The remediation time will vary from decades to less than a year respectively. Groundwater monitoring may also be needed during the remediation time.

The estimated costs of landfilling are shown in table 5.3. The fee to dispose of the soil in a landfill is not included and it will result in additional costs.

Table 5.3. Cost estimate for landfilling

ACTION	UNIT	QTY units	UNIT COST EEK/unit	COST EEK
Investment:				
Excavation of soil	m3	55 000	20	1 100 000
Transport of soil (10 km)	m3	55 000	20	1 100 000
Breaking of concrete slabs	m2	15 000	20	300 000
Earthworks in landfill	m3	55 000	10	550 000
Filling with sand and gravel	m3	55 000	80	4 400 000
Supervision of work	month	5	30 000	150 000
No operational and maintenance costs (included in possible fee to dispose of the soil)				
TOTAL				**7 600 000**

The main landfill cost arises from the need to replace excavated soil with the fill material (sand and gravel). The cost of the fill material is saved in the above-ground bio remediation method, if the remediated material is used as fill material. The estimated costs of above-ground bio remediation are shown in table 5.4. The cost of leasing the land needed for the bio remediation option has not been estimated.

Table 5.4. Cost estimates of above-ground bio remediation

ACTION	UNIT	QTY units	UNIT COST EEK/unit	COST EEK
Investment:				
Bio-assay, and respiratory tests		1	200 000	200 000
Excavation of soil	m3	55 000	20	1 100 000
Transport of soil (2*2 km)	m3	55 000	20	1 100 000
Breaking of concrete slabs	m2	15 000	20	300 000
Construction of area	m2	5 000	150	750 000
Bioventing equipment		1	500 000	500 000
Earthworks in bioremediation area	m3	55 000	20	1 100 000
Investment total				**5 050 000**
Operation and maintenance:				
Maintenance of the system	month	60	30 000	1 800 000
Sampling and analyses (3 times in a yea	times	15	30 000	450 000
Operation and maintenance total				**2 250 000**
TOTAL				**7 300 000**

If remediation strategy 1 is chosen, the following costs of undertaking remedial actions presented in table 5.2 will be incurred:

- removal of free phase oil: costs are discussed in section 5.2.4.
- above-ground bio-remediation of 1200 m^3 contaminated soil excavated from the trenches to achieve the removal of the free phase oil: Total estimated cost is from 0.3 to 1 million EEK.
- total area of contaminated surface soil, which requires some cover, is 0.5 to 1 hectare: total estimated cost of cover is 0.2 to 0.5 million EEK.

If remediation strategy 2 is chosen, the following costs of undertaking the remedial actions presented in table 5.2 will be incurred:

- above-ground bio remediation of 55 000 m^3 contaminated soil: total estimated cost is from 5 to 10 million EEK (includes possible cover of surface soils).

5.4 REMEDIATION OF CONTAMINATED GROUNDWATER

5.4.1 Remediation methods

The need to undertake any clean-up of the groundwater should be based on a risk assessment. The final decision as to the need for clean-up of the groundwater will need to be evaluated, when the remedial actions described in chapters 5.1 - 5.3 have been carried out and the continuing risk of contamination of groundwater has been reduced..

The fill materials at the facility and to the Southwest of the site contain contaminated groundwater. There is also free phase oil on the groundwater surface. This water discharges mainly into the drainage ditches of the area. Discharges of water and oil could be prevented by the remedial actions presented in chapters 5.1 and 5.2. Water outside the area of the boiler house will degrade naturally after the oil content of the soils has been reduced at the site (section 5.3).

The uppermost aquifer in the limestone is contaminated with oil in the area of the boiler house and the area to the Southwest. Contaminated groundwater is moving towards Paldiski bay located to the Southwest of the site. The water from the uppermost aquifer is not used and at the concentrations detected it is not believed that this represents a significant risk to the environment. No contamination has been detected in the water of the second aquifer in the upper sandstone layers. This water is not in use in region of Paldiski town (some local use occurs in other parts of the Paldiski peninsula which is not in the direction of groundwater flow from the site). Paldiski town takes its water from the third aquifer, which is very well geologically protected against pollution from the site. No remedial action for the groundwater is recommended, but the monitoring of groundwater is suggested to continue to observe the concentrations in the groundwater.

5.4.2 Cost estimates

If no remedial actions for the groundwater are carried out, no extra costs will be incurred. The monitoring of the groundwater will cost about 60 000 EEK per year, based on water samples being taken four times a year.

6. SUMMARY OF REMEDIATION COST ESTIMATES

A summary of the costs of the remedial actions as set out in the Cost Estimates -sections, is presented in table 6.1.

Table 6.1. Summary of estimated costs.

ACTION	ESTIMATED COST, million EEK		
	Minimum	Average	Maximum
5.1 Testing and repairing	**0,8**	**1,6**	**2,3**
5.2 Removal of free phase oil	**0,4**	**0,8**	**1,2**
5.3 Remediation of soil	**0,5**	**7**	**10**
5.4 Groundwater monitoring	**1,2**	**0,7**	**0,2**
TOTAL	**3**	**10**	**14**

The testing and repairing of the tanks and pipelines (5.1) will need to be done if it is intended to clean up the site. This is necessary to reduce the environmental risks to an acceptable level.

The most cost effective clean-up action is the removal of the free phase oil. If this is carried out effectively using the suggested trenches, up to 1 000 tons of oil could be recovered from the pipelines and from the ground, generating cost of around one million EEK. Furthermore these actions would result in the most significant reduction in the environmental risks. It is necessary to carry out this work before soil remediation takes place. The environmental risks will not be reduced to an acceptable level if free phase oil is not recovered.

If only the minimum actions for remediation of contaminated soil are carried out, the risk of spreading of oil will remain and a long period of monitoring of the site will be required. It is estimated that after the removal of the free phase oil it will be possible to recover 500 tons of oil, if the contaminated soil is remediated. Above-ground bio-remediation is the suggested remediation method. Prior to initiating a bio-remediation program a limited bio-assay should be conducted..

By pumping and treating the groundwater, only small amounts of contaminants will be recovered when compared to the removal of free phase oil and the remediation of the soil. The uppermost groundwater layer is contaminated, but the risk of the contamination of deeper groundwater aquifers and the health risks have been assessed to be low. No pumping and treating of groundwater is recommended, before the sources of contamination have been removed. However, the state of the groundwater should be observed by monitoring of the groundwater. If any significant changes in the concentrations of the contaminants is observed, the situation should be reconsidered.

7. PRELIMINARY TIMETABLE OF REMEDIAL ACTIONS

YEAR	1997				1998				1999				2000				2001			
QUARTERS	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
5.1 Prevent leakages																				
Repairing of pipes and tanks		x	x																	
Drainage and oil traps		x	x																	
Handling of oil	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1)
5.2 Removing free oil																				
from pipes and channels	x	x	x	x																
building of oil recovery syst.		x	x																	
from ground		x	x	x	x	x	x	x	x	x										
building of trenches		x	x	x																
5.3 Remediation of soil																				
soil from oil recovery system			x	x	x	x	x	x												2)
soil outside the facility					x	x	x	x	x	x	x	x								2)
soil inside the facility									x	x	x	x	x	x	x	x	x	x	x	2)
5.4 Cleaning of groundwater																				
monitoring		x		x		x				x				x				x		2)

1) Proper handling of oil should be continued to prevent leakages

2) Needed time is depending on the remediation method of soil to be chosen

APPENDIX 1

WORK PLAN

PALDISKI CENTRAL BOILER HOUSE REMEDIATION FEASIBILITY STUDY

WORK PLAN

FEASIBILITY STUDY OF PALDISKI CENTRAL BOILER HOUSE

CONTENT

1. BACKGROUND

The Pakri/Paldiski Peninsula has been a military base since 1939 and the area has mainly been used for military purposes. In addition to conventional military activities, the area has also housed a nuclear training plant and associated activities. The military activities have resulted in a poor state of the environment. The soil and water pollution are estimated to be severe and the living conditions of the inhabitants require the improvement.

Paldiski/Pakri Peninsula is located about 50 km westwards from the capital Tallinn. Pakri Peninsula is situated on the limestone plateau between Pakri and Lahepere Bays along the northern coast of Estonia. The area of Paldiski Peninsula is 40 km^2.

The Paldiski Town Government has decided to renovate the BOILERHOUSE at the old location, with NUTEK (Sweden), a new DE-25-14GM 6 MW boiler (wood, waste wood, etc.) have been taken into operation on March 1996. Paldiski town currently needs to 12 MW heat in the wintertime. Consequently, it is necessary to still employ one existing oil boiler.

The Ministry of the Environment of Estonia has instructed MAVES Ltd. and the Central BOILERHOUSE of Paldiski to begin the primary treatment of black oil contamination. The aim is to clean-up black oil from the surface. About 350 t of black oil, containing about 50% of water, was pumped out of the territory by the employees of the BOILERHOUSE during the summer of 1994. MAVES Ltd. operations during Sept-Nov 1994 have secured about 8 tons of separated black oil from the oil separator near the sea, and 244 tons from the territory and close vicinity of the BOILERHOUSE. During 1995 about 300 t of black oil with contaminated water was collected from the territory by workers of the BOILERHOUSE. In 1995 new oil separator was built and will be connected with storm water sewerage in spring of 1996.

The ground soil near the BOILERHOUSE still contains large quantity of black oil. As the scale of oil contamination is very large, more efficient pumps and separators are required for pumping oil and contaminated water out of the pools and ditches, etc. While pumping may be a short term remedy to contain the situation, the method alone is inadequate to clean-up and control the situation of the contaminated territory. The extent of oil contamination and also future risks must be assessed.

2. OBJECTIVE

The main objective of the Feasibility Study is to elaborate decision making material (technical and economical) for the authorities of Estonia to choose appropriate alternative, organisation and financing for the cleaning up activities to be carried out and thus reaching the objective of the Paldiski

Environmental Project in a later implementation Phase. The aim of the Feasibility study is to propose alternative ways for the actual cleaning works which will have to be executed under an implementation phase of the Paldiski Environmental Project.

The Feasibility Study is carried out in a three pronged strategy:

1. Prevent ongoing leakage/penetration of black oil. This may be partly addressed by:

   a) Checking and thereafter sealing/renovating the affected leaking oil storage tanks, pumps pipelines, valves etc.

   b) Prevent seepage of oil into the sea by connecting the new oil separator to the storm water sewerage latest by spring of 1996.

   These are carried out via separate ongoing works.

2. Localise the black oil contamination to the territory and close vicinity of the Boiler House.

   This involves the collection of black oil from a surface and ditches started in 1994, it continued in 1995 and expected to be continued also in 1996.

3. Specify, via a feasibility study, the hydrogeological regime, the nature, extent, rate (quantity), and direction of movement of contaminants from the facility.

The feasibility study shall address the following levels of work:

1. To clean-up the territory of Boiler House from free oil and solid oil residuals, localise the contamination using drainage systems and oil separators around the contaminated area.
2. Excavation and remediation of contaminated soil that is surrounded with subterranean concrete walls and covered with concrete slabs.
3. Excavation and remediation of contaminated soil outside the area covered with concrete slabs.
4. Assessment of the ground water/soil clean-up works that results in removal of a free oil phase from a ground water surface.
5. The amount of clean-up works to fulfil the criteria values for soil and groundwater

The Estonian Authorities would determine which alternative will be used on the basis of the feasibility study and the cost-benefits analyse.

3. SPECIFICATION OF WORK

3.1 SITE INSPECTION AND PREPARING DETAILED WORK PLAN

Site inspection and preparing a detailed work plan was made together with Estonian consultant Maves Ltd. Site inspection was based on reviewing all existing relevant background material. Detailed work plan was prepared based on site inspection.

3.2 FIELD SAMPLING AND LABORATORY WORK INSPECTION, SUPERVISION AND SUPPORT

Health and safety plan

Before executing field work, health and safety plan shall be made including among others the following aspects:

- description of potential hazardous materials at the site
- safety limits for hazardous materials for human health
- safety equipment and field measurements
- personal protection equipment for working in different situations
- rescue plan in the case of failures

Field sampling plan

Field sampling plan will include all necessary supervision and support, which is needed to realise all field investigations. This includes among others:

- Field investigation plan
- Sampling and field analysis methods
- Field documentation plan

Laboratory inspections, supervision and support

Laboratory inspections, supervision and support includes a review of local laboratories and relevant methods and standards comparing to Swedish and international laboratories and methods.

Laboratory support will also include the review of different relevant field analysing methods.

3.3 FINAL REPORT

Final Report includes technical recommendations and economical analyses (cost benefit and cost-effectiveness) of various alternatives as well as the time schedule for the works to be carried out and the organisation of the works. Co-operation between Estonian and Swedish consultants will be realised in this project.

4. TIMETABLE

The feasibility study shall be implemented during a period of five months accordingly to following time schedule.

TIME SCHEDULE

The Feasibility Study shall be implemented during a period of 5 months.

	I month				II month				III month				IV month				V month			
weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ESTONIAN FINANCING																				
Field works and sampling Estonian consultants and drilling team			x	x	x	x			x	x										
Localization of black oil contamination, Estonian team				x	x	x	x	x	x											
Cleaning and technical inspection works of heating oil tanks and pipelines					x	x	x	x												
PROPOSED SWEDISH FINANCING																				
Feasibility study draft and final reports, project managing																				
Swedish consultants				x		x	x	x		x			x	x					x	x
Estonian consultants				x		x	x	x		x							x		x	x

APPENDIX 2

HEALTH AND SAFETY PLAN

PALDISKI CENTRAL BOILER HOUSE REMEDIATION FEASIBILITY STUDY

TABLE OFCONTENTS

1. INTRODUCTION

The purpose of this document is to establish health and safety procedures for the site investigation works at Paldiski Central Boile house site. The hazards expected at this site have been identified from information provided from data obtained from a previous investigation at the site performed by Maves. The levels of protection are therefore based on the best information available. Levels of protection should be regarded as a minimum.

It was found out during the site visit and from the present information, that there are no potential hazardous chemicals and other things that needs some special care in a means of health and safety. This safety plan presents the structure of the safety plan.

2. SAFETY PERSONNEL

The safety personnel for this project include the following:

Site Health and Safety Officers

Office Health and Safety Officer

Project Manager

The office health and safety officer has overall responsibility for establishing appropriate health and safety measures.

The site health and safety officers are responsible for ensuring the designated procedures are followed.

The project manager has overall responsibility for project health and safety matters.

The ultimate responsibility for health and safety lies with the individual employees. Each employee is responsible for exercising the utmost care and good judgement in protecting their own and others health and safety. All Golder staff employed on this project will have undertaken a 24 - 40 hour health and safety course.

3. PROJECT DESCRIPTION

A number of explanatory probes and boreholes are to be performed at the site. These tasks will involve drilling through soils and into groundwater with hazards of exposure from deposited materials and contaminated groundwater. The available information has therefore been evaluated to determine which hazardous materials may be encountered at the site. These are listed below:

- Heavy heating oil
- Diesel fuel

This list should not be taken as exhaustive. All materials retrieved from drilling procedures should be treated with caution.

4. POTENTIAL HAZARDS

HAZARDS	PRESENT
Confined Space	No
Chemical	Yes
Radiological	No
Fire/Explosion	Yes
Noise	Yes
Temperature Stress	No
Electrical	Yes
Machinery	Yes
Trips, Slips, Falls	Yes
Trenching	No
Heavy Equipment	Yes
Overhead Hazards	Yes
Unstable/Uneven Terrain	No

The potential for exposure will exist through the following media:

- Surface soils
- Sub soils
- Groundwater
- Surface water
- Free phase oil

Site specific information has indicated the following contaminants to be present at the site:

- heavy fuel oil
- diesel fuel

It is possible that the site investigation exercise will cause site staff to be exposed to these compounds therefore exposure limits, relevant monitoring requirements and personal protective equipment requirements will be identified.

5. SITE MONITORING PROCEDURES

Special site monitoring procedures are not needed, because only little volatile hydrocarbons are present and the drilling work does not cause much dust.

6. ON SITE CONTROL

Special on site control is not needed.

7. PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following personal protective equipment (PPE) should be used during the field investigations:

Cloth overalls
Steel toed boots or shoes
Dust mask
Latex or nitrile gloves (inner)
Hard hats
Hearing protection (unless agreed otherwise with the Site Health and Safety officer and the Engineer)
Protective goggles to be work where there is a risk of eye contamination as determined by the Site Health and Safety Officer.

8. DECONTAMINATION

No special decontamination procedures are not needed at the site.

9. GENERAL WORK PRACTICES

General work practices to be followed, intended to minimise risk, include the following:

* Personal hygiene will be emphasised during all field activities

* Care will be taken to avoid any physical hazards.

10. EMERGENCY PROCEDURES

(This section is to be reproduced and posted in a prominent location on site).

Nearest telephone location
First Aid Kit location
Fire Extinguisher location.

Designated Personnel Trained in First Aid (Names).

....

10.1 Fire and Explosion

In the event of a fire or explosion, if the situation can be readily controlled with available resources without jeopardising the health and safety of yourself, the public, or other site personnel, take immediate action to do so, otherwise:

1 Notify emergency personnel by calling the fire brigade and/or ambulance services.

2 If possible, isolate the fire to prevent spreading

3 Evacuate the area.

10:2 On Site Injury or Illness

Should any person visiting or working at the site be injured or become ill, notify the Site Health and Safety Co-ordinator and initiate the following emergency response plan:

1 If able, the injured person should proceed to the nearest available source of first aid. If the injured party is extremely muddy, remove outer garments and if necessary, wash the injured area with soap and water. If the "injury" involves a potential over-exposure to hazardous gases or vapours (headache, dizziness, nausea, disorientation), get the victim to fresh air and take him or her to the on-site first aid centre for a complete physical examination as soon as possible.

If the injury involves foreign material in the eyes, immediately flush the eyes with emergency eye wash solution and rinse with copious amounts of water at the nearest emergency eye wash station. Obtain and administer first aid as required. If further medical treatment is required seek medical assistance as discussed below:

2 If the victim is unable to walk, but is conscious and there is not evidence of spinal injury, escort or transport the injured person to the nearest first aid facility. If the

victim cannot be moved without causing further injury such as in the case of a severe compound fracture, take necessary emergency steps to control bleeding and immediately call for medical assistance as discussed below.

If the victim is unconscious or unable to move, or if there is any evidence of spinal injury, **Do not move the injured person unless absolutely necessary to save his or her life**, until the nature of the injury has been determined. Administer artificial respiration if the victim is note breathing, control severe bleeding and **immediately** seek medical assistance as discussed below.

3 If further medical treatment is required and:

a) **the injury is not severe** take the injured party to the clinic/hospital by private automobile

b) **the injury is severe** immediately call an ambulance. In the interim advise the hospital of the situation.

10.3 Emergency Response Authority

The Site Health and Safety Officer shall also act as the designated site emergency co-ordinator and shall have final authority for initial response to on-site situations.

Upon arrival of the appropriate emergency response personnel, the Site Health and Safety Officer shall defer all authority but shall remain on the scene if necessary to provide any and all possible assistance. At the earliest opportunity, the Site Health and Safety Officer shall contact the office manager(s) at the respective office bases of the victim(s):

Golder Associates Officer Manager : John Hinchliff - Tel: (0602) 456544
Contractors' Office Manager :

10.4 Emergency Notification

A list of local emergency agencies (Fire, Police, Ambulance, Hospital) will be available for all site investigation staff. This will include addresses and telephone numbers.

Emergency Contact Nos.

Hospital
Ambulance
Police
Fire

11. SAFETY BRIEFING

A safety briefing organised by the Site Health and Safety Officer will be conducted on site prior to commencement of the site investigation work.

APPENDIX 3

FIELD SAMPLING PLAN

PALDISKI CENTRAL BOILER HOUSE REMEDIATION FEASIBILITY STUDY

TABLE OF CONTENTS

FIELD SAMPLING AND MAPPING WORK PROGRAM AT PALDISKI TOWN CENTRAL BOILERHOUSE

Field Methods and Procedures

This section provides the rational for the selection of water sample locations, as well as any additional details regarding the collection of water samples at these locations. Soil and water sampling will be carried out in accordance with the sampling protocols.

Shallow soil samples will be collected from topsoil layer for laboratory analysis in accordance with the field procedures discussed below. Soil samples will be collected from various areas outside and also within the facility.

The purpose of this sampling effort is to determine the identity and concentration of chemical conta-minants in the topsoil layer and to specify the contours of the contaminated area. Soil samples will be analysed in Estonian Central Environmental Laboratory for aromatic components and metals.

Shallow soil samples will be collected from 10 shallow boreholes with max. 3 m depth for soil sampling (1-2 soil samples from different depth levels from each borehole). A truck mounted a percussion hammer with an iron-made core barrel will be used for drilling. A stainless steel trowel or spoon will be used to collect an appropriate size sample. If necessary some soil samples will be collected also from boreholes for shallow water samples.

The soil sample will be placed in a clean pre-labelled glass jar and sealed with Teflon lined cap. Samples will be placed in a glass jar in a manner to minimise head space after the jar is closed. Then the samples will be immediately placed in a cooler with ice for shipment to the analytical laboratory. Samples will be shipped to the analytical laboratory under standard chain of custody procedures. Pertinent information concerning the soil sampling activities will be recorded in the filed notebook.

The field geologist will complete a lithologic log for each boring based on visual review of the samples and soil cuttings. A log for each boring will be prepared for the final report.

The soil sampling and drilling equipment will be decontaminated between each sampling. If duplicate samples will be collected concurrently with the field sample, the sampling equipment will not be decontaminated between the collection of the field sample and the duplicate sample.

After the samples have been collected from boring, the boring will be backfilled with remains of the soil from this boring.

Shallow ground water samples will be collected from Ordovician limestone water bearing unit for laboratory analysis in accordance with the field procedures discussed below.

Shallow water samples will be collected from various areas outside and also within the facility (Figure 1). Actual sampling locations, as noted on the sample location plan, are approximate only, final locations will be detailed after finishing collection of soil samples.

The purpose of this sampling effort is to determine the identity and concentration of chemical conta-minants in the first groundwater (Ordovician limestone) aquifer and to specify the contours of the contaminated groundwater area. Ground water samples will be analysed in Estonian Central Environmental Laboratory for aromatic components, toxic organic components and metals.

Shallow ground water samples will be collected from 10 monitoring wells, these wells will be installed by using a truck-mounted, mud-rotary drilling rig. The shallow monitoring wells will be constructed by first installing a surface casing of mild steel of 108 mm diameter into 132 mm borehole drilled to the depth of approximately 2-4 m below a ground surface. The borehole then will be advanced below the surface casing utilising a 93 mm diameter rock bit to a depth of approximately 10 metres below a ground surface. The casing will be cemented into place and the cement allowed to harden. The well will be completed by adding a steel protective cover with a locking cap embedded in concrete.

To ensure proper development of monitoring wells, water will be removed from each well for several hours until the ground water appeared to be free of suspended sediment. The absolute height of top of casing for each monitoring well will be levelled. A construction diagram for each monitoring well, along with a soil profile, will be presented in the final report.

Presents of free phase hydrocarbons on a watertable in each monitoring well will be checked by using special bailer. Prior to collecting of groundwater samples and after obtaining depth to ground water and total depth measurements, monitoring wells will be purged (using MP-1 pump and special hoses for sampling) until the temperature, pH and specific conductivity of purged water are stabilised. Field monitoring equipment, including the pH meter and conductivity meter will be calibrated each day prior to use at the sampling site.

All measurements and calculations will be recorded in a bound, water-resistant field notebook. Field sampling observations regarding noticeable odour, weather conditions, sample colour and sampling equipment problems will be documented. Purged groundwater will be containerised for disposal.
Water samples will be collected in appropriate containers, supplied by the analysing laboratory and containing the proper preservative, where appropriate. Each sample will be assigned a unique number and labelled. The samples will be immediately stored in an ice-filled cooler and maintained at 4°C prior to shipment on the laboratory for analysis. Standard chain of custody procedures will be followed from the time of sampling to completion of laboratory analysis.

The ground water sampling equipment and bailers, tapes etc. will be decontaminated after each use. If duplicate samples will be collected concurrently with the field sample, the

sampling equipment will not be decontaminated between the collection of the field sample and the duplicate sample.
If the drill and soil cuttings contain detectable levels of site-specific organic constituents (or metal constituents), the soil will be stored in containers and transported to an appropriate disposal facility.

Deep monitoring wells will be installed to collect water samples from deeper confined Ordovician-Cambrian Aquifer. Actual sampling locations, as noted on the sample location plan (Figure 1), are approximate only, final locations will be detailed after finishing collection of shallow ground water samples. The purpose of this sampling effort is to determine the migration of contaminants into Ordovician-Cambrian Aquifer.

The deep monitoring wells will be constructed by first installing a surface casing of mild steel of approximately 159 mm diameter into a 191 mm diameter borehole drilled to a depth of 2-4 m below a ground surface with a tri cone rock bit. Then Conductor casing of 108 mm diameter will be installed in a borehole of 132 mm diameter drilled to depth of approximately 2 meters into the top of the sandstone water bearing unit (Ordovician-Cambrian Aquifer). The conductor casing prevents water in the overlying Ordovician limestone water bearing unit from mixing with the water from the confined aquifer. The conductor casing will be cemented into place and the cement allowed to harden. The remains of the cement in the conductor casing will be drilled out and the borehole 93 mm diameter will be advanced approximately 6-8 m below the bottom of conductor casing. The well will be completed by adding a steel protective cover with a locking cap embedded in concrete.

To ensure proper development of monitoring wells, water will be removed from each well for several hours until the ground water appeared to be free of suspended sediment. The absolute height of top of casing for each monitoring well will be levelled. A construction diagram for each monitoring well, along with a soil profile, will be presented in the final report.

Presents of free phase hydrocarbons on a water table in each monitoring well will be checked using special bailer. Prior to collecting of groundwater samples and after obtaining depth to ground water and total depth measurements, monitoring wells will be purged (using MP-1 pump and special hoses for sampling) until the temperature, pH and specific conductivity of purged water are stabilised. Field monitoring equipment, including the pH meter and conductivity meter will be calibrated each day prior to use at the sampling site.

All measurements and calculations will be recorded in a bound, water-resistant field notebook. Field sampling observations regarding noticeable odour, weather conditions, sample colour and sampling equipment problems will be documented. Purged groundwater will be containerised for disposal.

Water samples will be collected in appropriate containers, supplied by the analysing laboratory and containing the proper preservative, where appropriate. Each sample will be assigned a unique number and labelled. The samples will be immediately stored in an ice-filled cooler and maintained at 4°C prior to shipment on the laboratory for analysis.

Standard chain of custody procedures will be followed from the time of sampling to completion of laboratory analysis.

The ground water sampling equipment and bailers, tapes etc. will be decontaminated after each use. If duplicate samples will be collected concurrently with the field sample, the sampling equipment will not be decontaminated between the collection of the field sample and the duplicate sample.

If the drill and soil cuttings contain detectable levels of site-specific organic constituents (or metal constituents), the soil will be stored in containers and transported to an appropriate disposal facility.

APPENDIX 4

RESULTS OF LABORATORY ANALYSES IN SWEDISH LABORATORIES

PALDISKI CENTRAL BOILER HOUSE REMEDIATION FEASIBILITY STUDY

AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom 1996-10-09 Analysrapport klar 1996-10-26 Journalnr AG000732-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	–
Provets märkning	S 12-0.6

Analysnamn	Resultat	Enhet	KRUT-kod
Torrsubstans	872	g/kg	TRP
Tot.extraherb. aromatiska ämnen	<4.6	mg/kg Ts	ORGF-AI
Opolära alifatiska kolväten	5.4	mg/kg Ts	ORGF-0I

Anna Börjesson

Analysansvarig

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
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031-61 37 40
0511-131 55

Telefax
0510-664 38
031-15 05 12
0511-186 40

AnalyCen

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REPORT issued by an Accredited Laboratory

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Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom 1996-10-09, Analysrapport klar 1996-10-26, Journalnr AG000733-96, Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	S 2-1.2

Analysnamn	Resultat	Enhet	KRUT-kod
Torrsubstans	646	g/kg	TRP
Tot.extraherb. aromatiska ämnen	<6.2	mg/kg Ts	ORGF-AI
Opolära alifatiska kolväten	45	mg/kg Ts	ORGF-0I

Anna Börjesson

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0511-131 55

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031-15 05 12
0511-186 40

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RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:
Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom:1996-10-09 Analysrapport klar:1996-10-26 Journalnr:AG000734-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	S 16-1.2

Analysnamn	Resultat	Enhet	KRUT-kod
Torrsubstans	841	g/kg	TRP
Tot.extraherb. aromatiska ämnen	<4.8	mg/kg Ts	ORGF-AI
Opolära alifatiska kolväten	2000	mg/kg Ts	ORGF-0I

Anna Börjesson

Analysansvarig

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Gråbrödragatan 5, Skara

Telefon
0510-887 00
031-61 37 40
0511-131 55

Telefax
0510-664 38
031-15 05 12
0511-186 40

AnalyCen

Dato

Vor ref.

AB AnalyCen
Niels Ericssonsgatan 17
Göteborg

Att.: Kem. lab.

Vedr. prøve AG 730, AG 731, AG735, AG736 samt AG737.

Kromatogrammerne viser indhold af mellem til højt kogende kulbrinter.

Med venlig hilsen

kem. ing. Thomas L. Ågren

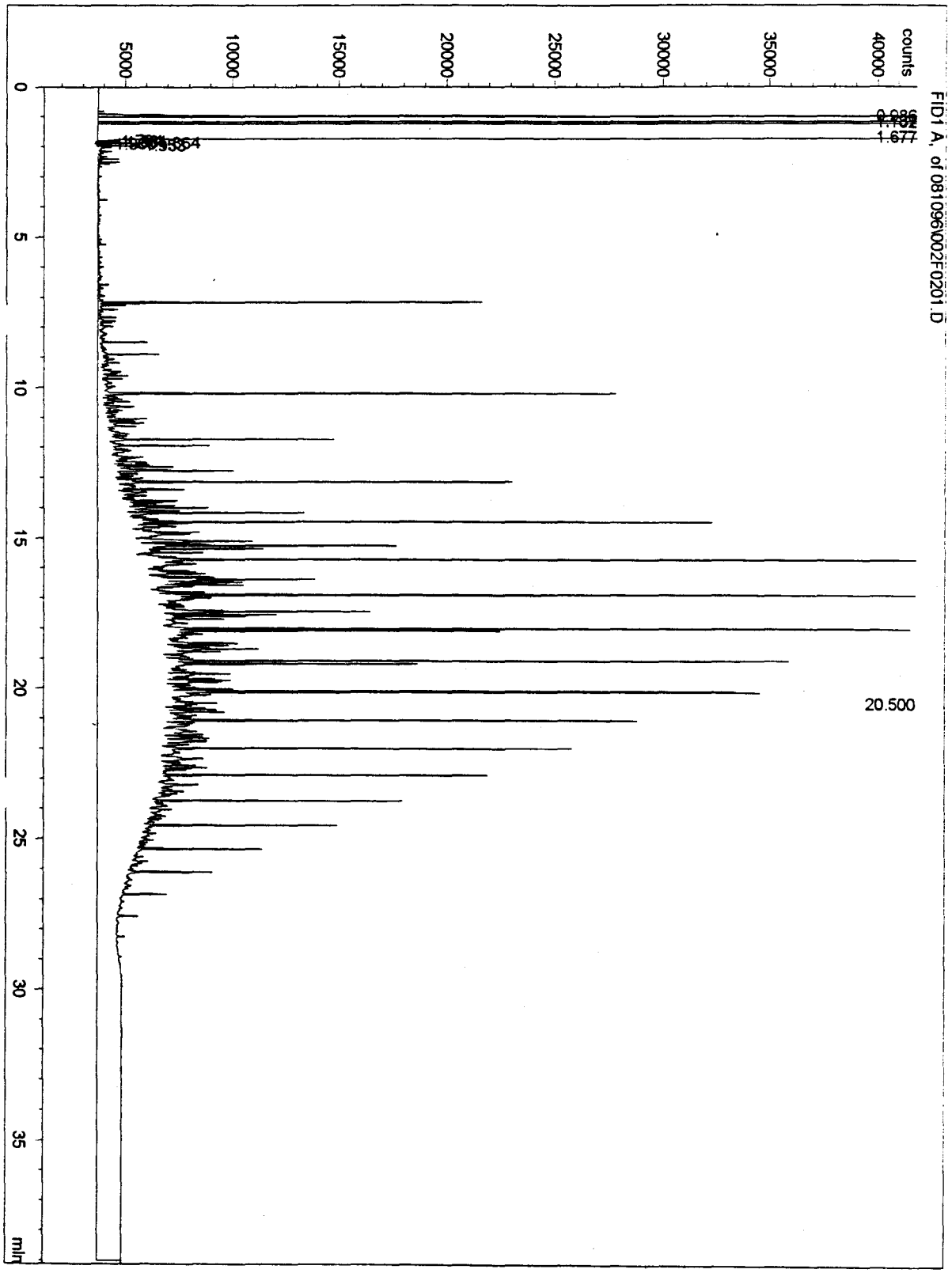
Postadresse	Besøgsadresse	Telefon	Telefax
AB AnalyCen, Vesterbrogade 15, DK-7000 FREDERICIA	Fredericia Miljøcenter, [illegible]	+45 75 92 50 30	+45 75 94 50 37
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

Data File C:\HPCHEM\1\DATA\081096\002F0201.D Sample Name: diesel 500 mg/l

Injection Date : 08-10-96 16.08.02
Sample Name : diesel 500 mg/l
Acq. Operator : ahm

Seq. Line : 2
Vial : 2
Inj : 1
Inj Volume : 1 µl

Sequence File : C:\HPCHEM\1\SEQUENCE\081096.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer



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REPORT issued by an Accredited Laboratory

RAPPORT till:
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Provet ankom 1996-10-09 Analysrapport klar 1996-10-26 Journalnr AG000736-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	M 1

Analysnamn	Resultat	Enhet	KRUT-kod

Se bifogad rapport från Analycen i Danmark.

Anna Börjesson

Analysansvarig

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AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
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0511-186 40

AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. AG 736
Dato 17/10/96 **Prøve nr.** 12-96-003688
Reg.nr. 000-0001-99

U N D E R S Ø G E L S E   A F
D i v e r s e

Rekvirent:

AB AnalyCen
Nils Ericssonsgatan 17
0000 Ikke oplyst

Kopi til:
A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen
Nils Ericssonsgatan 17
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. **Analyse påbegyndt.**
02/09/96 00:00 03/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± **Total kulbrinter**	mg/kg VV	500000	KG 14

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.

Med venlig hilsen

TL Ågren

Kemi ing. Thomas L. Ågren

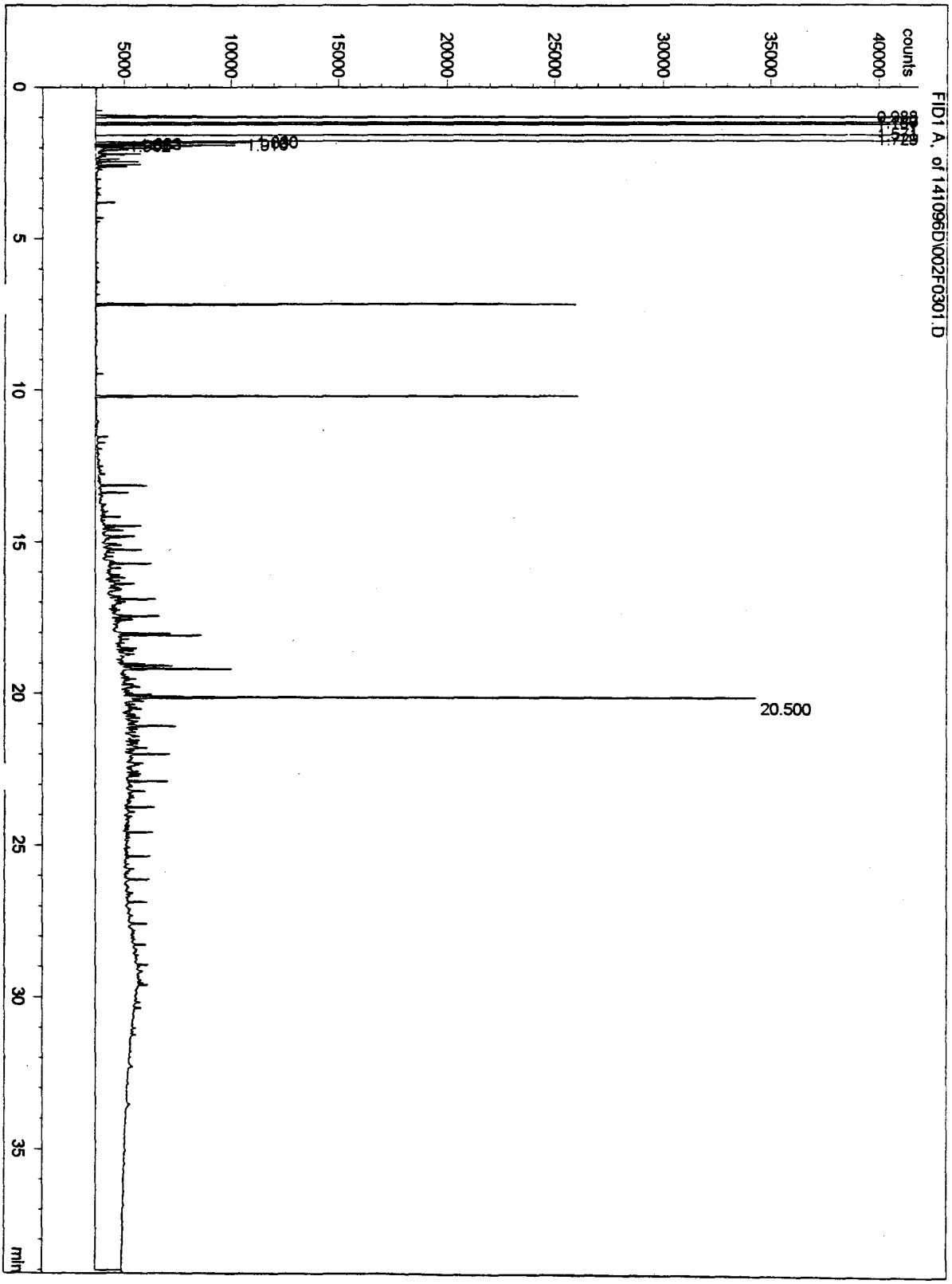
Undersøgelser mærket # er ikke omfattet af akkrediteringen
Oplysninger om usikkerhed på resultaterne kan fås ved henvendelse til laboratoriet.
Analyseresultatet vedrører kun det prøvede emne.
Analyserapporten må ikke gengives, undtagen i sin helhed.

Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, [illegible] DK-7000 FREDERICIA	Fredericia [illegible]	+45 75 94 50 30	+45 75 94 50 37
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

Injection Date : 15-10-96 17.58.50
Sample Name : 12-3688
Acq. Operator : ahm

Seq. Line : 3
Vial : 2
Inj : 1
Inj Volume : 1 µl

Sequence File : C:\HPCHEM\1\SEQUENCE\141096D.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer



AnalyCen

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RAPPORT
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REPORT issued by an Accredited Laboratory

RAPPORT till:
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Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom 1996-10-09 Analysrapport klar 1996-11-01 Journalnr AG000735-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	S 32-2.0

Analysnamn	Resultat	Enhet	KRUT-kod
Naftalen	0.3	mg/kg Ts	
Acenaftylen	<0.1	mg/kg Ts	
Acenaften	<0.1	mg/kg Ts	
Fluoren	<0.1	mg/kg Ts	
Fenantren	<0.1	mg/kg Ts	
Antracen	<0.1	mg/kg Ts	
Fluoranten	0.2	mg/kg Ts	
Pyren	0.8	mg/kg Ts	
Benso(a)antracen	<0.1	mg/kg Ts	
Krysen	0.6	mg/kg Ts	
Benso(b)fluoranten	0.3	mg/kg Ts	
Benso(k)fluoranten	0.3	mg/kg Ts	
Benso(a)pyren	0.2	mg/kg Ts	
Indeno(1,2,3-c,d)pyren	0.6	mg/kg Ts	
Dibenso(a,h)antracen	0.6	mg/kg Ts	
Benso(g,h,i)perylen	0.4	mg/kg Ts	

Benso(b)fluoranten och Benso(k)fluoranten separerar ej , summan av de båda är 0.3 mg/kg Ts.
Detsamma gäller för Indeno(1,2,3-cd)pyren och Dibenso(a,h)antracen där summan för de båda är 0.6 mg/kg Ts

Anna Börjesson

Analysansvarig

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AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. AG 735
Dato 17/10/96 **Prøve nr.** 12-96-003687
Reg.nr. 000-0001-99

U N D E R S Ø G E L S E A F
D i v e r s e

Rekvirent:

AB AnalyCen
Nils Ericssonsgatan 17
0000 Ikke oplyst

Kopi til:
A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen
Nils Ericssonsgatan 17
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. **Analyse påbegyndt.**
02/09/96 00:00 03/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± Total kulbrinter	mg/kg TS	11000	KG 14
Tørstof,total	mg/kg VV	917000	DS 204

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.

Med venlig hilsen

Kemi ing. Thomas L. Ågren

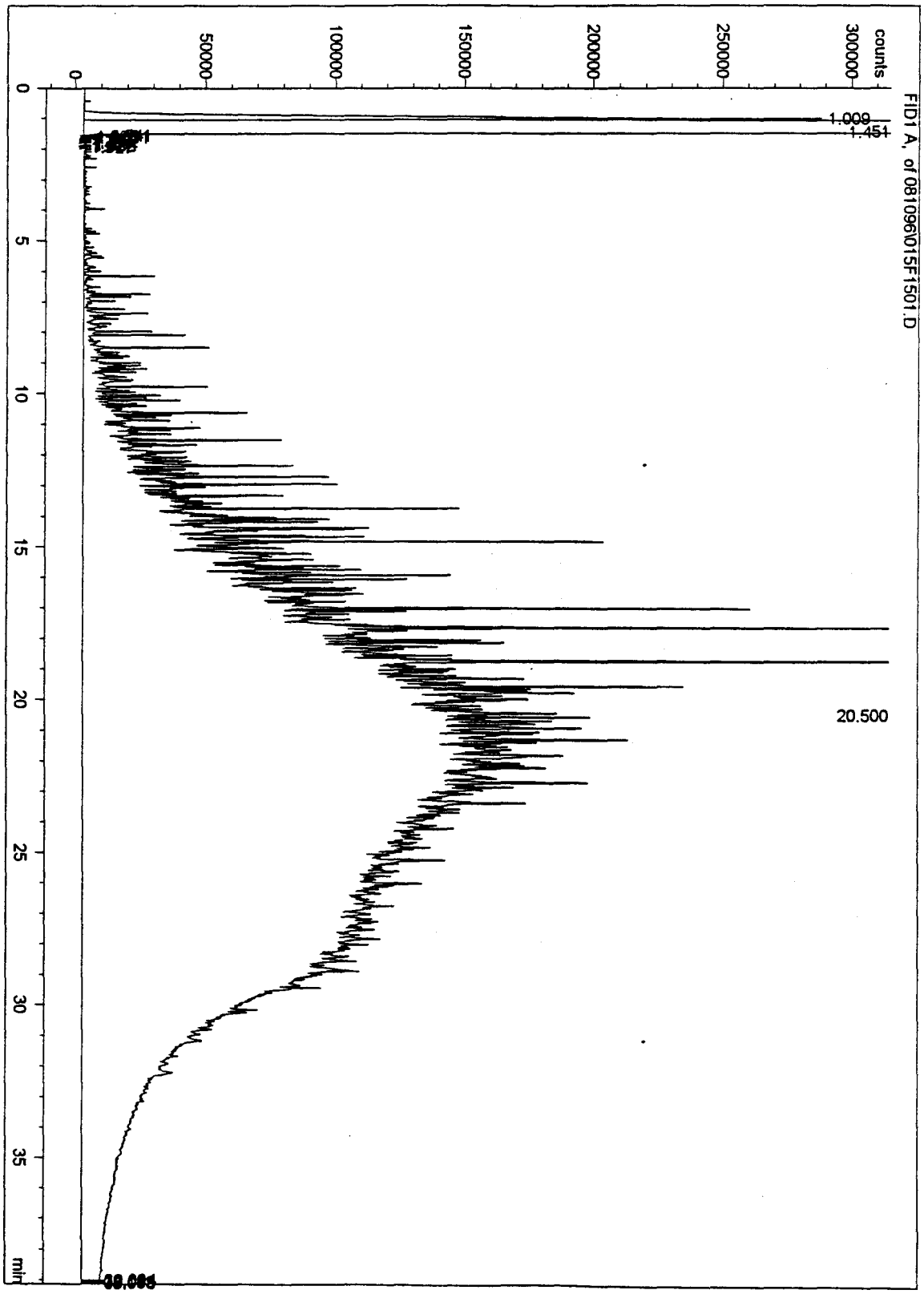
Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, Vestermarie 11, DK-7000 FREDERICIA	Fredericia Center	[illegible]	[illegible]
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

ata File C:\HPCHEM\1\DATA\081096\015F1501.D Sample Name: 12-3687

Injection Date : 10/9/96 4:15:57 AM Seq. Line : 15
Sample Name : 12-3687 Vial : 15
Acq. Operator : ahm Inj : 1
Inj Volume : 1 µl

Acq. Method : C:\HPCHEM\1\METHODS\GCSCR.M
Last changed : 9/13/96 7:58:11 AM by lij
Analysis Method : C:\HPCHEM\1\METHODS\GCSCR.M
Last changed : 10/16/96 12:29:58 PM by rsp
(modified after loading)

GC-SCREENING



AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom 1996-10-09 Analysrapport klar 1996-10-26 Journalnr AG000780-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	S 15-0.7

Analysnamn	Resultat	Enhet	KRUT-kod

Se bifogad rapport från Analycen i Danmark.

Anna Börjesson

Analysansvarig

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
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AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. AG 730
Dato 16/10/96 **Prøve nr.** 12-96-003685
Reg.nr. 000-0001-99

U N D E R S Ø G E L S E A F
D i v e r s e

Rekvirent:

AB AnalyCen
Nils Ericssonsgatan 17
0000 Ikke oplyst

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A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen
Nils Ericssonsgatan 17
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. **Analyse påbegyndt.**
02/09/96 00:00 03/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± Total kulbrinter	mg/kg TS	25000	KG 14
Tørstof,total	mg/kg VV	793000	DS 204

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.

Med venlig hilsen

TL Ågren

Kemi ing. Thomas L. Ågren

SIDE 1 Af 1

Undersøgelser mærket # er ikke omfattet af akkrediteringen
Oplysninger om usikkerhed på resultaterne kan fås ved henvendelse til laboratoriet.
Analyseresultatet vedrører kun det prøvede emne.
Analyserapporten må ikke gengives, undtagen i sin helhed.

Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, Vesterballevej 4, DK-7000 FREDERICIA	Fredericia Miljøcenter	+45 75 94 50 30	+45 75 94 50 37
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
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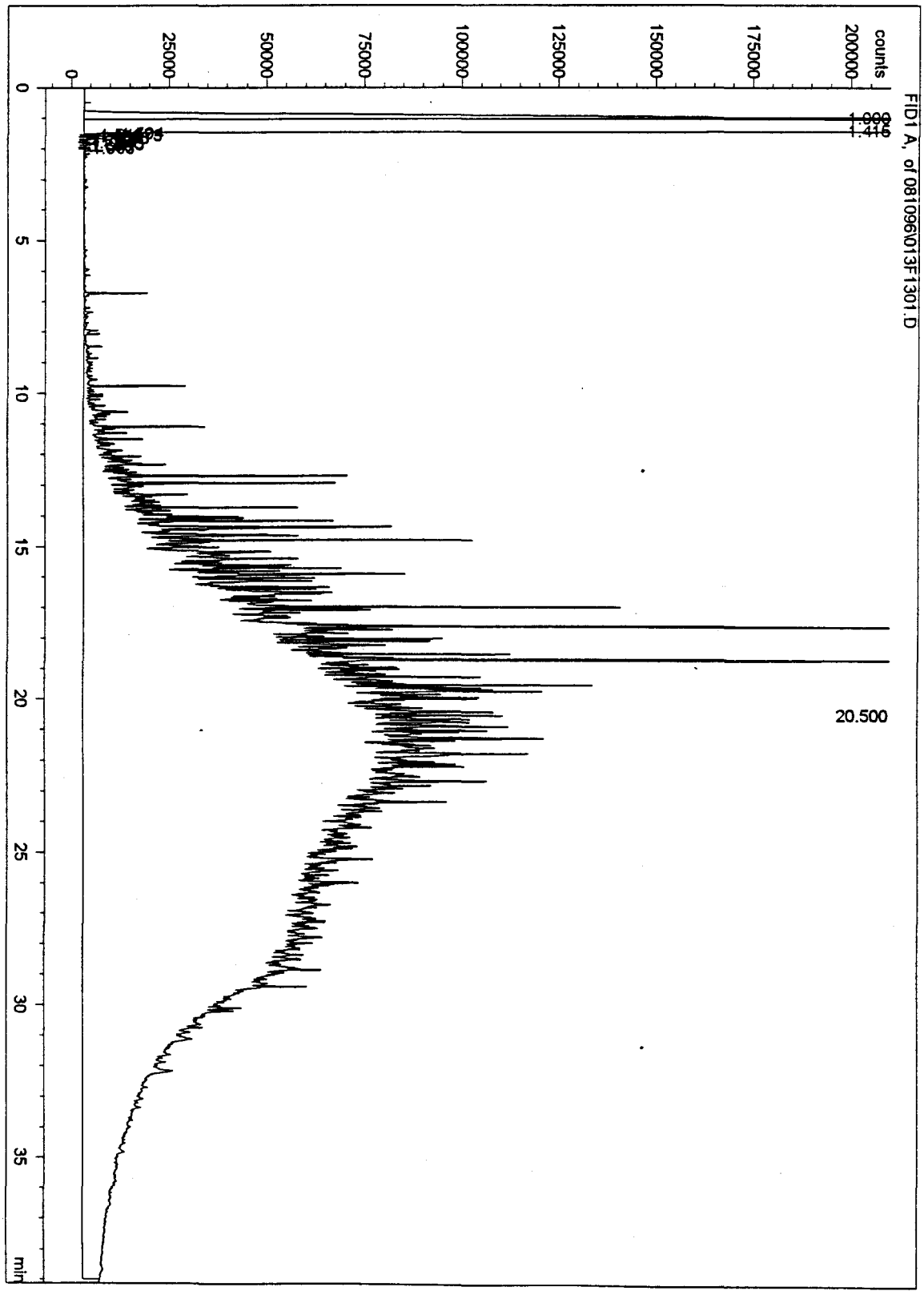
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

Data File C:\HPCHEM\1\DATA\081096\013F1301.D Sample Name: 12-3685

Injection Date	: 10/9/96 2:24:39 AM	Seq. Line	: 13
Sample Name	: 12-3685	Vial	: 13
Acq. Operator	: ahm	Inj	: 1
		Inj Volume	: 1 µl

Acq. Method : C:\HPCHEM\1\METHODS\GCSCR.M
Last changed : 9/13/96 7:58:11 AM by lij
Analysis Method : C:\HPCHEM\1\METHODS\GCSCR.M
Last changed : 10/16/96 12:29:01 PM by rsp
(modified after loading)

GC-SCREENING



AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom 1996-10-09 Analysrapport klar 1996-10-26 Journalnr AG000731-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	S 9-1.5

Analysnamn	Resultat	Enhet	KRUT-kod

Se bifogad rapport från Analycen i Danmark.

Anna Börjesson

Analysansvarig

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
Styrelsens säte: Lidköping. Vat.nr SE556065795801

Besöksadress
Sjöhagsgatan 3, Lidköping
Nils Ericsonsgatan 17, Göteborg
Gråbrödragatan 5, Skara

Telefon
0510-887 00
031-61 37 40
0511-131 55

Telefax
0510-664 38
031-15 05 12
0511-186 40

AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. Ag 731
Dato 16/10/96 **Prøve nr.** 12-96-003686
Reg.nr. 000-0001-99

U N D E R S Ø G E L S E A F
D i v e r s e

Rekvirent:

AB AnalyCen
Nils Ericssonsgatan 17
0000 Ikke oplyst

Kopi til:
A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen
Nils Ericssonsgatan 17
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. **Analyse påbegyndt.**
02/09/96 00:00 03/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± Total kulbrinter	mg/kg TS	29000	KG 14
Tørstof,total	mg/kg VV	898000	DS 204

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.

Med venlig hilsen

Kemi ing. Thomas L. Ågren

SIDE 1 AF 1

Undersøgelser mærket # er ikke omfattet af akkrediteringen
Oplysninger om usikkerhed på resultaterne kan fås ved henvendelse til laboratoriet.
Analyseresultatet vedrører kun det prøvede emne.
Analyserapporten må ikke gengives, undtagen i sin helhed.

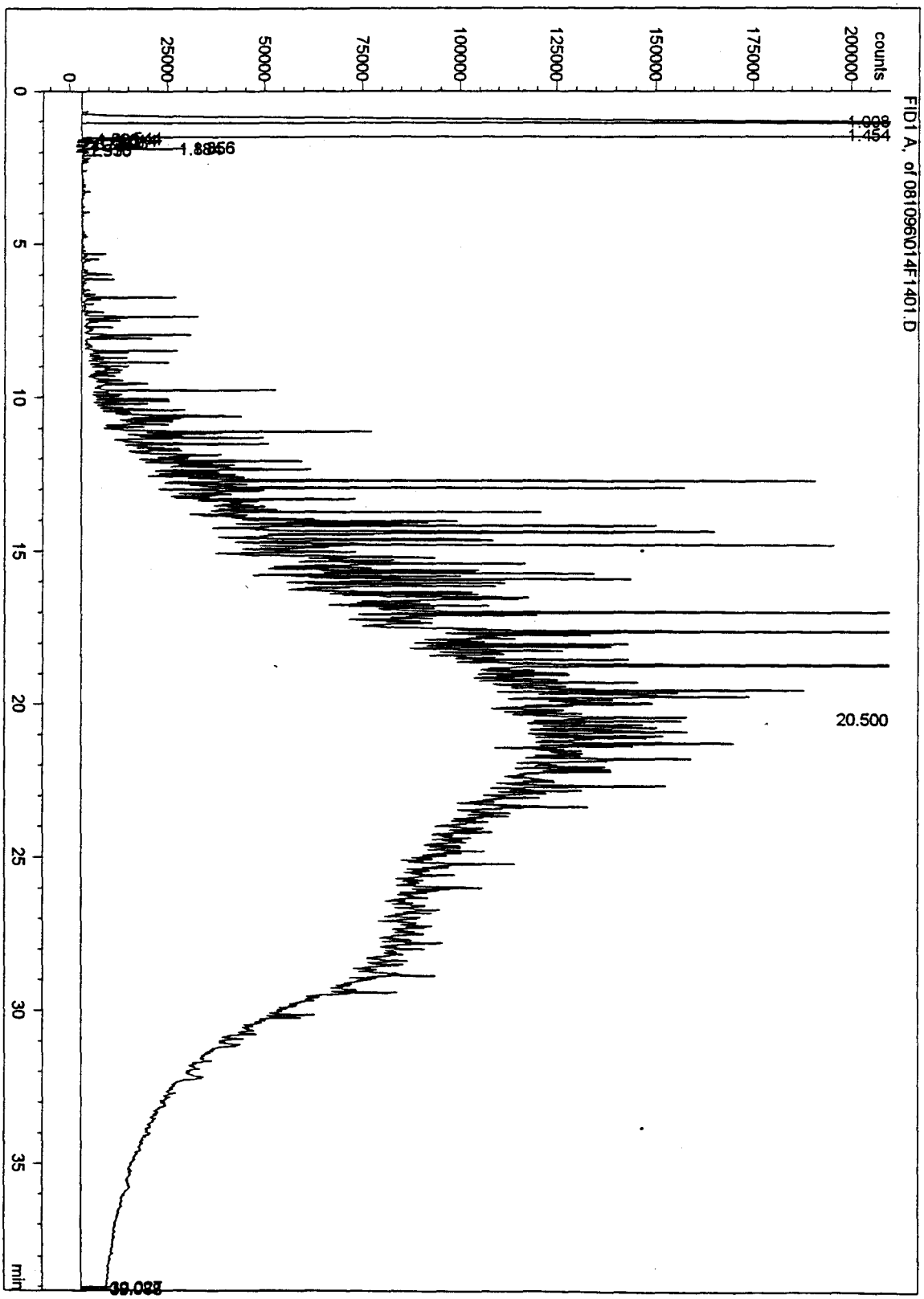
Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, Vesterbaalevej 8, DK-7000 FREDERICIA	Fredericia Miljøcenter, [illegible]	+45 75 94 50 30	+45 75 94 50 37
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

Data File C:\HPCHEM\1\DATA\081096\014F1401.D Sample Name: 12-8686

Injection Date	: 10/9/96 3:20:17 AM	Seq. Line	: 14
Sample Name	: 12-8686	Vial	: 14
Acq. Operator	: ahm	Inj	: 1
		Inj Volume	: 1 µl

Acq. Method : C:\HPCHEM\1\METHODS\GCSCR.M
Last changed : 9/13/96 7:58:11 AM by lij
Analysis Method : C:\HPCHEM\1\METHODS\GCSCR.M
Last changed : 10/16/96 12:29:01 PM by rsp
(modified after loading)

GC-SCREENING



AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

ANKOM 1996 -10- 3

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Personsgatan 12
416 64 Göteborg

Provet ankom:1996-10-09 Analysrapport klar:1996-10-26 Journalnr:AG000737-96 Sida 1 (1)

Kundnr	8406999-034904
Provtyp	Jord
Provtagningsdatum	1996-10-09
Provtagare	-
Provets märkning	M 2

Analysnamn	Resultat	Enhet	KRUT-kod

Se bifogad rapport från Analycen i Danmark.

Anna Börjesson

Analysansvarig

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
Styrelsens säte: Lidköping. Vat.nr SE556065795801

Besöksadress
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Gråbrödragatan 5, Skara

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Telefax
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031-15 05 12
0511-186 40

AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. AG 737
Dato 17/10/96 **Prøve nr.** 12-96-003689
Reg.nr. 000-0001-99

U N D E R S Ø G E L S E A F
D i v e r s e

Rekvirent:

AB AnalyCen
Nils Ericssonsgatan 17
0000 Ikke oplyst

Kopi til:
A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen
Nils Ericssonsgatan 17
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. **Analyse påbegyndt.**
02/09/96 00:00 03/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± Total kulbrinter	mg/kg VV	500000	KG 14

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.

Med venlig hilsen

Kemi ing. Thomas L. Ågren

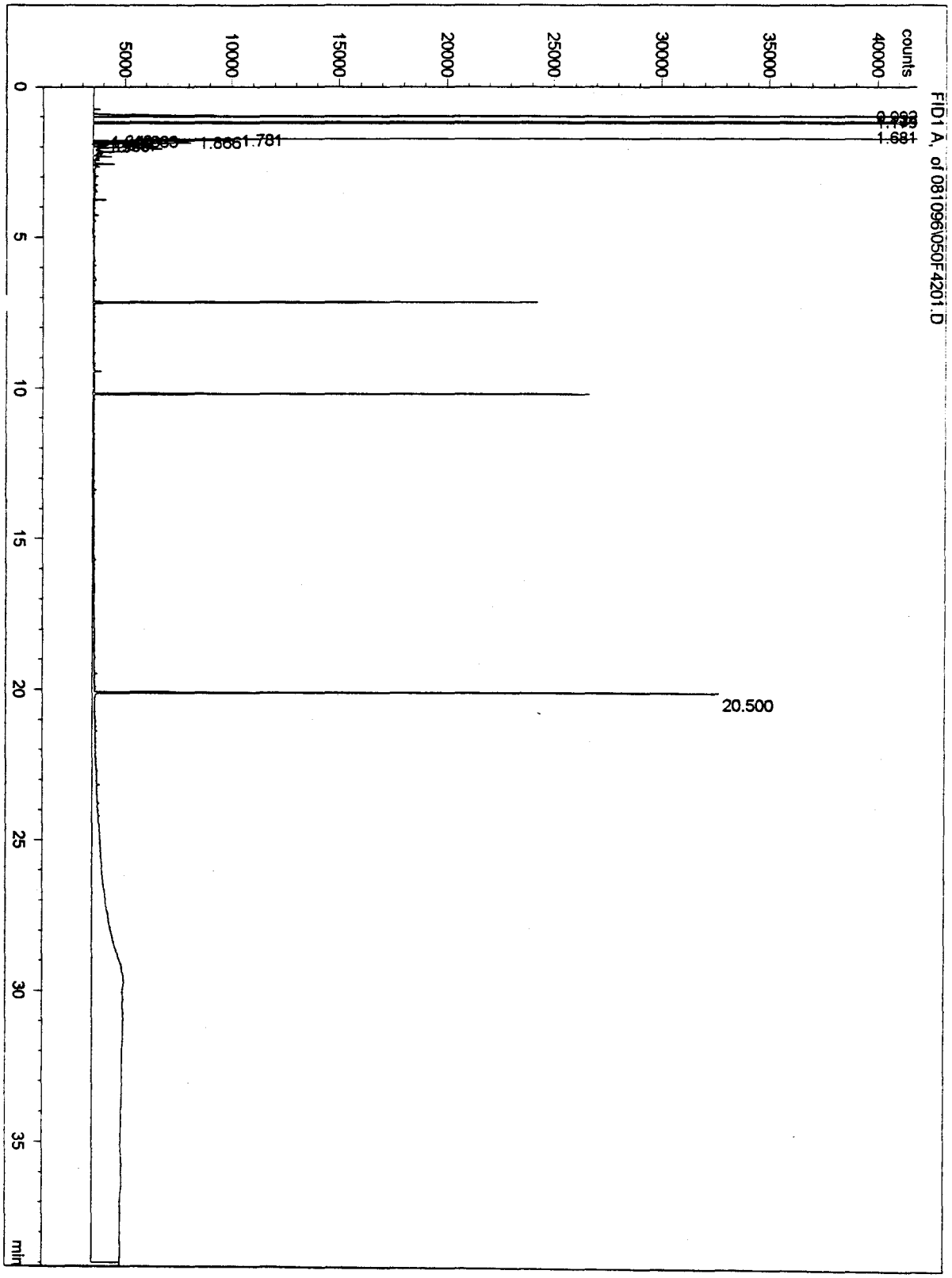
Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, Vesterhalsvej 2, DK-7000 FREDERICIA	Vesterhalsvej 2, 7000 Fredericia	+45 75 94 50 30	+45 75 94 50 37
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

Data File C:\HPCHEM\1\DATA\081096\050F4201.D Sample Name: Dichlor is

Injection Date	: 11-10-96 01.48.01	Seq. Line	: 42
Sample Name	: Dichlor is	Vial	: 50
Acq. Operator	: ahm	Inj	: 1
		Inj Volume	: 1 µl

Sequence File : C:\HPCHEM\1\SEQUENCE\081096.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer

m2 ?



Chikeline 11-10-96 02.27.19 ahm

AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom:1996-10-21 Analysrapport klar:1996-11-15 Journalnr:V000534-96 Sida 1 (1)

Kundnr	8406999-037050
Provtyp	Industrivatten
Provtagningsdatum	1996-10-15
Provets märkning	Proj. nr 962294. Prov nr L 7.

Analysnamn	Resultat	Enhet	KRUT-kod
Kolvätesammansättning	se bif. rapport		

Eddie Klingstedt/0510-88729

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
Styrelsens säte: Lidköping. Vat.nr SE556065795801

Besöksadress
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Nils Ericsonsgatan 17, Göteborg
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0511-131 55

Telefax
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031-15 05 12
0511-186 40

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RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Personsgatan 12
416 64 Göteborg

Provet ankom:1996-10-21 Analysrapport klar:1996-11-15 Journalnr:V000535-96 Sida 1 (1)

Kundnr	8406999-037050
Provtyp	Industrivatten
Provtagningsdatum	1996-10-15
Provets märkning	Proj. nr 962294. Prov nr L 21.

Analysnamn	Resultat	Enhet	KRUT-kod
Kolvätesammansättning	se bif. rapport		

Eddie Klingstedt/0510-88729

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
Styrelsens säte: Lidköping. Vat.nr SE556065795801

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031-61 37 40
0511-131 55

Telefax
0510-664 38
031-15 05 12
0511-186 40

AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. V 534
Dato 05/11/96 **Prøve nr.** 12-96-004595
Reg.nr. 000-0005-20

U N D E R S Ø G E L S E A F V A N D .

Rekvirent:

AB AnalyCen. Box 905
Sjöhagsgatan.S-531 19 Lidköping
0000 Ikke oplyst

Kopi til:
A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen. Box 905
Sjöhagsgatan.S-531 19 Lidköping
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. **Analyse påbegyndt.**
23/10/96 00:00 30/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± Total kulbrinter	mg/l	< 0.02	KG 14

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.
prøven mrk. L7/HC.

Med venlig hilsen

N. Weibel

Civ. ing. Niels Weibel

Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, Vesterballevej 4, DK-7000 FREDERICIA	**Fredericia Miljøcenter**	**+45 75 94 50 30**	**+45 75 94 50 37**
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

AnalyCen

DANAK
Reg.nr. 343

Analyserapport nr. V 535
Dato 05/11/96 **Prøve nr.** 12-96-004596
Reg.nr. 000-0005-20

U N D E R S Ø G E L S E A F V A N D .

Rekvirent:

AB AnalyCen. Box 905
Sjöhagsgatan.S-531 19 Lidköping
0000 Ikke oplyst

Kopi til:
A/S AnalyCen

Årsag:
Ikke oplyst
Virksomhed:
AB AnalyCen. Box 905
Sjöhagsgatan.S-531 19 Lidköping
0 Ikke oplyst
Prøvetager:
Rekvirent
Prøvetagn.tidspkt. 23/10/96 00:00 **Analyse påbegyndt.** 30/10/96 00:00

UNDERSØGELSER	Enhed	Resultat	Metode
± Total kulbrinter	mg/l	0.052	KG 14

Laboratoriets bemærkninger:
± Kvantificeret med dieselolie som standard.
prøven mrk. L21/HC.

Med venlig hilsen

N Weibel

Civ. ing. Niels Weibel

SIDE 1 AF 1

Postadresse
A/S AnalyCen, Vesterballevej 4, DK-7000 FREDERICIA
AB AnalyCen, Box 905, S-531 19 LIDKÖPING
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA

Besøgsadresse
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Nils Ericssonsgatan 17, Göteborg
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+46 31-61 37 40
+46 511-131 55

Telefax
+45 75 94 50 37
+46 510-664 38
+46 31-15 05 12
+46 511-186 40

AnalyCen

Dato

Vor ref.

AB AnalyCen
Sjøhagsgatan
Lidkøbing

Vedr. V 534 (Lab.nr. 12-96-4595) og V 535 (Lab.nr. 12-96-4596)

To vandrøver er ekstraheret med pentan tilsat intern standard og pentanfasen er analyseret ved GC-screening.

Prøve V 534 viser ikke indhold af detekterbare kulbrinter.

Prøve V 535 viser spor af BTEX-indhold samt af uidentificerede mellemkogende kulbrinter med kogepunkt ved ca. 150°C til ca. 300°C.

Med Venlig Hilsen

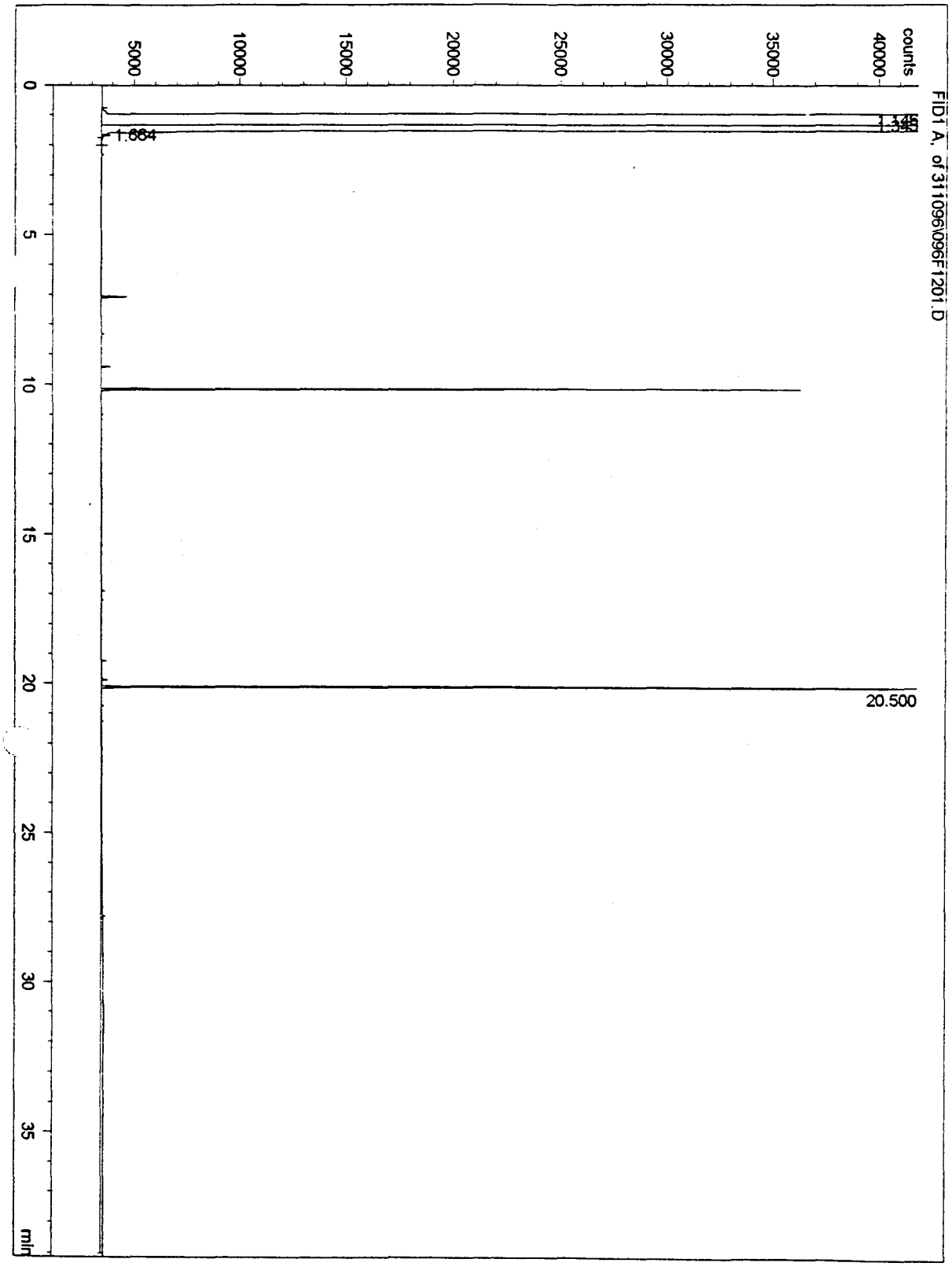
Civ.ing. Niels Weibel

Postadresse	Besøgsadresse	Telefon	Telefax
A/S AnalyCen, Vesterballevej 4, DK-7000 FREDERICIA	Fredericia Miljøcenter	+45 75 94 50 30	+45 75 94 50 37
AB AnalyCen, Box 905, S-531 19 LIDKÖPING	Sjöhagsgatan, Lidköping	+46 510-887 00	+46 510-664 38
AB AnalyCen, Box 11404, S-404 29 GÖTEBORG	Nils Ericssonsgatan 17, Göteborg	+46 31-61 37 40	+46 31-15 05 12
AB AnalyCen Växtodling, Box 244, S-532 23 SKARA	Gråbrödragatan 5, 532 31 Skara	+46 511-131 55	+46 511-186 40

Data File C:\HPCHEM\1\DATA\311096\096F1201.D Sample Name: 12-4595 500/1

Injection Date	: 02-11-96 02.49.14	Seq. Line :	12
Sample Name	: 12-4595 500/1	Vial :	96
Acq. Operator	: rita	Inj :	1
		Inj Volume :	1 µl

Sequence File : C:\HPCHEM\1\SEQUENCE\311096.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer

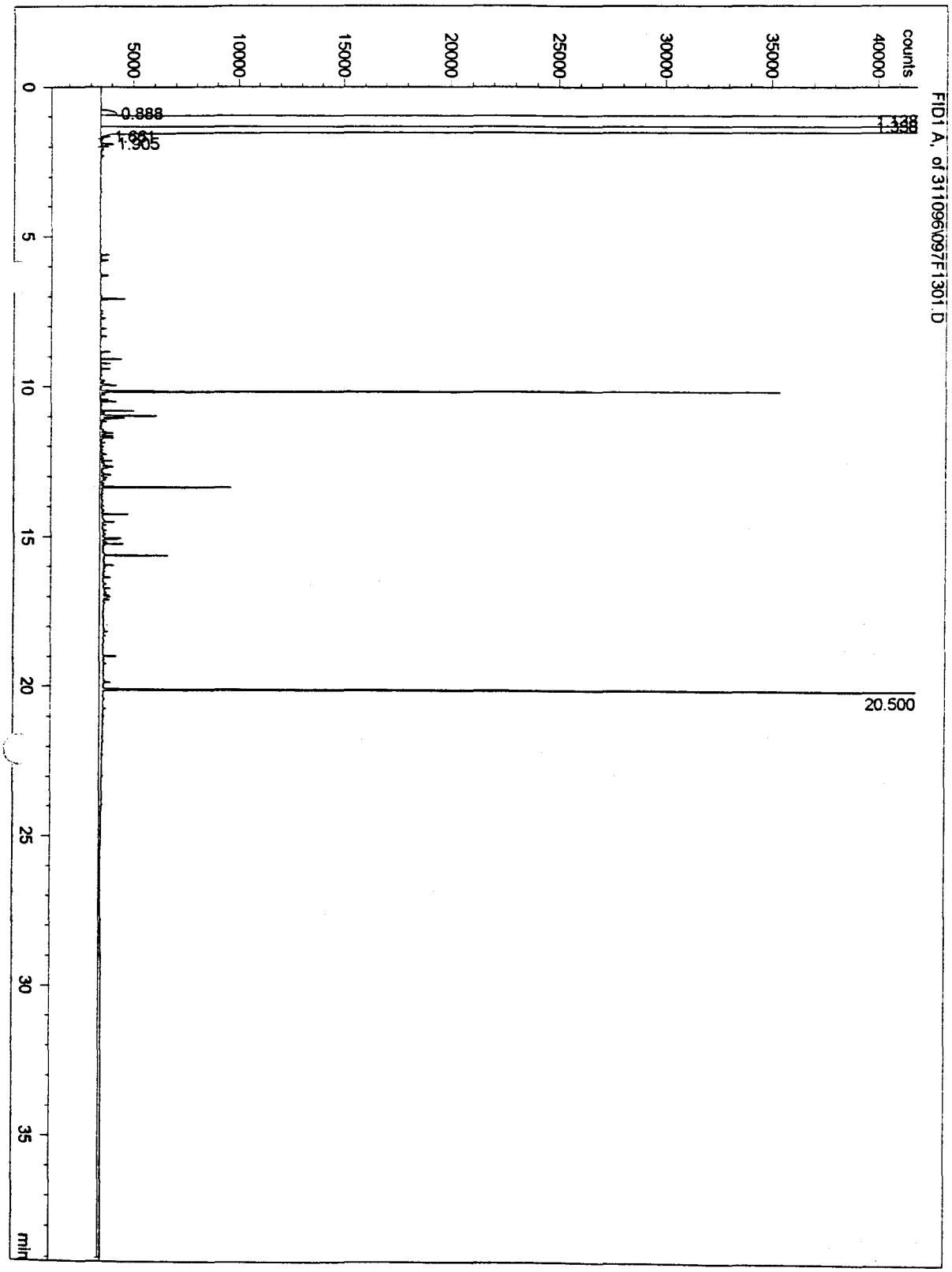


Baseline 02-11-96 03.28.35 rita

Data File C:\HPCHEM\1\DATA\311096\097F1301.D Sample Name: 12-4596 500/1

Injection Date	: 02-11-96 03.43.42	Seq. Line	: 13
Sample Name	: 12-4596 500/1	Vial	: 97
Acq. Operator	: rita	Inj	: 1
		Inj Volume	: 1 µl

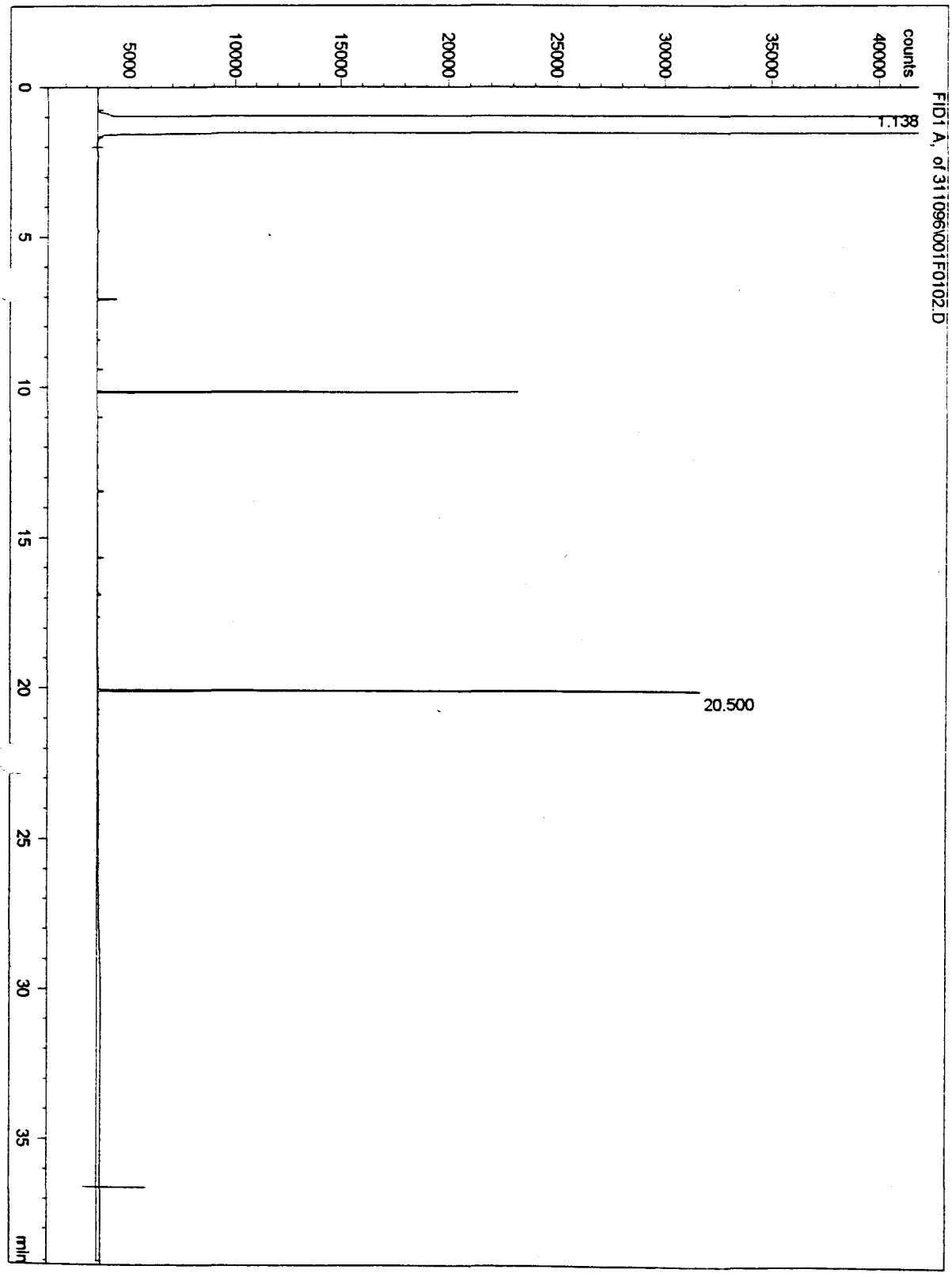
Sequence File : C:\HPCHEM\1\SEQUENCE\311096.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer



)a a File C:\HPCHEM\1\DATA\311096\001F0102.D Sample Name: pentan is

Injection Date : 31-10-96 17.53.47 Seq. Line : 1
Sample Name : pentan is Vial : 1
Acq. Operator : rita Inj : 2
Inj Volume : 1 µl

Sequence File : C:\HPCHEM\1\SEQUENCE\311096.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer



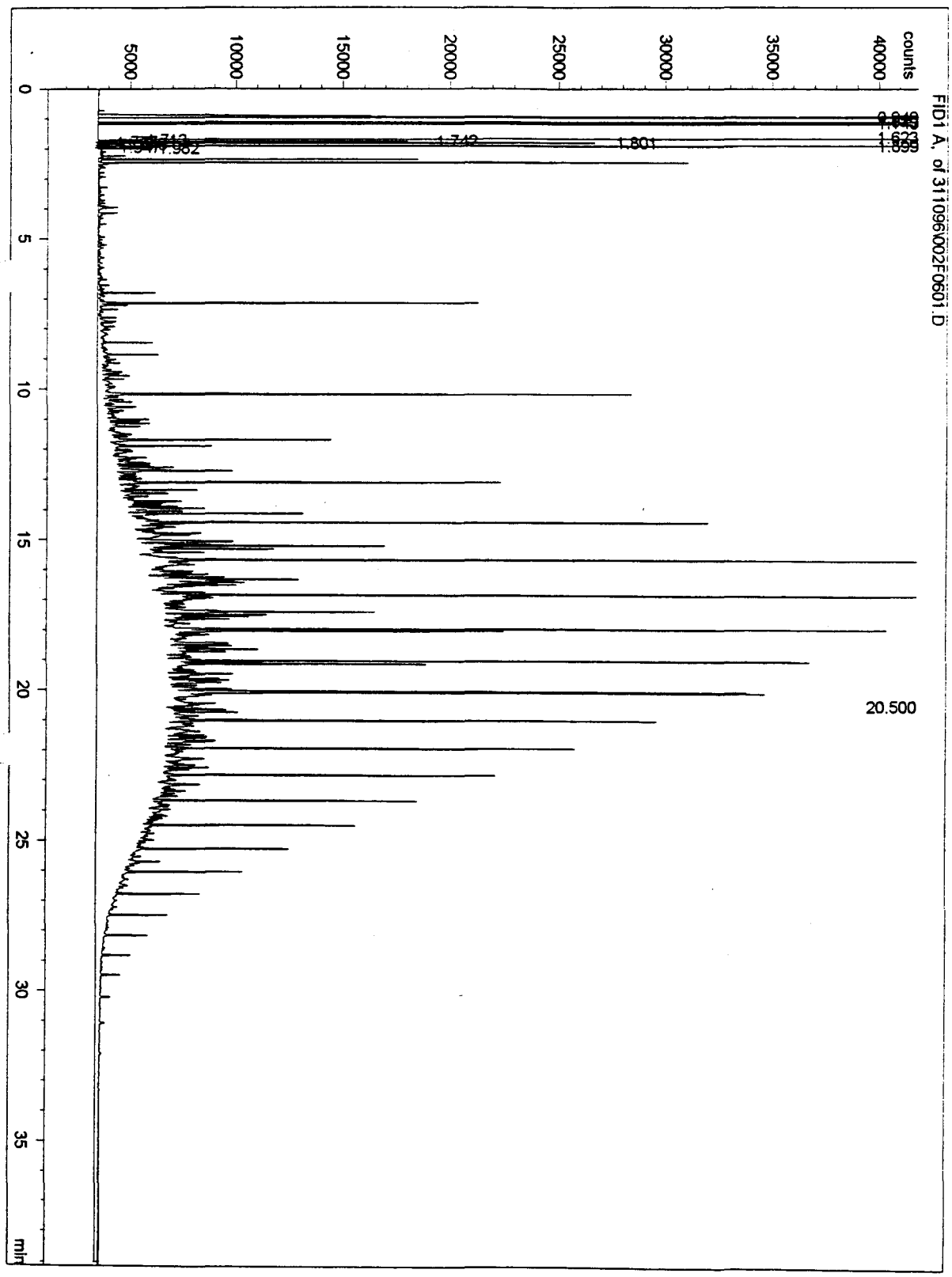
:i keline 31-10-96 18.33.05 rita

Data File C:\HPCHEM\1\DATA\311096\002F0601.D Sample Name: diesel 500 mg/l

Injection Date : 31-10-96 22.30.42
Sample Name : diesel 500 mg/l
Acq. Operator : rita

Seq. Line : 6
Vial : 2
Inj : 1
Inj Volume : 1 µl

Sequence File : C:\HPCHEM\1\SEQUENCE\311096.S
Method : C:\HPCHEM\1\METHODS\GCSCR2.M
Last changed : 08-08-96 09.07.10 by rsp
GC-Screening med to injectorer



AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom:1996-10-21 Analysrapport klar:1996-11-15 Journalnr:V000536-96 Sida 1 (1)

Kundnr	8406999-037050
Provtyp	Industrivatten
Provtagningsdatum	1996-10-15
Provets märkning	Proj. nr 962294. Prov nr L 3.

Analysnamn	Resultat	Enhet	KRUT-kod
Acenaften	0.39	µg/l	
Antracen	<0.1	µg/l	
Benzo (a) antracen	<0.1	µg/l	
Benzo (a) pyren	<0.1	µg/l	
Dibenzo(ah)antracen	<0.1	µg/l	
Indeno(123-cd)pyren	<0.1	µg/l	
Acennaftylen	0.16	µg/l	
Fenantren	<0.1	µg/l	
Fluoranten	<0.1	µg/l	
Fluoren	<0.1	µg/l	
Benzo (k) fluoranten	<0.1	µg/l	
Benzo (b) fluoranten	<0.1	µg/l	
Krysen	<0.1	µg/l	
1-Metylnaftalen	<0.1	µg/l	
2-Metylnaftalen	<0.1	µg/l	
Naftalen	<0.1	µg/l	
Pyren	0.14	µg/l	
Benzo (ghi) perylen	<0.1	µg/l	

Eddie Klingstedt/0510-88729

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
Styrelsens säte: Lidköping. Vat.nr SE556065795801

Besöksadress
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Nils Ericsonsgatan 17, Göteborg
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031-61 37 40
0511-131 55

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031-15 05 12
0511-186 40

AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom:1996-10-21 Analysrapport klar:1996-11-15 Journalnr:V000537-96 Sida 1 (1)

Kundnr	8406999-037050
Provtyp	Industrivatten
Provtagningsdatum	1996-10-15
Provets märkning	Proj. nr 962294. Prov nr L 21.

Analysnamn	Resultat	Enhet	KRUT-kod
Acenaften	<0.1	µg/l	
Antracen	<0.1	µg/l	
Benzo (a) antracen	<0.1	µg/l	
Benzo (a) pyren	<0.1	µg/l	
Dibenzo(ah)antracen	<0.1	µg/l	
Indeno(123-cd)pyren	<0.1	µg/l	
Acennaftylen	<0.1	µg/l	
Fenantren	0.35	µg/l	
Fluoranten	<0.1	µg/l	
Fluoren	<0.1	µg/l	
Benzo (k) fluoranten	<0.1	µg/l	
Benzo (b) fluoranten	<0.1	µg/l	
Krysen	<0.1	µg/l	
1-Metylnaftalen	0.93	µg/l	
2-Metylnaftalen	0.32	µg/l	
Naftalen	<0.1	µg/l	
Pyren	<0.1	µg/l	
Benzo (ghi) perylen	<0.1	µg/l	

Eddie Klingstedt/0510-88729

Postadress
AnalyCen Nordic AB, Box 905, 531 19 LIDKÖPING
AnalyCen Nordic AB, Box 11404, 404 29 GÖTEBORG
AnalyCen Nordic AB Växtodling, Box 244, 532 23 SKARA
Styrelsens säte: Lidköping. Vat.nr SE556065795801

Besöksadress
Sjöhagsgatan 3, Lidköping
Nils Ericsonsgatan 17, Göteborg
Gråbrödragatan 5, Skara

Telefon
0510-887 00
031-61 37 40
0511-131 55

Telefax
0510-664 38
031-15 05 12
0511-186 40

AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:
Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom:1996-10-21 Analysrapport klar:1996-11-15 Journalnr:V000538-96 Sida 1 (1)

Kundnr	8406999-037050
Provtyp	Industrivatten
Provtagningsdatum	1996-10-15
Provets märkning	Proj. nr 962294. Prov nr 34.

Analysnamn	Resultat	Enhet	KRUT-kod	
Bly Pb	<0.0002	mg/l	PB-NG	
Aluminium Al	0.002	mg/l	AL-NG	
Koppar Cu	0.003	mg/l	CU-NG	
Kobolt Co	0.001	mg/l	CO-NG	
Strontium Sr	170	ug/l	SR-NK	
Magnesium Mg	8.5	mg/l	NA-DI	
Kalcium Ca	122	mg/l	CA-DI	
Kadmium Cd	0.1	ug/l	CD-DG	
Arsenik As	0.004	mg/l	AS-NG	
Mangan Mn	0.010	mg/l	MN-NG	
Zink Zn	0.005	mg/l	ZN-NG	
Järn Fe	0.018	mg/l	FE-NG	
Magnesium Mg	8.5	mg/l	MG-DI	
Kalium K	18	mg/l	K-DI	
Kvicksilver Hg	<0.2	µg/l	HGM	
Krom Cr	0.003	mg/l	CR-NG	
Nickel Ni	<0.001	mg/l	NI-NG	
Barium Ba	0.104	mg/l	BA-NG	
Kisel Si	2.3	mg/l	SI-D	analys utf av VVL
Svavel S	10	mg/l	S-NI	

Eddie Klingstedt/0510-88729

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AnalyCen

SWEDAC ACKREDITERING 1125

RAPPORT
utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

RAPPORT till:

Golder Associates AB
Anders Bank
Anders Perssonsgatan 12
416 64 Göteborg

Provet ankom:1996-10-21 Analysrapport klar:1996-11-15 Journalnr:V000539-96 Sida 1 (1)

Kundnr	8406999-037050
Provtyp	Industrivatten
Provtagningsdatum	1996-10-15
Provets märkning	Proj. nr 962294. Prov nr 191.

Analysnamn	Resultat	Enhet	KRUT-kod	
Bly Pb	<0.0002	mg/l	PB-NG	
Aluminium Al	0.005	mg/l	AL-NG	
Koppar Cu	0.002	mg/l	CU-NG	
Kobolt Co	0.0017	mg/l	CO-NG	
Strontium Sr	302	ug/l	SR-NK	
Magnesium Mg	12	mg/l	NA-DI	
Kalcium Ca	123	mg/l	CA-DI	
Kadmium Cd	0.67	ug/l	CD-DG	
Arsenik As	0.003	mg/l	AS-NG	
Mangan Mn	0.62	mg/l	MN-NG	
Zink Zn	<0.001	mg/l	ZN-NG	
Järn Fe	0.050	mg/l	FE-NG	
Magnesium Mg	12	mg/l	MG-DI	
Kalcium Ca	123	mg/l	CA-DI	
Kvicksilver Hg	<0.2	µg/l	HGM	
Krom Cr	0.002	mg/l	CR-NG	
Barium Ba	0.138	mg/l	BA-NG	
Kisel Si	4.0	mg/l	SI-D	analys utf av VVL
Svavel S	10	mg/l	S-NI	

Eddie Klingstedt/0510-88729

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APPENDIX 5

PRELIMINARY ENVIRONMENTAL QUALITY OBJECTIVES FOR THE CONTAMINANTS IN SOIL AND GROUND WATER

PALDISKI CENTRAL BOILER HOUSE REMEDIATION FEASIBILITY STUDY

PRELIMINARY ENVIRONMENTAL QUALITY OBJECTIVES FOR THE CONTAMINANTS IN SOIL AND GROUND WATER

(Approved with Regulation No. 174 of the Government of Estonia on April 11, 1995)

No.	Chemical	Objectives for soil, mg/kg			Objectives for ground water, µg/l	
		Target value	Guidance value in living zone	Guidance value in industrial zone	Target value	Guidance value
I	**Heavy Metals**					
1.	Mercury (Hg)	0.5	2	10	0.4	2
2.	Cadmium (Cd)	1	5	20	1	10
3.	Lead (Pb)	50	300	600	10	200
4.	Zinc (Zn)	200	500	1500	50	5000
5.	Arsenic (As)	20	30	50	5	100
6.	Nickel (Ni)	50	150	500	10	200
7.	Chromium (Cr)	100	300	800	10	200
8.	Copper (Cu)	100	150	500	15	1000
9.	Cobalt (Co)	20	50	300	5	300
10.	Molybdenum (Mo)	10	20	200	5	70
11.	Tin (Sn)	10	50	300	3	150
12.	Barium (Ba)	500	750	2000	50	700
II	**Other Inorganic Compounds**					
13.	Fluorides (as F^--ion, total)	450	1200	2000	1500	4000
14.	Cyanides (as CN^--ion, free)	1	10	100	5	100
15.	Cyanides (as CN^--ion, total)	5	50	500	100	200
III	**Aromatic Hydrocarbons**					
16.	Benzene	0.05	0.5	5	0.2	5
17.	Ethyl benzene	0.1	5	50	0.5	60
18.	Toluene	0.1	3	30	0.5	50
19.	Xylene	0.1	5	50	0.5	60
20.	Phenols (individual compounds)	0.1	1	10	0.5	50
21.	Chlorophenols (individual compounds)	0.05	0.5	5		
22.	Aromatic hydrocarbons (total)	0.5	10	70	1	100

No.	Chemical	Objectives for soil, mg/kg			Objectives for ground water, µg/l	
		Target value	Guidance value in living zone	Guidance value in industrial zone	Target value	Guidance value
23.	Oil products	100	500	5000	20	600
IV	**Polycyclic Aromatic Hydrocarbons (PAH)**					
24.	Benzo[a]pyrene	0.1	1	10	0.01	1
25.	PAH (total)	5	20	200	0.2	10
V	**Halogenated Hydrocarbons**					
26.	Aliphatic chlorinated and aromatic hydrocarbons (individual compounds)	0.1	5	50	1	70
27.	Polychlorinated biphenyls (PCB, total)	0.1	5	10	0.1	1
VI	**Aromatics**					
28.	Aromatic amines (aniline, xylidines) (total)	5	10	50	0.1	5
29.	Aliphatic amines (total)	50	300	700	1	20
VII	**Pesticides**					
30.	Organochlorine pesticides (individual compounds)	0.1	0.5	5	0.05	1
31.	Organochlorine pesticides (total)	0.2	1	10	0.1	2
32.	Pesticides (total)	0.5	5	20	0.3	5

Annexure 1

Explanation:

1. The objectives in the list are either target or guidance values. **The target value** for a pollutant in the environment indicates the concentration which is considered harmless for human health and ecosystems and which is set as a goal of consistent and systematic efforts of the society. **The guidance value** indicates the concentration which, when exceeded, would cause unacceptable health or environmental risk at the specific location. In order to take decisions concerning the possibility of further use or the necessary treatment method, investigations should be carried out at the risky site and/or region.

2. Values for the **groups of substances** (e. g. cyanides, phenols) should be considered as maximum values in the given group, unless indicated otherwise. In the case of necessity, more strict requirements for individual compounds in the group may be established, depending on their risk.
3. If the guidance value is exceeded in an industrial zone, the establishment of new enterprises and the expansion of existing enterprises should be avoided at the specific site.

APPENDIX 6

PHOTOGRAPHS

PALDISKI CENTRAL BOILER HOUSE
REMEDIATION FEASIBILITY STUDY

Photo 1. General view of the Central Boiler House (viewed from the south).

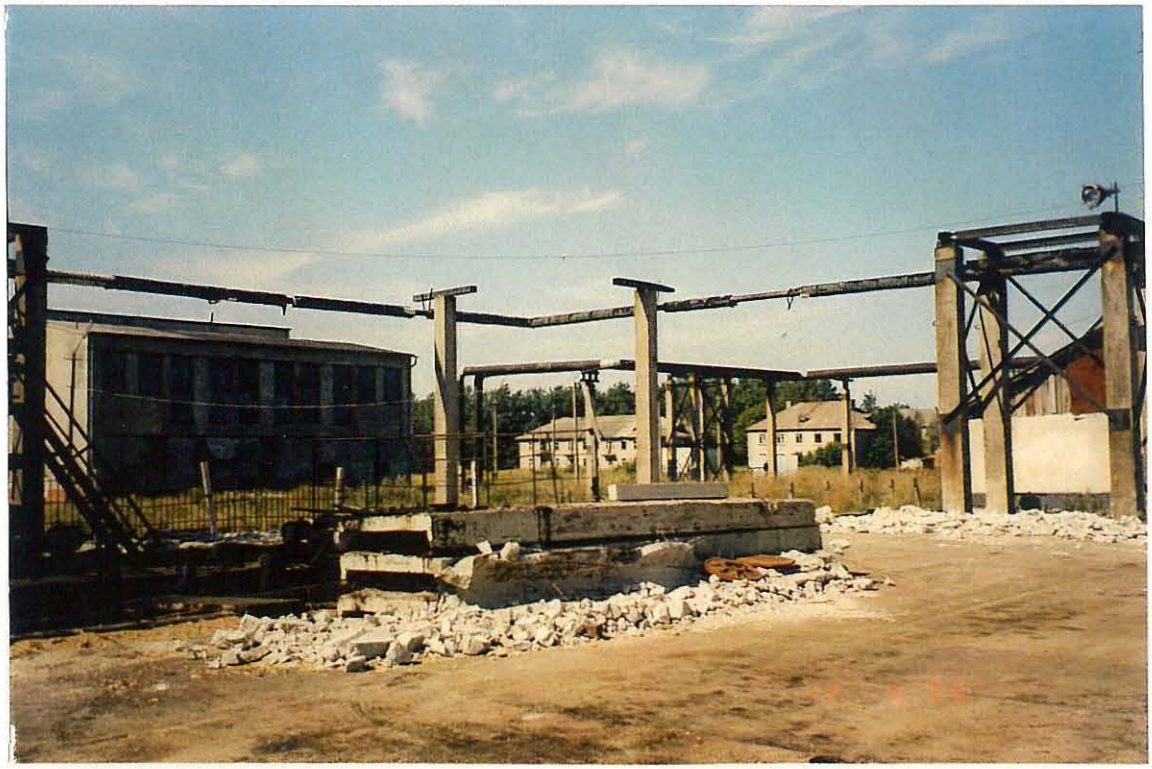

Photo 2. Area where the underground tank is situated (viewed from the east).

Photo 3. Two old 1000 m^3 storage tanks, not in use (viewed from the south).

Photo 4. Two new 2000 m^3 storage tanks (viewed from the south).

Photo 5. Four 100 m^3 oil tanks in concrete basin (viewed from the south).

Photo 6. Railway junction for unloading of tank wagons.

Photo 7. Oil and oily water flowing on the concrete slabs in southern part of the facility (viewed from the east).

Photo 8. Underground concrete wall (viewed from the south).

Photo 9. New oil separator near Paldiski Bay.

Photo 10. Limestone at the coast stained with oily water from the oil separator.

Photo 11. Soil sample PA-20, pores filled with oil.

Photo 12. Sampling point PA-4, depth of free phase oil about 0.7 m from ground surface.

Photo 13. Drainage ditches in the South from the site (viewed from the Southeast)

Photo 14. Oil in the drainage ditches on the Western side of the site.

APPENDIX 7

TERMS OF REFERENCES

PALDISKI CENTRAL BOILER HOUSE REMEDIATION FEASIBILITY STUDY

TERMS OF REFERENCE

We thank you for your request for quotation and have the pleasure of offering you our services. We hope our offer meets your requirements and look forward to doing business with you in future.

1. COSTS

*Separately in closed envelope specified as **Appendix 1.***

2. SPECIFICATION OF WORK.

*The services by the Engineer for this Offer are outlined in **Appendix 2** (hereinafter called "Services").*

3. GENERAL CONDITIONS

3.1. Language and Law

English is the language in which the Offer is drawn up and according to which the Offer is to be interpreted.

The Republic of Estonia is the country, the law of which is to apply to the Offer and according to which the Offer is to be constructed.

3.2. Changes in Legislation

If in Sweden or during the work in Estonia there should occur, subsequent to the coming into force of this offer, changes to any legislation which causes additional or decreased cost to the Engineer in the performance of the Services, such additional or reduced cost shall be paid or credited to the Client and the agreed remuneration adjusted accordingly.

3.3. Notices

All notices under this Offer will be given in writing or by telefax.

Client's address: *Ministry of the Environment*
Mr. Harry Liiv
Toompuiestee 24
EE0100 Tallinn
ESTONIA

Client's telephone:+372 6262 850
Client's telefax: *+372 6262 801*

Engineer's address: *Golder Associates AB*
Dr Lennart Karlqvist
Björkgatan 73
S-752 23 Uppsala
SWEDEN

Engineer's telephone: *+46 18 651600*
Engineer's telefax: *+46 18 651601*

3.5. Commencement Date

The Engineer shall commence the Contract negotiations within one (1) week after the invitation to the negotiations. The place for the negotiations is Estonian Ministry of the Environment.

3.6. Assignment

The Engineer shall not, without the written consent of the Client, in any way assign or transfer the obligations of the Offer or any part thereof.

3.7. Force Majeure

The Engineer shall promptly notify the Client, in writing, of any situation or event arising from circumstances beyond his control and which he could not reasonably foresee which makes it impossible for the Engineer to carry out in whole or in part his obligations under this Offer.

4. RESPONSIBILITY

4.1. Quality of provided services

The Engineer shall exercise all reasonable skill, care and diligence in the performance of the Services under the Offer and shall carry out all his responsibilities in accordance with recognised professional standards.

The Engineer and his employees, whilst in Estonia, shall respect the law and constitutions of that country.

4.2. Remuneration

The remuneration of the Engineer charged to the Client shall constitute his only remuneration in connection with the Offer and neither he nor his personnel shall accept any trade commission, discount, allowance or indirect payment or other consideration in connection with or in relation to the Offer or to the discharge of his obligations thereunder.

4.3. Data and information furnishing

The client shall furnish without charge and within a reasonable time all pertinent data and information available to him and shall give such assistance as shall reasonably be required by the Engineer for the carrying out of his duties under this Offer.

4.4. Visas, permits and access

The Client shall facilitate the timely granting to the Engineer, and any of his personnel, of:

a: *necessary visas, licenses, permits and customs clearance for entry and exit, if needed*

b: *unobstructed access to all sites and locations involved in carrying out the Services*

4.5. Custom clearance

The Client shall facilitate the clearance through customs of any equipment, materials and supplies required for the Services and of the personal effects of the Engineer's personnel.

5. PAYMENT OF WORK

Payment shall be effected to the Engineer in accordance with the payment schedule agreed and in the manner set forth in Appendix 1. Payments shall exclusively be in Swedish Kronor (SEK).

6. PERSONNEL

6.1. Specified staff

The services shall be carried out by personnel specified in ***Appendix 3.***

6.2. Project officers

The Engineer shall designate a Project Director to be overall responsible on his behalf for this Offer and also the performance of the Services and the liaison between the Client and the Engineer.

6.3. Replacement of personnel

Should it become necessary to replace any person specified by name in ***Appendix 3*** *hereof, the Engineer shall forthwith arrange for such replacement with a person of comparable experience. The relevant financing agency shall be notified and approve any such replacement of key staff.*

7. VALIDITY OF OFFER

This offer is valid for 60 days the date below.

8. COMPANY

The firms general experience in the field of environmental researches, groundwater modelling, economic and financial analyses of various alternatives for remediation works including the knowledge and experience of the project environment in Estonia and the nearby region is enclosed in ***Appendix 4.***

9. TERMS OF PAYMENT

30 days net from date of invoice, 16 % interest for delayed payment.

Uppsala 10 th July 1996

GOLDER ASSOCIATES AB

Lennart Karlqvist
President