Tampere Polytechnic
Environmental Management

Final Thesis

Petri Jokinen

Remediation of Contaminated Soils
- Methods and Implementations

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Commissioned by:
Kari Hietala, City of Tampere
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Tampereen Ammattikorkeakoulu
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Petri Jokinen Pilaantuneiden maiden puhdistaminen - menetelmät ja käytännöt.
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Tiivistelmä

Pilaantuneiden maiden kunnostuksessa käytetään erilaisia menetelmiä, joista yksi menetelmä on muita yleisempi helppoutensa ja nopeutensa takia.

Tässä tutkintotyössä on käyty läpi tavallisimpia menetelmävaihtoehtoja, sekä vertailtu niiden ajallista kestoa ja kustannuksia sekä niiden ympäristövaikutuksia.

Lisäksi työssä on esitelty kaksi puhdistusprojektia, jotka suoritettiin Tampereen kaupungissa vuosina 2004 ja 2005.

Tampere Polytechnic
Environmental Management
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Abstract

In remediation of contaminated soils there are several methods to use. Of these, one method is easier to implement and faster, and therefore more common.

In this thesis several common remediation methods are introduced and their duration, costs and environmental effects are compared.

In addition two remediation projects, taken place in City of Tampere in 2004 and 2005 are introduced.

1 Introduction

According to the legislation [26 Chapter 12, Section 75], the municipalities in Finland are ultimately responsible for treatment of polluted soils. In Finland, approximately 500 sites are remediated every year, and the costs have been estimated to be approximately 50 to 60 million euros per year for next 10 years.

In the year 2004, the city of Tampere was involved in many projects related with remediating contaminated soils. Two of those projects are described in this thesis. One project, cleaning the soils of an old sawmill and taking the lot for residential use, has already finished. The other, cleaning the soils of railway area in order to use the soil for roads and for office buildings, is still under work when this thesis is written. The work is estimated to finish in the summer of 2005.

During the planning phase of these projects we went through several methods of remediating contaminated soils. These methods and some other methods that could be possible in the future projects are described in this thesis.
[27, 29, 32]

2 Glossary and some definitions

CEC	Cation Exchange Capacity expresses the capacity of the soil to hold exchangeable cations. [3]
Density of the soil	In this thesis some volumes have been changed into masses or vice versa. For this the average density of soil has been estimated to be 1,8 t/m^3. [1, page 16, table 1]
€	All currencies that have been in US dollars have been changed into euros with rate of $1 equals 0,75 €, which is approximately the exchange rate in March 2005. [2]
Ex situ	Excavation and treating or disposing the soil somewhere else than the site of contamination.
Guide value	Is a limit set by the Ministry of Environment in Finland for soils. If the contaminant concentration is below the guide value, no action is needed. If the concentration is above it, the use of the land is restricted. See also *Limit value*.
In situ	Treating the soil where it is.
Limit value	Is a limit set by the Ministry of Environment in Finland for soils. If the contaminant concentration is below the limit value, the use of the land is restricted. If the concentration is above it, the soil cannot be used for any purposes, and renovation must be considered. See also *Guide value*.
On site	Excavating and treating the soil at the contaminated site and returning it to the same place
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorated biphenyl
SVOC	Semi-volatile organic compounds
VOC	Volatile organic compounds
THD	Total hydrocarbons
TCDD	Full name 2,3,7,8 – tetrachlorodibenzodioxin. It is one of the most hazardous dioxin compounds. Generally used as a reference value to describe the total dioxin concentration in the soil.

3 History of Soil Remediation in Finland

From 1989 to 1994, the Ministry of the Environment in Finland assigned a survey of polluted soils (in Finnish: Saastuneiden maa-alueiden selvitys- ja kunnostusprojekti, SAMASE).

In the survey it was estimated that there are approximately 10 000 sites that require remediation in Finland, and the cleaning those sites would cost approximately. Also in the survey the guide values and limit values for some substances were defined.

After the survey the state and local governments begin to subsidize remediation for the most urgent and environmentally hazardous sites.

At the same time, the strategy for building and maintaining landfill sites has changed and remediation of obsolete landfill sites begin; and in 1997 launched the SOILI project for renovating old petroleum station.

In 2004, the Finnish Environment Institute with Ramboll Finland Ltd published a report of the Remediation Costs of Polluted Soils in Finland. According to the report, there are more than 20 000 sites possibly contaminated.

In the report it is also estimated that between years 2005 and 2025 there are 330 cleaning projects annually and the costs would be 60 million euros a year.

All this has concluded an exponential increase in the number of projects for soil remediation.

[27, 30, 34]

4 Alternatives of Soil Remediation

There are several choices for soil remediation in literature. Nowadays the most common that are used are natural attenuation and soil excavation and ex-situ treatment in some proper location, for example at a landfill site.
[29, 35]

4.1 Monitored natural attenuation

In natural attenuation (also known as natural biodegradation) the polluted soils are let to clean themselves, by natural biological, physical, and chemical reactions. It is important to notice if the pollutants are spreading to the surrounding environment, and therefore possibly diluting the concentration, is prohibited in the Finnish legal praxis, albeit it is in some contexts considered as natural attenuation. On the contrary, since the natural attenuation is rather slow process, spreading of the pollutants has to be prevented.

Natural attenuation is very suitable and inexpensive "cleaning method" for sites that are not in use and that are not located on a ground water area. It is not suitable for cleaning sites that are polluted by inorganic compounds, such as heavy metals.

The key factors in natural attenuation are the conditions, such as temperature, acidity and the composition of the soil. The naturally existing microbes do the most effective work in natural attenuation, and they require suitable pH and temperature values in order to flourish. The most suitable soil type is sand or humus, which contain enough oxygen for the microbes.

The main problem in monitored natural attenuation is the long time for the process to work. Also there is uncertainty whether the process is actually working, and that are the conditions suitable. A risk of spread of the pollutants to the surroundings also exists.

There are speculations that because of the long winter natural attenuation would not be suitable method of remediation. On the other hand the temperature conditions below the frost are rather stable around the year. Also there are research data that some microbes can survive in the cold environment.
[9, 29, 33]

4.2 Bioventing

Bioventing is as a cleaning process rather similar than natural attenuation. In bioventing air or oxygen is lead to the soil in order to improve the efficiency of natural microbes. The method differs from soil vapour extraction where the volatile pollutants are released to the air. In bioventing the gas pressure is rather low, so that it does not escape from the soil. If the polluted soil layer is near the surface (<60 centimetres), the soil is covered in order to prevent the gas to escape.

As in natural attenuation, in bioventing the method is not suitable for non-organic compounds. Other factors that prevent the use of this method are impermeable soil such as clay. Also the ground water layer is restricting the use of the method; it can be used only above the ground water layer.

As in natural attenuation, the acidity and the temperature of the soil are also influencing the efficiency of the method.

There are several companies in Finland that are prepared to use this method, and some successful projects have taken place.

The costs of bioventing have been estimated to be 4 to 30 € per tonne.

[4, 10, 12, 29]

4.3 Enhanced bioremediation

Enhanced bioremediation is a process where the living conditions of natural microbes are improved by supplying sufficient amount of oxygen and nutrients or other substances. This is done by injecting oxygen and uncontaminated water into the soil. The process can also be anaerobic, depending on the quality of contamination.

This method is also applicable only for organic compounds. The soil has to be suitable, not too impermeable.

The method requires suitable temperature conditions to work. Since the process it very slow, results can be expected within years, the method is more suitable for warmer climate than in Finland.

In enhanced bioremediation there is a risk for spreading the contaminants into a wider area. This requires extra caution when applying the method.

The costs of enhanced bioremediation have been estimated to be 12 to 40 € per tonne. [13, 29]

4.4 Soil vapour extraction

In soil vapour extraction, SVE, a vacuum is applied to the soil in order to remove all volatile or semi-volatile contaminants from the soil. The acquired air must be treated, e.g. by activated carbon treatment or by catalytic burning.
SVE is suitable method only for volatile or semi-volatile contaminants, not for heavy metals, heavy oils, PCB, or dioxins.
Ground water level restricts the depth of the treatment. However it is possible to lower the ground water level by depression pumps. It is also possible that during the treatment the vacuum affects also to the ground water and causes it to rise. Therefore the use of pumps may be required.
The costs for SVE range between 4 and 20 € per tonne.
[5, 6, 14, 29]

4.5 Phytoremediation

In phytoremediation plants are used to remove, break down or stabilize the contaminants in the soils. Phytoremediation consists many different mechanisms.

- In **enhanced rhizosphere biodegration** the roots of the plant enhance the biodegradation within the surrounding soils.
- In **phyto-accumulation** the plants are used to uptake the contaminants. The plants are then collected and disposed properly.
- In **phyto-degradation** the plants uptake the contaminants and process them within the plant to a less harmful form.
- In **phyto-stabilization** the plants binds the contaminants in the soils.

Phytoremediation can be applied to a large variety of contaminants. Some strongly bound compounds such as PCB cannot be easily removed, but increasing studies of the topic and possibly using genetically manipulated plants create future prospects for this method.
The method is rather slow, 1 to 10 years or even more.

The costs for phytoremediation are difficult to determine, since the main cost is not the plant itself, but the capital tied within the land for a long period of time.
In the United States the US Army Environmental Centre estimates that applying phytoremediation to a one acre (4047 m^2) lead-contaminated soil to a depth of 0,5 m would cost 45 000 to 75 000 €. That is 12 to 21 € per tonne.
[15, 29, 33, 36]

4.6 Land farming

In land farming the method is to excavate the polluted soils and spread them on some suitable area where leaching can be controlled. After that the conditions for microbes is adjusted to be suitable, including moisture content, oxygen availability, acidity and nutrients. The soil layer cannot be thicker than 0,5 m, and the method is most effective and requires less operation with thickness less than 0,2 m.
The method is most suitable for non- or slow-volatile hydrocarbons. The degradation process takes more time for complex compounds and therefore the method requires time related with the complicity of the hydrocarbons. In the long run, these heavier hydrocarbons cumulate in the soil, and can cause limitations for the land use.
The costs are less than 40 € per tonne with an additional 20 000 to 40 000 € as fixed costs (maximum of 75 000 € for a pilot project).
[11, 16, 29, 33]

4.7 Composting

The difference between composting and merely disposing the soils somewhere is that in composting the remediation process is constantly monitored and adjusted. The main factors to be adjusted are the temperature, moisture content, oxygen availability, pH and nutrient content.

The soil is first mixed with certain agents, such as wood chips and other organic matter in order to ensure the porosity. Then the mixture is placed into windrows. To ensure the suitable temperature conditions the windrows can be heated with for example by air. In some systems the windrows are placed in a hall. In a hall the temperature is easily adjusted as well possible volatile gases are easily gathered. Oxygen availability can be ensured by mechanically turning the windrows frequently. This should be avoided in the beginning of the degradation process to avoid those quick-degradating volatile contaminants to escape. Oxygen injection and heating-with-air can naturally be combined.

The method is rather time consuming, in Finland it is from several months up to few years.
The costs in Finland are from 25 € to 100 € per tonne.
[29, 33]

4.8 Bioreactors

This method is quite similar with the composting. The difference is that in a bioreactor the biodegradation process takes place in closed environment, and therefore the process parameters (temperature, moisture etc.) are controlled much easier. There are different kinds of bioreactors such as rotation composter, slurry phase biological treatment and static composter.
In a rotation composter the rotating motion enhances the soil degradation. Often the composter is working continuously, so that contaminated land is fed into the composter from the other end and the treated soil comes out from the other.
In a slurry phase composter soil is mixed with slurry after stones and other big particles are removed. The slurry is then stirred and with microbe activity the larger particles such as sand can be removed as clean and the finer particles and the water cleaned further, possibly separately.
In a static composter the soil is put into a large container, which has heating, aeration, and watering systems.

Bioreactor is much faster method than the composting. The average time is about six weeks to operate.
The cost is approximately 30 € per tonne.
[17, 29]

4.9 Soil washing

The idea of this method is that the most of the contaminants are bind, either chemically or physically with the fine particles in the soil. The fine particles in the soil are either attached to coarse particles or forms their own layer.
The soil composition in Finland is often consists a coarse layer (e.g. 10% gravel, 70% sand, 20% silt or finer) atop and finer layer (silt and clay) below. In our studies we have found that the contaminants penetrate the finer layer very slowly, and therefore most of the contaminants can be found in the coarser layer. In the soil washing method this coarser layer is washed in order to separate the soil types from each other, and therefore enrich the contaminant concentration and get clean, coarser, soil.
The highly contaminated silt/clay-water mixture is then treated using some other method.

The benefit of this method is that the most expensive factor in cleaning methods in general is the volume of the contaminated soil, not the concentration of the contaminant.

This method has some limitations. The range of suitable composition of the soil is rather small, usually 5 to 30 % finer particles in otherwise mostly sandy soil. The nearby ground water or surface water hinders the method because the method has high possibility for spills or overflow. Also the high cation exchange capacity (CEC) of the soil hinders the process because of the stronger chemical bind between the contaminants and the soil.
The cost of the method is from 25 to 50 € per tonne.
[7, 18, 29]

4.10 Soil flushing

Soil flushing is a method where water (pure or mixed with some aqueous dissolvent such as alcohol) is injected into the soil. The cleaning water dissolves contaminants and possibly mixes with ground water. The cleaning water or the ground water is then pumped up and cleaned with some suitable method or disposed properly.

The problems of this method are the increasing mobility of the contamination, possible contamination of ground water and the fact that it impossible to pump all the water.

The soil type can limit the method; impermeable soil types such as clay are not suitable.

The cleaning of the contaminated water can be too expensive, depending on the volumes and the nature of the contaminants.

The cost of this method is 10 to 100 € per tonne.

[19, 29]

4.11 Electrokinetic separation

In electrokinetic separation anode(s) and cathode(s) are placed underground. Then a direct current is established between them. Because of that, the charged particles such as metals, salts and esters and some organic compounds are drawn near the anode or the cathode. The pH of the soil is also changing, increasing near the cathode and decreasing near the anode. Especially the acidification of the soil increases the mobility of certain metals, which increases the effectiveness of the method.

The contaminants can then be removed with different methods such as electroplating, where a thin metal layer gathers the contaminants; precipitation; pumping of water near the electrode; or in-situ letting the natural microbes to do the cleaning, which is much easier and quicker when the compounds are free. Also it is possible for the last choice to change the polarity of the process. As a result the contaminants merely get loose instead of gathering to one place.

Moisture content of 14 to 18 % has been found most effective.

The cost of the method is estimated to be from 20 to 200 € per tonne, with the price of the electricity of approximately 4 c/kWh (the average price for the electricity in Finland in spring 2005 is 2,35 c/kWh). The energy consumption is 100 to 150 kWh per cubic metre (55 to 80 kWh per tonne), depending on the tightness of the soil.

[8, 20, 29]

4.12 Incineration

Incineration is a very simple method. In high temperature (above 700 ºC) in aerobic conditions more than 99,99% of the contaminants can be removed.
Off gases and combustion residuals need to be treated with an appropriate method.
Some contaminants such as heavy metals, volatile heavy metals, sodium, potassium etc require special cautions during the incineration.
Incineration is very suitable for multipolluted soils, which cleaning with other methods would be difficult and expensive.
The cost of incineration is approximately 65 € per tonne for common burning and 300 € per tonne for dioxins, furans, PCB, PAH's or organic pesticides.
[21, 29]

4.13 Thermal desorption

In thermal desorption, the contaminants are heated in such temperatures that volatilize the contaminants, but are not so high that they would oxidize the contaminants.
There are three different main types of thermal desorption:

1. In direct fire method the contaminated soil is exposed to open fire. Technically easy to operate, but will cause some contaminants to oxidize.
2. In indirect fire method air or water is heated and injected into the contaminated soil. The contaminants are desorbed from the soil into the heated air or water.
3. In indirect heat method the contaminated soil is placed into a rotary dryer, which is then externally heated.

The temperature scale in this method is divided into two categories:

1. High temperature thermal desorption (HTTD), where the temperature of the soil is between 320 ºC and 560 ºC. Mostly efficient with semi-volatile contaminants and PAH's and PCB.

2. Low temperature thermal desorption (LTTD), where the temperature of the soil is between 90 ºC and 320 ºC. This temperature scale is especially suitable for oil-contaminated soils or with other volatile contaminants.

The method is rather fast, and costs 40 to 100 € per tonne, with lower prices with coarser soil types.
[22, 29]

4.14 Waste fixation

This method is also known as stabilization and solidification. The method in principle does not actually clean the contaminants, merely increases the bind between the soil and the contaminant in order to immobilize the contaminant and therefore decreases the risk of the contaminant to pollute more soil or water and the harmfulness of the soil. A leaching test in made to ensure the fixation.
The method is valid for all soil types and for most types of contaminants and can be executed either *in situ* or *ex situ*. A problem with organic contaminants is that there does not exist a suitable leaching test for them.

Common methods used in Finland are bituminization and cement stabilization. In bituminization the contaminated soil is mixed with bitumen. Bituminization is suitable for medium and heavy oils and for heavy metals.
In cement stabilization the contaminated soil is mixed with cement, water and additives into a solid mass. The method is mostly suitable for heavy metals; the high pH of the cement hinders the solubility of heavy metals.
For organic contaminants the problem is still the lack of suitable leaching test.
The mixture made by bituminization and cement stabilization is mostly used as a construction material when constructing open areas such as airports or landfill sites.
The method is quick, the costs range from 25 € to 70 € per tonne. Cement stabilization is a little more expensive than bituminization.
[23, 24, 29]

4.15 Encapsulation

With encapsulation the spreading of the contaminants is prevented by some structures around it. *In-situ* the area is either covered in order to prevent rainwater to penetrate the soil and wash the contaminants into ground water or the surrounding soils or walls are placed to isolate the area from surroundings in order to prevent contaminant spreading. *Ex-situ* the contaminated soil is excavated and placed into a structure in some suitable place.

The most common isolating materials used with this method in Finland are cement, bentonite (certain type of clay), common clay, geomembrane (plastic sheet), fly ash (coal), fabric sludge (from the forest industry), and de-inking (also from forest industry).

The method is not suitable for easily drifting contaminants or volatile contaminants.

Isolation of the contaminated soil is not actually a cleaning method since the contaminants remain in the soil and risk for leaking or future mishandling exists.

The method requires constant observing of the condition of the encapsulation construction and the surrounding soil, air and water.

The costs of the method vary depending on the target.

[28, 29, 31]

4.16 Excavation & Off-site disposal

Excavation and off-site disposal, which is also known as mass exchange, is actually not a renovating method at all. It always has to be combined with some other method to do the actual cleaning. From the constructor and landowner point of view excavation is a renovating method and therefore it is included in this list. In Finland this method is the most common method to renovate contaminated sites at the moment.

In the method there is a significant risk for migration of contaminants to the surroundings, especially during the excavation and transportation.

Most waste treatment sites in Finland are not permitted to receive contaminated soil that is polluted over the limit value.

The total costs of the method vary depending on the distance between the site and the nearest waste treatment site. The disposal cost are 15 to 50 € per tonne. [25, 29]

5 Comparison of different methods

Table 1: Applicability of remediation methods for different soil types and contaminants

Remediation method	**Soil type**					**Applicability**	
	Sand	Silt	Clay	Moraine	Humus	**organics**	**inorganics**
Monitored natural attenuation	x	(x)	(x)	(x)	x	biodegradable contaminants	no
Bioventing	x	x		x	(x)	aerobically biodegradable contaminants (oils, PAH's, possibly chlorified solvents)	no
Enhanced bio-remediation	x	(x)		(x)	x	fuels, oils, creosote oil, PAH's, chlorified hydrocarbons	no
Soil vapour extraction	x	x	(x)	x	(x)	VOC, SVOC if heated	no
Phyto-remediation	depends on the plant					BTEX, chlorified solvents, PAH's, explosives, excess nutrients	heavy metals
Land farming	x	x	x	x	x	oils, not suitable for volatile contaminants	no
Composting	x	x	x	x	x	biodegradable contaminants, not suitable for easily volatile contaminants	no
Bioreactors	x	x	x	x	x	biodegradable contaminants such as oils, chlorophenols, PAH's	no
Soil washing	x			x		oils, PCB, PCP, pesticides, creosote	heavy metals, cyanides
Soil flushing	x	(x)		(x)		VOC, SVOC, fuels, pesticides	heavy metals, radioactive material
Electrokinetic remediation	x	x	x	x	x	polaric organic contaminants	anions such as chloride, nitrate, cyanide & fluoride, cations such as ammonium ions & heavy metals
Incineration	x	x	(x)	x	x	all	all in high temperatures (>1300 ºC)
Thermal desorption	x	x	x	x	x	VOC, SVOC, possibly PCB, PAH's and pesticides	no
Waste fixation	x	x	x	x	x	depends on the binding agent	heavy metals, asbestos, cyanides, non-metals
Encapsulation	x	x	x	x	x	limited, e.g. chlorified solvents can escape	heavy metals, asbestos, cyanides, non-metals
Excavation & Off-site disposal	x	x	x	x	x	almost everything, concentration as a limiting factor	

Table 2: Duration and costs of different remediation methods

Remediation method	**Time required**	**Cost estimation**
Monitored natural attenuation	1+ years	
Bioventing	months to years	4 to 30 € per tonne
Enhanced bio-remediation	years	12 to 40 € per tonne
Soil vapour extraction	months to years	4 to 20 € per tonne
Phyto-remediation	1 to 10+ years	12 to 21 € per tonne
Land farming	1+ years	less than 40 € per tonne (20 000 to 40 000 € as fixed costs)
Composting	months to years	25 € to 100 € per tonne
Bioreactors	months	30 € per tonne
Soil washing	weeks	25 to 50 € per tonne
Soil flushing	weeks to months	10 to 100 € per tonne
Electrokinetic remediation	weeks to months	20 to 200 € per tonne
Incineration	days to weeks	65 € per tonne for common burning and 300 € per tonne for dioxins, furans, PCB, PAH's or organic pesticides
Thermal desorption	days to weeks	40 to 100 € per tonne
Waste fixation	days to weeks	25 € to 70 € per tonne
Encapsulation	days to weeks	vary
Excavation & Off-site disposal	days to weeks	15 to 50 € per tonne

6 A Project: Old sawmill by Lake Kaukajärvi

6.1 Introduction

In this work contaminated soils of former sawmill were excavated and disposed. Work was done between 11th November 2004 and 1st February 2005.

6.2 Preliminary work

The site has been expected to be polluted ever since the sawmill was operating in the area. After the site has been zoned for residential use, it has been studied and the expectations have been proven right. Oil, PAH and dioxins and furans have been found from the area.

For this project excavation and off-site disposal were chosen as a remediation method due to the haste to have the site ready for residential use.

6.3 The site

The site is located in Vehmainen district in the city of Tampere, Finland. The lot has a land register code of 837-045-4538-001 and 002. Street address is Kangasalantie 102.

The distance from the centre of Tampere is about 9 kilometres.

There has been a small sawmill in the area for decades, but the buildings have been demolished earlier.

The area is zoned for housing; according to the zoning plan 7731 (accepted in 2002).

Surrounding area is mostly light residential area with some light and medium industry. From the south side the site is adjacent to the Lake Kaukajärvi. See map (General map from the old sawmill).

Most of the surface soil was landfill, made up by industrial debris, including waste from a nearby foundry. The thickness of the landfill was 0,5 – 1,0 m. Natural soil was mostly silt. In some places landfill was in several layers, which

means it has been brought there in several phases. Ground water has been discovered near the lake at the depth of 1,5 m.
Ground level at the site is +89 to +95 metres from the sea level.
The site is not on a ground water formation area.

6.4 Permission procedure

Permission for cleaning the contaminated site was applied from Pirkanmaa Regional Environmental Centre. The permission was granted 27th October 2004 (record number PIR-2004-Y-294-18).
In the permission all contaminated soils with concentrations of contaminants above the limits by the Ministry of Environment (based on the SAMASE – research mentioned earlier) were ordered to be remediated and if excavated then disposed properly.

6.5 Excavation supervision

As a representative of Pirkanmaa Regional Environmental Centre: inspector Kari Pyötsiä, tel +358-3-2420635.

Head supervisor of excavation: master builder Sakari Oittinen, city of Tampere, tel. +358-3-31466592.

Field supervisor of excavation and controlling the sampling: Juha-Pekka Aho, city of Tampere.

Assistant field supervisor and reporting: trainee Petri Jokinen, city of Tampere

Planning and consulting the excavation: planner Maarit Joukainen, Geotesti Oy, tel. +358-3-2468900

Laboratory analyses were made at Oy Juve AC, laboratory manager Jani Kangas, tel. +358-50-5536520.

Excavation: Street Construction Unit of city of Tampere, site manager: master builder Hannu Jokinen, tel. +358-50-5593873.

6.6 Methods for analysing the level of contamination

Before the excavation work the area has been studied by soil sampling. The soil was found to be contaminated by oils, different heavy metals, polyaromatic hydrocarbons (PAH's) and by dioxins and furans (TCDD/F).
On based of these studies Geotesti Oy made a plan for the excavation.
During the excavation more soil samples were taken, based on assumptions of contamination. Also all excavation was finished only after the soil was verified to be clean.
During the work the area to be cleaned widened remarkably.

The soil samples were studied either in a laboratory (oil by Oy Juve AC Ltd method 001, metals by ICP-AES, dioxins and furans by Oy Juve AC Ltd method 016) or by field measuring devices (PetroFLAG; Dexsil Corporation [37], EPA SW-846 Method 9074; and InnovX X-Ray Fluorescence Spectroscopy [40]; and PAH Soil Test [38])

6.7 Results

Samples were taken before the renovation work:

Table 3: Earlier sampling, only above the limits (see also map: Earlier sampling from the old sawmill)

Point	Heavy metals [ppm]	THC [ppm]	PCB [ppm]	2,3,7,8-TCDD [ppb]	PAH [ppm]
601/1 0,8 m	B 17, Pb 202, Zn 934			520 / 450	
602/2 0,4 m					
603/3 0,2 m					
605/5 0,6 m					
606/6 0,6 m	Zn 153	460			162
607/7 0,3 m					
608/8 0,5-1,0 m		1300			599
613/9 0,3-0,5 m					50,2
614/10 0,2m					
615/11 0,3-0,6 m					
615/11 0,9 m					
616/12 0,3-0,9 m		850			
617/13 0,3-0,6 m					
617/13 0,6 m				660 / 610	
618/14 0,3 m				2100 / 1900	

During the remediation samples were taken as follows:

Table 4: Samples taken during the work (see also map: Sample map from the old sawmill)

		Heavy metals (only if above the guide value) [ppm]	**THC [ppm]**	**PAH [ppm]**	**2,3,7,8-TCDD [ppb]**
Guide value		Cu 100, V 50, Zn 150, As 10, B 5	100/300/600	20	20
Limit value		Cu 400, V 500, Zn 700, As 50, B 50	500/1000/2000	200	500
Identification on the map	**Sample ID**				
595	595 0,3 m				0,3
595	595 0,7 m		69	9,48	48
	Warehouse middle, north side	Cu 220, V 69, Zn 210	<50	34,1	3,1
	Warehouse middle, bottom	V 54	<50	<0,1	0
	Warehouse middle, south side	clean	<50	16	2,0
	Warehouse west, south side	clean	<50	4,91	0
	Warehouse west, bottom	clean	<50	<0,1	0
	Warehouse west, north side	V 68	<50	11,2	0
	Warehouse east, east side	As 12, B 5, V 69	77	49,3	0
	Warehouse east, south side	clean	<50	26,5	6,8
	Warehouse east, bottom	V 68	<50	<0,1	0
	Warehouse east, north side	V 83	<50	1,63	0

Table 4: continue

		Heavy metals (only if above the guide value) [ppm]	**THC [ppm]**	**PAH [ppm]**	**2,3,7,8-TCDD [ppb]**
Guide value		Cu 100, V 50, Zn 150, As 10, B 5	100/300/600	20	20
Limit value		Cu 400, V 500, Zn 700, As 50, B 50	500/1000/2000	200	500
Identification on the map	**Sample ID**				
Drainpipe	Drainpipe, north end	V 72	<50	<0,1	
P31	P31-677>681/ sides	As 11	150	5,21	140
P30, sides	P30, 684, 685 sides	As 12	<50	1,11	
P30, area	P30, 684, 685/ area	V 60	<50	11,2	0
Area 31	Area 31, 683	As 12 V 82	<50	<0,1	0
680 west	679, 680 > 681, west -0,10 m				0,63
680 east	677 > 680 / -0,10m				1,8
Park, south	Park, south	B 9, V 51, Zn 157	<50		
Park, north	Park, north	V 68	<50		
	Warehouse middle, north side, new sample	As 12, V 89		4,14	
617	617, bottom				0,62
617	617, west side				6,9
617	617, north side				67,0
North side, new sample	New sample of the north side of the sawmill				3,6
	716			2,38	
	717			83,9	

From the preceding table we can point those samples that were clean and created limits for the excavation work. See table 5.

Table 5: Final samples. Also see work description in the next chapter.

Sample ID	**Notes**
Warehouse middle, bottom	
Warehouse middle, south side	
Warehouse middle, north side, new sample	First sample from this area was found contaminated by PAH's and heavy metals. Therefore excavation was continued for more than one metre until clearly natural soil. From that soil this sample was taken and was found clean.
Warehouse west, south side	
Warehouse west, bottom	
Warehouse west, north side	
Warehouse east, east side	
Warehouse east, south side	
Warehouse east, bottom	
Warehouse east, north side	
Drainpipe, north end	During the excavation and removal of the drainpipe it was noted that the area east from that was contaminated by the foundry waste. This area was therefore cleaned. The foundry waste layer became thinner when going further to the east, so the pit had a shape of a gentle slope. This sample is a combined sample from the bottom of the slope.
P31-677>681/ sides	Western, southern and eastern sides
Area 31, 683	Bottom
P30, 684, 685 sides	All sides
P30, 684, 685/ area	Bottom
679, 680 > 681, west -0,10m	The area contaminated by dioxins and furans was divided into two parts. This is the bottom sample of the western side.
677 > 680 / -0,10m	The area contaminated by dioxins and furans was divided into two parts. This is the bottom sample of the eastern side.
Park, south	
Park, north	
617, bottom	
617, west side	
New sample of the north side of the sawmill	Point "617, north side" was found contaminated, and therefore the excavation was continued until clearly natural soil. Then this sample was taken and it was found clean.

Table 6: Samples studied by field measuring devices. See also map: Sample map from the old sawmill

Sample ID	**Heavy metals (only when exceeding guide values) [ppm]**	**THC [ppm]**	**PAH [ppm]**
	InnovX	PetroFLAG	PAH Soil Test
683 / 0,3 m		647	
683 / 0,6 m		2070	
683 / 1,1 m		201	
716 / 0,5 m		86	more than 200
716 / 1,0 m		60	more than 200
716 / 1,8 m		464	more than 200
717 / 0,6 m		668	more than 200
717 / 1,6 m		1207	more than 200
717 / 2,5 m		438	more than 200
718 / 0,25 m			more than 200
718 / 0,9 m			more than 200
719 /0,3 m			more than 200
719 / 0,6 m			more than 200
720 / 0,3 m	clean	367	
720 / 0,8 m	Ni 116, Mo 9, Zn 368	93	
720 1,3 m	Cr 249, Ni 174	147	

According to the sampling we were able to define the contaminated area. Final samples were used to secure the cleanliness of the remaining soil. With some certain heavy metals (As, B, V, Zn) there were still some samples where the values exceeded the guide values. With consultation by the Pirkanmaa Regional Environmental Centre these small exceedings were seen to fall within the error margin of the measurements.

6.8 Excavation work

6.8.1 Uphill area

The excavation work begun in November 2004 at the uphill area. Clean surface soils were taken to Rusko landfill site, and contaminated soils according to the plan to Tarastenjärvi Solid Waste Management Site (later Tarastenjärvi). The contaminated soils were mostly consisting of industrial waste including for example brick debris.

The contaminated area was found much larger than it was estimated in the remediation plan. After the contaminated area was found to continue over the area limits into the area that in the zoning plan is designated to recreational area, we consulted the Pirkanmaa Regional Environmental Centre for the necessity to continue the cleaning. After that it was decided to continue excavation further until clean soil. Final samples were taken from the bottom and the western side of the area.


Figure 1: Eastern edge of the Uphill area. Orientation: North.

6.8.2 Area contaminated by dioxins and furans (remains of the sawmill)

According to the plan some of the soils were taken to Kiimassuo Envitech-Area in Forssa (later Forssa) and some to Tarastenjärvi. After sampling the area had to be expanded twice to north. Final samples were taken from the sides and from the bottom.

Figure 2: Remains of the sawmill. Orientation: Southwest.

6.8.3 Area of the drainpipe

Through the area there was an obsolete rainwater drainpipe, which was decided to be removed during the work. During the removal it was noted that there also was industrial waste. After studying the contamination concentrations of the waste it was decided to be excavated and taken to Tarastenjärvi. The contaminated area continued east from the pit and was all excavated.

Figure 3: Rainwater drainpipe. Orientation: South.

6.8.4 Mouth of the drainpipe

The area of the mouth of the drainpipe was cleaned according to the plan. Some contaminated soils were taken to Tarastenjärvi and some to Forssa. Final samples were taken from the sides and from the bottom.

Figure 4: The mouth of the drainpipe. Drainpipe has already been removed. Orientation southwest.

6.8.5 Warehouse area

When the area of the mouth of the drainpipe was removed, we noticed that in the eastern corner the soil was black and stinky. The soil was studied and found contaminated. The area was found to be rather large. The contaminated soils were taken to Tarastenjärvi.

In the western part of the area (the beginning) the contaminated soil was mostly industrial waste. Gradually the composition of the soil changed to have more and more wood chips and sawdust. Finally the soil became composed only by the wood materials. At that point the total PAH concentration had fallen relatively low, to 26,5 and 49 ppm, when the guide value is 20 ppm and the limit value is 200 ppm. At that point we had a meeting of continuing the cleaning with the Pirkanmaa Regional Environmental Centre. With the data mentioned earlier and with the fact that this particular area is not going to be under the houses but as a park area, it was decided that the cleaning was sufficient.

From the other sides and from the bottom the contaminated soils were excavated up till natural soil which purity was confirmed by sampling.

To the southern side of the area were placed a filter fabric to show the limit of cleaned soil. This was done with an idea that it is possible that the adjacent lake will be studied and possibly renovated later.


Figure 5: Warehouse area. Orientation east.

6.9 Excavated masses

Approximately 3400 m^3 of contaminated soils were excavated and transported, 299 truckloads. In addition approximately 1130 m^3 clean surplus soils were transported to Rusko landfill site, 113 truckloads, and concrete waste (mostly from the ruins of the sawmill) to a local company (Toivosen Rauta Oy) to be recycled. Also 3 truckloads of tree materials (mostly from some forest that was growing on the contaminated areas) were taken to Tarastenjärvi as biowaste.

Contaminated soils were transported to the Tarastenjärvi Solid Waste Management Site (269 truck loads, 3690,2 tonnes) and to the Kiimassuo Envitech-Area in Forssa (30 truck loads, 989,8 tonnes). Those soils that were taken to Forssa were soils that Tarastenjärvi would not accept. Tarastenjärvi Solid Waste Management Site does not have permit to accept contaminated soils that have concentration above the limit value, except when contaminated by oil.

For Tarastenjärvi masses the disposal cost 41588,82 €, which is 11,27 € per tonne, approximately 13,6 € per cubic metre. In addition to these costs are the costs from the other disposal sites, the labour costs, transportation costs and machinery costs. According to master builder Hannu Jokinen, the total costs for the project were 143 408,10 € (vat 0%), which gives a cost of 30,6 € per tonne, approximately 42 € per cubic metre.

7 A Project: Ratapihankatu

7.1 Location

The site is located in XVII district (also known as Tulli) in the city of Tampere, Finland. The lot has a land register code of 837-17-308-1 and 4-7. The distance from the centre of Tampere is less than 1 kilometre.

The surrounding area is partly heavy residential area, partly light industrial area. From the east side the site is adjacent to existing railway area.

Most of the surface soil was landfill. The thickness of the landfill (moraine with some debris) was 0,5 – 2 m, occasionally till 4 m. Natural soil was mostly silt. In general, the area was very messy; it has been in railway and in industrial use such a long time. Ground water has been discovered only once, at the depth of 18,0 m from the ground level. Ground level at the site is +95 to +96 metres from the sea level.

The site is not on a ground water formation area.

Figure 6: Ratapihankatu renovation in process. Orientation north.

7.2 History and the Future Use

The national railway company has used the area for decades. In the area there has been a locomotive engine shed, where the engines have been stored and maintained. The shed was demolished in 2001. In the area there has also been a number of other storage rooms. After the engine maintaining has finished, the area has been also used for other vehicle services.

It is assumed that the area was contaminated with oils from the locomotive engines and the service operations, with PCB from the isolation materials used and heavy metals from various sources, especially from the painting and protection materials used. Also PAH compounds could have been used.

In the zoning plan (zoning map no. 7750, archive no. 93188, attached) the area has been divided in two parts; the western and northern part are street area (Ratapihankatu and Åkerlundinkatu) and the rest is light industrial area.

7.3 Preliminary work

7.3.1 Sampling

The city of Tampere has taken 6 samples from the area in year 2000. In year 2001 a cable excavation was made in the area and during that work some samples were taken.

In the summer/autumn 2004 66 samples were taken from the area. Later, during the excavation, so far 80 samples have been taken.

The samples were studied either in a laboratory or/and by field measuring devices (PetroFLAG; Dexsil Corporation [37], EPA SW-846 Method 9074; and InnovX X-Ray Fluorescence Spectroscopy [40]; and PCB Soil Test [39].)

7.3.2 Classifying the area

According to the samples taken from the area before the excavation, a map was drawn which divided the area into sub areas with individual depths. Therefore before the work the contaminated masses were estimated to be 230 m^3 of 300 to 1000 ppm of oil, 1350 m^3 of 1000 to 10000 ppm of oil, and 4000 m^3 of over 10000 ppm of oil. Also 13 m^3 of soils were estimated to be multipolluted by PCB and oils. Some of above-mentioned soils also had heavy metals with concentration more than guide value but less than limit value.

The area was divided by the future use into a road area and into an office area. This division has an important influence on the classification and the remediation of the area, because the office area has to be cleaned under the guide value and the road area only under the limit value. Therefore in practise in the road area only those masses which were contaminated by oils with concentration above 1000 ppm.

7.3.3 Choosing the remediation method

Before the remediation work some research was made to determine the appropriate remediation method. After sampling it was clear that the heavily polluted /multipolluted area was rather isolated and most of the area was polluted only by oils.

First method that was taken into consideration was bituminization, where the oil-contaminated soils would have been used in making asphalt. However that was not possible due to the impropriate structure of the soil; most of the contaminated area was landfill consisting wood debris, construction waste etc.

Second method that was considered was enhanced bioremediation by a company called Bioremedia. In their method the chemical called Aquaquick 2000 B 480 would have been injected with water and air to the contaminated soils. The price for that method would have been approximately 50 € per cubic metre. The remediation work would have taken approximately one year.
As a variation method by them was to find a temporary location for the above-mentioned method, but no suitable location was available.
Also they suggested that the multipolluted soils should also be treated with the same method in order to decrease the oil concentration and therefore to make it either easier to remove PCB or heavy metals or make in less expensive to take them to the waste management site.

Third method that was considered was soil vapour extraction / enhanced bioremediation by a company called Nordic Envicon. Unfortunately they were only prepared to begin the work in the spring of 2005.

Fourth method that was considered was soil washing / wet sorting by a company called Doranova. According to the email conversation with the CEO Pasi Mäkelä in November 2004, the price would have been 45 to 55 € per tonne.

These methods could not carried out due to the lack of time. The deadline given to the project was May 2005, which could only be achieved by excavation and off-site disposal, which has been carried out.

7.4 Permission Procedure

Permission for cleaning the contaminated masses was applied from Pirkanmaa Regional Environmental Centre for the road area. The permission was granted for the road area and an administrative compulsion order was given for the office area 24th August 2004 (record number PIR-2003-Y-198-121).

In those decisions it was determined that for the road area the soils with concentrations of contaminants above the limit values of the SAMASE-report were ordered to be remediated and for the office area the soils with concentrations of contaminants above the guide values of the SAMASE-report were ordered to be remediated.

7.5 Excavation Supervision

As a representative of Pirkanmaa Regional Environmental Centre: inspector Kari Pyötsiä, tel +358-3-2420635.

Head supervisor of excavation: master builder Sakari Oittinen, city of Tampere, tel. +358-3-31466592.

Sampling: Martti Orpana, Pertti Kangas and Vesa Hänninen, city of Tampere
Field supervisor of excavation and sampling: Veijo Wallgren, Ville Saarilahti and Jari Kivioja, city of Tampere.

Assistant field supervisor, sampling, planning and reporting: trainee Petri Jokinen, city of Tampere.

Planning: Tomi Pulkkinen, Ramboll Finland, tel. +358-20-7556860

Laboratory analyses were made at Oy Juve AC, laboratory manager Jani Kangas, tel. +358-50-5536520, at University of Jyväskylä, Institute of Environmental Research, chemist Keijo Mäntykoski, tel. +358-14-2603874, and at Tampere Polytechnic, Environmental Monitoring, engineer Seija Haapamäki, tel. +358-3-2647624.

Excavation: Street Construction Unit of city of Tampere, site manager: master builder Hannu Jokinen, tel. +358-50-5593873 and master builder Kari-Pekka Kortetjärvi, tel. +358-3-31463926.

7.6 Unexpected Events

During the excavation there were several unexpected events. In front of the demolished engine shed there has been a turntable for the engines that has been used to direct the engines inside the shed. All overground structures of the turntable have been demolished earlier, but from underground we found the walls of the turntable. The walls of the turntable were in a shape of a cylinder, approximately 3 metres high and half a meter wide concrete structure with a diameter approximately 22 metres.
It was found with sampling that inside the cylinder the soil was quite polluted with heavy metals and it had to be excavated to depth of 6,5 metres.

Also some other foundations of some structures were found in the area. A big problem for the efficiency was all the unknown cables found all around the ground. Fortunately they were all not in use anymore.

7.7 Remediation in figures

The remediation work is still in progress when this is written, but it is possible to estimate that more than 90 % of the contaminated masses have already been excavated. Since the middle of March 2005, 1149 truckloads of soils have been excavated. That is approximately 10480 cubic metres of soils. Of that, 7360 cubic metres have been contaminated soils and 3120 cubic metres have been clean soils that have been taken to a landfill if it has been clay or silt, or it has been reused at the site if it has been coarser soil.

To the Tarastenjärvi Solid Waste Management Site we have taken so far 11 560 tonnes of contaminated soils. Disposing them costs 182 800 €, that is 15,8 € per tonne.

8 Conclusion

Unfortunately the mass exchange is the most common method of renovation in Finland due the construction schedules. Excavation and transportation of the contaminated masses creates a hazard for the environment. In most cases the mass exchange could be avoided by sustainable planning of the remediation. Especially since most of the contamination is very well known the soils could easily be cleaned well advance to the constructing.
In addition, our waste treatment sites are filling up with vast amount of lightly contaminated soil, which could be cleaned *in-situ* or on site without too much effort and economically.

The best way to approach the problem of contaminated soils is with patience and with long term planning. Alternative methods provide cheaper and more environmentally sustainable ways to clean the sites that require remediation. Especially those cities in Finland that the problem mostly concerns (big, industrial cities) should have a strategy and centralized planning for renovating contaminated soils.

References

1. **Accident Investigation Board Finland:** *Proomu Caran kaatuminen Raahen edustalla 25.5.1997*. Accident Investigation Board Finland. 1997. Available in the Internet: http://www.onnettomuustutkinta.fi/uploads/x0fesjmfzg64p.pdf

2. **Bank of Finland**: *Euron dollari- ja jenikurssit, päivittäin*. [Daily exchange rates of euro vs. US$ and the yen] The Bank of Finland. Updates daily. Available in the Internet:
http://www.suomenpankki.fi/fin/5_tilastot/5.1_Tilastografiikkaa/5.1.3_valuuttakurssit_ja_valuuttamarkkinat/index.stm

3. **Canadian Soil Information System**: *Cation exchange capacity.* Ministry of Agriculture and Agri-Food. Canada. Updated 30th February 1996. Available in the Internet:
http://sis.agr.gc.ca/cansis/glossary/cation_exchange_cap.html

4. **Doranova:** *Bioventing*. Doranova. Available in the Internet:
http://www.doranova.fi/english/tuotteet/tuotteet1f.html

5. **Doranova:** *Soil Vapour Extraction*. Doranova. Available in the Internet:
http://www.doranova.fi/english/tuotteet/tuotteet1d.html

6. **Ekokem:** *Huokosilmakäsittely*. Ekokem Group. Available in the Internet:
http://www.ekokem.fi/main/FrontPage.asp?ItemId=1240

7. **Ekokem:** *Pesu*. Ekokem Group. Available in the Internet:
http://www.ekokem.fi/main/FrontPage.asp?ItemId=1242

8. **EMV:** *Sähkön hintavertailu* [Comparison of electricity price]. Energiamarkkinavirasto. Available in the Internet:
http://www.energiamarkkinavirasto.fi/calc2.asp?Hakukohde=Siirtohinnat&Tyyppikayttaja=T3&Round=2

9. **Environmental Protection Agency:** *A Citizens guide to Monitored natural attenuation.* United States Environmental Protection Agency, Hazardous waste clean-up information.
Available in the Internet: http://www.clu-in.org/download/citizens/mna.pdf

10. **Environmental Protection Agency:** *Bioventing*. United States Environmental Protection Agency. Updated 10th March 2003. Available in the Internet:
http://www.epa.gov/swerust1/cat/biovent.htm

11. **Environmental Protection Agency:** *Landfarming*. United States Environmental Protection Agency. Updated 10th March 2003. Available in the Internet:
http://www.epa.gov/swerust1/cat/landfarm.htm

12. **Federal Remediation Technologies Roundtable:** *Bioventing*. Available in the Internet:

http://www.frtr.gov/matrix2/section4/4_1.html

13. **Federal Remediation Technologies Roundtable:** *Enhanced Bioremediation*. Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-2.html

14. **Federal Remediation Technologies Roundtable:** *Soil Vapor Extraction.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-7.html

15. **Federal Remediation Technologies Roundtable:** *Phytoremediation*. Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-3.html

16. **Federal Remediation Technologies Roundtable:** *Landfarming*. Available in the Internet:
http://www.frtr.gov/matrix2/section4/4_13a.html

17. **Federal Remediation Technologies Roundtable:** *Slurry Phase Biological Treatment.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-14.html

18. **Federal Remediation Technologies Roundtable:** *Soil Washing*. Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-19.html

19. **Federal Remediation Technologies Roundtable:** *Soil Flushing.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-6.html

20. **Federal Remediation Technologies Roundtable:** *Electrokinetic Separation.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-4.html

21. **Federal Remediation Technologies Roundtable:** *Incineration*. Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-23.html

22. **Federal Remediation Technologies Roundtable:** *Thermal Desorption.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-26.html

23. **Federal Remediation Technologies Roundtable:** *Solidification/Stabilization In Situ.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-8.html

24. **Federal Remediation Technologies Roundtable:** *Solidification/Stabilization Ex Situ.* Available in the Internet:
http://www.frtr.gov/matrix2/section4/4-21.html

25. **Federal Remediation Technologies Roundtable:** *Excavation, Retrieval, and Off-Site.* Available in the Internet: http://www.frtr.gov/matrix2/section4/4-29.html

26. **Finlex Data Bank**: *Environmental Protection Act*. The Ministry of Justice, Finland. Issued in Helsinki 4th February 2000. Available in the Internet: http://www.finlex.fi/en/laki/kaannokset/2000/en20000086.pdf

27. **Finnish Environment Institute**: *Pilaantuneilla alueilla tehdyt kunnostukset*. [Remediations of contaminated soils]. The Ministry of the Environment. Updated 21st December 2004. Available in the Internet: http://www.ymparisto.fi/default.asp?contentid=59158&lan=fi

28. **New York State Department of Environmental Conservation:** *Region 8 Citizen's Glossary of Environmental Terms G through P, geomembrane.* Available in the Internet: http://www.dec.state.ny.us/website/reg8/der/glossG_P.html

29. **Penttinen Riina:** *Maaperän ja pohjaveden kunnostus.* [Remediation of soil and ground water] Finnish Environment Institute. Oy Edita Ab, Helsinki, 2001. ISBN 952-11-0943-2, ISSN 1455-0792. Also available in the Internet: http://www.ymparisto.fi/download.asp?contentid=12461&lan=FI

30. **Ramboll:** *Remediation costs of contaminated sites in Finland*. Espoo 5th November 2004. Available in the Internet: http://www.ymparisto.fi/download.asp?contentid=24837&lan=en

31. **Schlumberger, the Oilfield Glossary:** *Bentonite*. Schlumberger. Available in the Internet: http://www.glossary.oilfield.slb.com/Display.cfm?Term=bentonite

32. **Seppälä, Jyri; Idman, Hannu (eds.):** *Maaperän suojelu – Geologian tutkimuskeskuksen ja Suomen ympäristökeskuksen tutkimusseminaari 5.11.2004* [Soil protection – Research seminar of the Geological Survey of Finland and the Finnish Environment Institute 5.11.2004] Finnish Environment Institute. Dark Oy, Vantaa, 2004. ISBN 952-11-1830-X, ISSN 1238-7312. Also available in the Internet: http://www.ymparisto.fi/download.asp?contentid=26568&lan=FI ISBN 952-11-1831-8 (PDF)

33. **Singh, Ajay; Ward, Owen P. (Eds.):** *Applied bioremediation and phytoremediation*. Springer-Verlag, Germany, 2004. ISBN:3-540-21020-2

34. **Southwest Finland Environmental Centre**: *Saastuneiden maa-alueiden selvitys- ja kunnostusprojekti (SAMASE)*. [Survey and remediation project of contaminated soils]. The Ministry of the Environment. Updated 18th September 2003. Available in the Internet: http://www.ymparisto.fi/default.asp?contentid=12869&lan=FI

35. **Thiemann, William; Palladino, Michael A.:** *Introduction to biotechnology*. Addison Wesley, 2003. ISBN: 0-8053-4825-5

36. **USAEC:** *Phytoremediation of Lead-contaminated Soil.* US Army Environmental Center. Updated 1st October 2003. Available in the Internet: http://aec.army.mil/usaec/technology/cleanup04b.html

Field measuring devices:

37. **Dexsil:** *Petroflag*. Dexsil Corporation, USA. Available in the Internet: http://www.dexsil.com/products.php?page=petroflag

38. **Envitop:** *PAH soil test.* Envitop Oy, Finland Available in the Internet: http://www.envitop.com/tuotteet/pikatestit_fin/pah_fin.htm

39. **Envitop:** *PCB soil test.* Envitop Oy, Finland Available in the Internet: http://www.envitop.com/tuotteet/pikatestit_fin/pcb_fin.htm

40. **GWM-engineering:** *Kenttätestit ja raskasmetallianalysaattorit.* [Field testing and heavy metal analysators]. GWM-engineering Oy, Finland. Available in the Internet: http://www.gwm-engineering.fi/innovx.html

HYVÄKSYTTÄVÄ ASEMAKAAVA

T A M P E R E

ASEMAKAAVAN MUUTOS

Kaupunginosa: XVII
Kortteli nro: 308
Tontit nro: 1, 4, 5, 6, ja 7
Katu- ja rautatien aluetta

Kaupunginosa: XVIII
Katualuetta
Kaupunginosan rajaa

ASEMAKAAVAN MUUTOKSELLA MUODOSTUU

Kaupunginosa: XVII
Korttelit nro: 308 osa
nro: 302 osa
Katualuetta

Kaupunginosa: XVIII
Katualuetta
Kaupunginosan rajaa

ASEMAKAAVAMERKINNÄT JA -MÄÄRÄYKSET:

K-24	Liike- ja toimistorakennusten korttelialue, jolle saadaan rakentaa myös tiloja opetustoimintaa ja julkisia palveluja varten. Tontin rakennusalalla sallitaan kerrosalaan laskettavien maanalaisten liike- ja työtilojen rakentaminen. Tontille on varattava autopaikkoja merkinnän osoittama määrä.
KTTY-6	Liike-, toimisto- ja tuotantorakennusten sekä tutkimustoimintaa palvelevien rakennusten korttelialue, jolla ympäristö asettaa toiminnan laadulle erityisiä vaatimuksia. Kokonaiskerrosalasta saadaan enintään prosenttilukujen osoittamat määrät käyttää liike- ja tuotantotiloiksi. Autopaikkoja tulee varata vähintään merkinnän osoittama määrä.
KL-8	Liikerakennusten korttelialue majoituspalvelurakennuksia varten. Alueelle saadaan sijoittaa myös opetustoimintaa palvelevia tiloja sekä liike- ja myymälätilaa. Autopaikkoja on varattava merkinnän osoittama määrä.
YKT-2	Yleisten rakennusten ja toimistorakennusten korttelialue, jolle saadaan rakentaa myös liiketilaa.
YO-15	Opetustoimintaa palvelevien rakennusten korttelialue, jolle saadaan rakentaa myös opetustoimintaa palvelevaa liiketilaa.Autopaikkoja on varattava merkinnän osoittama määrä.
LPA	Autopaikkojen korttelialue.
	3m kaava-alueen ulkopuolella oleva viiva.
	Kaupunginosan raja.
	Korttelin, korttelinosan ja alueen raja.
	Ohjeellinen tontin raja.
	Osa-alueen raja.
	Ohjeellinen alueen tai osa-alueen raja.
	Poikkiviiva osoittaa rajan sen puolen, johon merkintä kohdistuu.
XVII	Kaupunginosan numero.
302	Korttelin numero.
2	Ohjeellisen tontin numero.
KALEVANTIE	Kadun nimi.
22000	Rakennusoikeus kerrosalaneliömetreinä.
m 10280	Myymälätilojen rakennusoikeus kerrosalaneliömetreinä.
19700+jk-2/5100-l 850	Lukusarja, jossa ensimmäinen luku ilmoittaa rakennusalalla sallitun pääkäyttötarkoituksen mukaisen kerrosalan neliömetreinä. Toinen luku ilmoittaa edellä mainitun kerrosalan lisäksi sallitun katetun yleiselle jalankululle varatun tilan kerrosalan neliömetreinä ja kolmas luku viimeksi mainittuun kerrosalaan sisältyvien jalankulkualueilla sallittavien liiketilojen enimmäismäärän neliömetreinä.
18000+säi	Rakennusoikeus kerrosalaneliömetreinä. Olemassa olevassa rakennuksessa saadaan kerrosalaan kuulumattomia tiloja muuttaa kerrosalaan laskettaviksi tiloiksi riippumatta siitä, mitä asemakaavassa on määrätty tontin tai rakennusalan enimmäiskerrosalasta.
4050+ma/yo850	Lukusarja, jossa ensimmäinen luku ilmoittaa rakennusalalla sallitun pääkäyttötarkoituksen mukaisen kerrosalan neliömetreinä. Toinen luku ilmoittaa edellä mainitun kerrosalan lisäksi sallitun maanalaisen opetustoimintaa palvelevien tilojen kerrosalan neliömetreinä.
l3%	Merkintä osoittaa, kuinka monta prosenttia rakennusalalle sallitusta kerrosalasta saadaan enintään käyttää liiketiloina.
mat5%	Merkintä osoittaa, kuinka monta prosenttia rakennusalalle sallitusta kerrosalasta saadaan enintään käyttää maanalaisiksi työ tiloiksi.
tuo25%	Merkintä osoittaa, kuinka monta prosenttia rakennusalalle sallitusta kerrosalasta saadaan käyttää tuotantotiloiksi.
y2%	Merkintä osoittaa, kuinka monta prosenttia rakennusalalle sallitusta kerrosalasta saadaan enintään käyttää julkisia palveluja varten varattaviksi tiloiksi.

V	Roomalainen numero osoittaa rakennusten, rakennuksen tai sen osan suurimman sallitun kerrosluvun.
u 5/6	Murtoluku roomalaisen numeron jäljessä osoittaa, kuinka suuren osan rakennuksen suurimman kerroksen alasta ullakon tasolla saa käyttää kerrosalaan laskettavaksi tilaksi.
+95.1	Maanpinnan likimääräinen korkeusasema.
+150.6	Rakennuksen vesikaton ylimmän kohdan korkeusasema.
+118.80	Rakennuksen julkisivupinnan ja vesikaton leikkauskohdan ylin korkeusasema.
min+165.6	Korkeusasema, jonka tasolle rakennuksen julkisivun yläreuna on vähintään rakennettava.
ma	Maanalainen tila.
	Rakennusala.
va-4	Rakennusalalle saa rakentaa pääosiltaan läpinäkyvän valokaton. Valokatto saa ulottua ympäröiville rakennuksille annettua ylintä korkeusasemaa ylemmäksi.
k-ma3	Tontin rakennusalalle saadaan rakentaa kolme kellarikerrosta.
k-ma2	Tontin rakennusalalle saadaan rakentaa kaksi kellarikerrosta.
ma-9	Tontin rakennusalalle saadaan rakentaa kerrosalaan luettavia maanalaisia pääkäyttötarkoituksen mukaisia tiloja.
ma-10/840	Tontin rakennusalalle saadaan sijoittaa maanalaisia kerrosalaan laskettavia tiloja enintään 840 m2.
ma-10/10280	Tontin rakennusalalle saadaan sijoittaa maanalaisia kerrosalaan laskettavia tiloja enintään 10280 m2.
u-3	Uloke, joka on rakennettava vähintään 3 m jalankulkuväylän yläpuolelle.
su	Alueen osa, jolla ullakolle saadaan tehdä sauna tarpeellisine lisätiloineen talon omaan käyttöön.
	Katu.
ajo	Alueella oleva ajoyhteys.
jk-2(+94.50-+102.00)	Yleiselle jalankululle tasoissa +94.50 - +102.00 varattu korttelin osa. Alueelle tulee sijoittaa yleistä viihtyvyyttä lisääviä istutuksia, kalusteita ja rakenteita. Alueelle saa sijoittaa liiketilaa enintään merkinnän osoittaman määrän.
py-3/+97.90	Merkintä osoittaa rakennusalalla sallittavien pysäköintitasojen suurimman määrän sekä ylimmän pysäköintitason korkeusaseman.
s-j/1	Säilyvä viemäri. Viemärin korkeusasema sekä padotuskorkeus on rakennustoimenpiteen yhteydessä tarkistettava.
j-u/1	Uusi viemäri. Viemärin korkeusasema sekä padotuskorkeus on rakennustoimenpiteen yhteydessä tarkistettava.
ma/a-5	Katualueen osa, jolle saadaan rakentaa viereiseen tonttiin liittyviä pysäköintitiloja ja kulkukäytäviä katutason alapuolelle. Korttelin rajalla ei tarvita rajaseinää.
1ap/100m2	Merkintä osoittaa, kuinka monta kerrosalaneliömetriä kohti on rakennettava yksi autopaikka.
(308-11)	Suluissa olevat numerot osoittavat ne korttelit tai korttelin osat, joiden autopaikkoja alueelle saadaan sijoittaa.
[308-11]	Hakasuluissa olevat numerot osoittavat sen korttelin tai korttelin osan, jolta autopaikat saadaan osoittaa.
s-piha1	Piha tulee rakentaa ottaen huomioon alueen käyttö ja luonne kulttuurihistoriallisesti arvokkaan ympäristön osana.
sr-2	Kulttuurihistoriallisesti arvokas ja kaupunkikuvan säilymisen kannalta tärkeä rakennus. Rakennusta ei saa purkaa. Rakennuksessa suoritettavien korjaus- ja muutostöiden tulee olla sellaisia, että rakennuksen kulttuurihistoriallisesti arvokas ja kaupunkikuvan kannalta merkittävä luonne säilyy. Mikäli tämän pyrkimyksen vastaisesti on rakennuksessa aiemmin suoritettu rakennus toimenpiteitä, on rakennus korjaus- ja muutostöiden yhteydessä pyrittävä korjaamaan entistäen.

sr-8	Rakennustaiteellisesti arvokas ja kaupunkikuvan säilymisen kannalta tärkeä rakennus. Rakennusta ei saa purkaa. Rakennuksessa suoritettavien korjaus- ja muutostöiden tulee olla sellaisia, että rakennuksen rakennustaiteellisesti arvokas ja kaupunkikuvan kannalta merkittävä luonne säilyy.
sr-18	Rakennustaiteellisesti ja kulttuurihistoriallisesti arvokas sekä kaupunkikuvan säilymisen kannalta tärkeä rakennus. Rakennusta ei saa purkaa. Rakennuksessa suoritettavilla korjaus- ja muutostöillä ei saa turmella rakennuksen rakennustaiteellisia arvoja.
sr/r	Historiallisesti ja kaupunkikuvan säilymisen kannalta tärkeä rakenne, jota ei saa purkaa.
ju-19	Rakennuksen julkisivujen tulee olla värisävyltään vaaleita.
ju-46	Rakennuksen julkisivujen tulee olla värisävyltään tummia.
ju-32	Nuoli osoittaa rakennusalan sivun, jonka puoleisen julkisivun pääasiallisena julkisivumateriaalina tulee käyttää vaaleata rappausta ja / tai vaaleata keraamista laattaa. Rappauksen saa korvata karkeata rappausta vastaavalla pintakäsittelyllä. Julkisivun värien, mittasuhteiden, pintojen ja muiden julkisivun rakennustaiteelliseen käsittelyyn liittyvien yksityiskohtien tulee sopeutua naapurina olevaan säilytettävään rakennukseen.
rs	Rajan osa, jossa ei tarvita rajaseinää.
rs-1	Rajan osa, jossa rajaseinään saadaan tehdä aukkoja tasojen +94.00- +114.50 välisellä osalla ja jossa rakennuksen julkisivuun saadaan tehdä pääikkunoita ja kulkuaukkoja.
2h	Tontin suurin sallittu asuinhuoneistomäärä.
si-1 (+101.50-+106.50)	Rakennusala, jolle saa sijoittaa kävelysillan tasojen (+101.50 - +106.509 välille.
	Maanalaisiin tiloihin johtava ajoluiska.
u-III	Alueen osa, jolle saa rakentaa ulokkeen. Roomalainen numero osoittaa ulokkeen suurimman sallitun kerrosluvun.
[pl-1]	Merkintä osoittaa, että tontin autopaikkoja saadaan sijoittaa enintään 300 m päässä olevaan pysäköintilaitokseen.
ma/a p	Alue, jolle saadaan rakentaa maanalainen autojen säilytyspaikka ja sen päälle pysäköimispaikka.
30dBA	Merkintä osoittaa rakennusalan sivun, jonka puoleisten rakennuksen ulkoseinien sekä ikkunoiden ja muiden rakenteiden ääneneristävyyden liikennemelua vastaan on oltava vähintään rakennusalalla osoitetun dBA-luvun mukainen.
	Katualueen rajan osa, jonka kohdalta ei saa järjestää ajoneuvoliittymää.
ro-7750-1	Merkintä osoittaa, että tätä asemakaavaa varten on laadittu rakentamistapaohjeistot, jotka ovat asemakaavaselostuksessa. Ensimmäinen luku tarkoittaa asemakaavan numeroa ja toinen luku viittaa siihen ohjeistoon, joka koskee kyseistä tonttia tai tontteja.
ek-3(4.5m)	Rakennusala eritasoiselle, pihatason, katualueen tai pysäköintilaitoksen yläpuolelle rakennettavalle kulkuyhteydelle, jonka alikulkukorkeus on vähintään luvun osoittama metrimäärä.

YLEISMÄÄRÄYS:

Ennen alueella tapahtuvaa rakentamista on huolehdittava siitä, että saastunut maaperä on poistettu ympäristösuojeluviranomaisten hyväksymien käsittelysuunnitelmien mukaisesti.

TÄMÄN ASEMAKAAVAN ALUEELLA TONTTIJAKO LAADITAAN SITOVANA JA ERILLISENÄ.

TÄHÄN ASEMAKAAVAKARTTAAN LIITTYY ASEMAKAAVAN SELOSTUS, HAVAINNEPIIRROS JA POISTETTAVA ASEMAKAAVAKARTTA.

ASEMAKAAVAEHDOTUS PERUSTUU POHJAKARTTAAN, JOKA TÄYTTÄÄ 1.1.2000 VOIMAAN TULLEEN KAAVOITUSMITTAUSASETUKSEN (1284/1999) VAATIMUKSET.
Tampereella 8 pnä marraskuuta 2001.

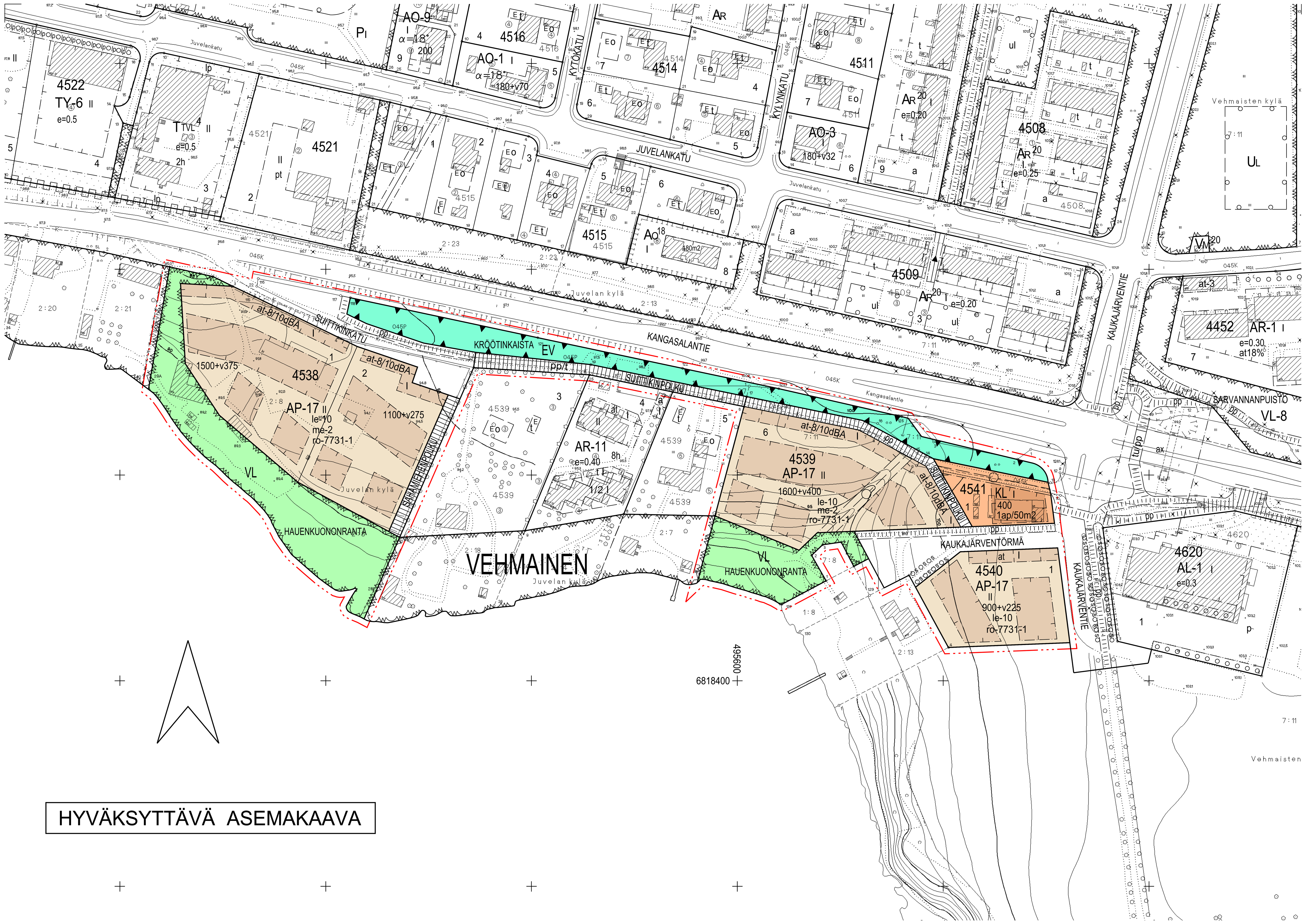
Kiinteistöinsinööri

1:1000 0 10 20 30 40 50 100 150

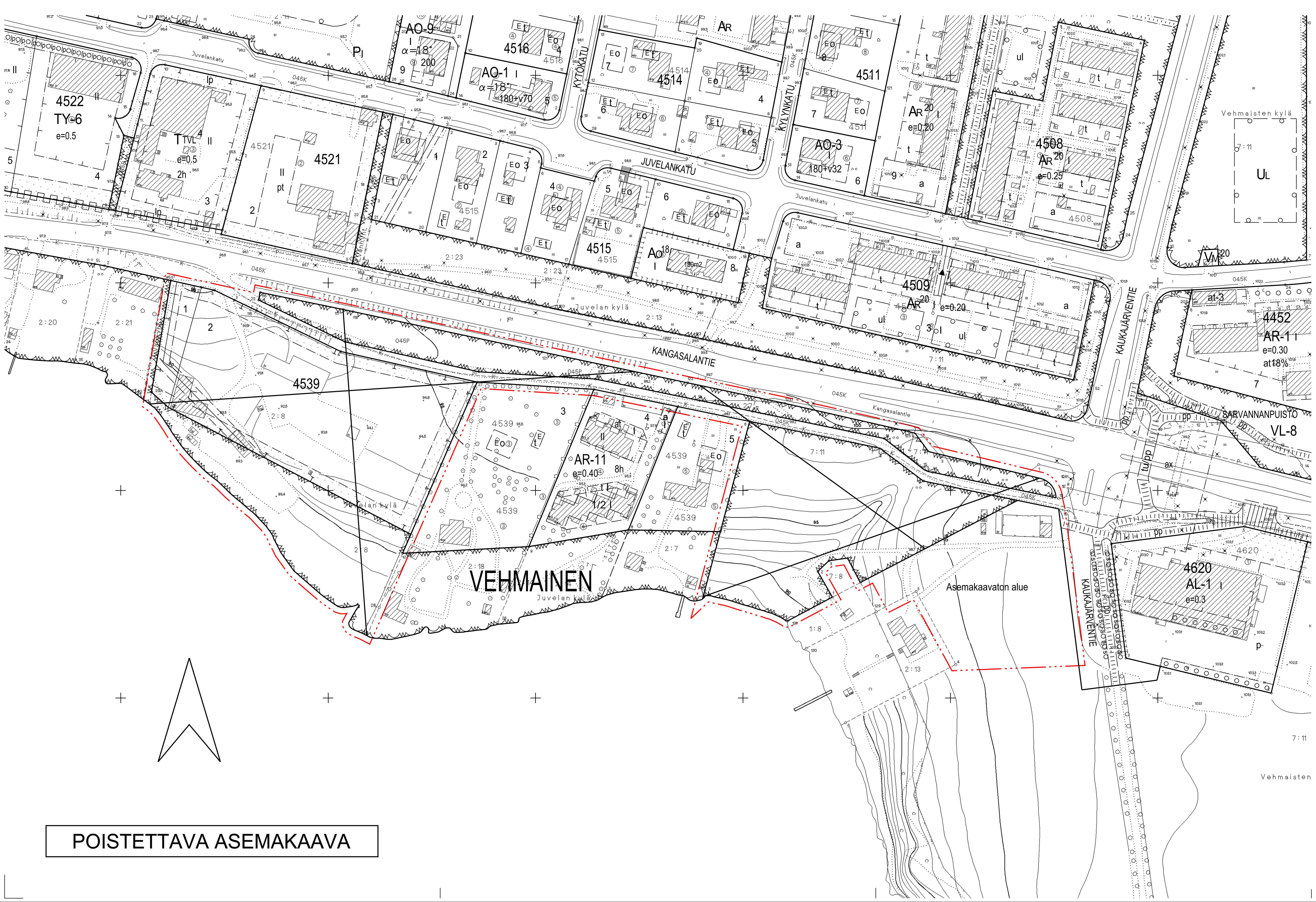
Tampereen kaupunki ympäristötoimi kaavoitusyksikkö
XVII-308-1, 4-7 ja katu- ja rautatien aluetta
XVIII katualuetta, kaupunginosan rajaa.
Asemakaavan muutos

Tark. 05.12. 2001
Pvm. 16.11.2001
Mikko Järvi
asemakaava-arkkitehti

Suunnittelija Juha Jaakola
Piirtäjä Taija Ahoniemi Kartta nro 7750
KV hyv. Ark. nro 93188 atk/vid



HYVÄKSYTTÄVÄ ASEMAKAAVA



POISTETTAVA ASEMAKAAVA

T A M P E R E

ASEMAKAAVA

Kaupunginosa: VEHMAINEN
Korttelit nro: 4539 / osa
4540
4541 / osa
Katualuetta.

ASEMAKAAVAN MUUTOS

Kaupunginosa: VEHMAINEN
Kortteli nro: 4539
Tontit nro: 1 ja 2
Katu- ja puistoalueetta.

ASEMAKAAVALLA JA ASEMAKAAVAN MUUTOKSELLA MUODOSTUU

Kaupunginosa: VEHMAINEN
Korttelit nro: 4538
4539 / osa
4540
4541
Katu-, virkistys- ja erityisaluetta.

ASEMAKAAVAMERKINNÄT JA -MÄÄRÄYKSET:

AP-17	Asuinpientalojen korttelialue kytkettyjä tai erillisiä yksi- tai kaksiasuntoisia pientaloja varten. Tontilta on varattava yksi autopaikka asuntoa kohti.
KL	Liikerakennusten korttelialue.
VL	Lähivirkistysalue.
EV	Suojaviheralue.
	3 m kaava-alueen rajan ulkopuolella oleva viiva.
	Korttelin, korttelinosan ja alueen raja.
	Osa-alueen raja.
	Ohjeellinen alueen tai osa-alueen raja.
	Poikkiviiva osoittaa rajan sen puolen, johon merkintä kohdistuu.
	Ohjeellinen tontin raja.
	Risti merkinnän päällä osoittaa merkinnän poistamista.
VEHM	Kaupunginosan nimi.
4539	Korttelin numero.
1	Ohjeellisen tontin numero.
KAUKAJÄRVEN	Kadun, puiston tai muun yleisen alueen nimi.
400	Rakennusoikeus kerrosalaneliömetreinä.
1600+v400	Lukusarja, jossa ensimmäinen luku ilmoittaa sallitun asuntokerrosalan neliömetrimäärän ja toinen luku ainoastaan maanpäälliseksi autosuoja- ja taloustilaksi varattavan kerrosalan neliömetrimäärän.
II	Roomalainen numero osoittaa rakennusten, rakennuksen tai sen osan suurimman sallitun kerrosluvun.
	Rakennusala.
at	Auton säilytyspaikan ja talousrakennuksen rakennusala.
at-8/10dBA	Auton säilytyspaikan ja talousrakennuksen rakennusala. Alueelle on muodostettava rakennuksista, polveilevasta meluseinästä tai niiden yhdistelmästä yhtenäinen vähintään 2 m korkea melusuoja, jonka ääneneristävyys liikennemelua vastaan on vähintään ilmoitetun dBA-luvun mukainen.
le-10	Korttelialueelta on varattava lasten leikkipaikoiksi ja asukkaiden oleskeluun sopivaa yhtenäistä aluetta vähintään 7 m2 asuntoa kohti. Leikkipaikan pinta-alan tulee olla vähintään 100 m2.
osososososos	Säilytettävä puurivi.
	Katu.
	Jalankululle varattu katu.
pp	Jalankululle ja polkupyöräilylle varattu katu.
pp/t	Jalankululle ja polkupyöräilylle varattu katu, jolla tontille ajo on sallittu.
pp	Ohjeellinen yleiselle jalankululle ja polkupyöräilylle varattu alueen osa.
	Maanalainen johto.
	Maanalaista johtoa varten varattu alueen osa.
1ap/50m2	Merkintä osoittaa, kuinka monta kerrosalaneliömetriä kohti on rakennettava yksi autopaikka.
me-2	Rakennuslupa-asiakirjoihin on liitettävä rakennushankkeen pohjalta laadittu meluntorjuntasuunnitelma. Asemakaavassa vaadittuja melusuojarakenteita on tarvittaessa korotettava.
ro-7731-1	Merkintä osoittaa, että tätä asemakaavaa varten on laadittu rakentamistapaohjeistot, jotka ovat asemakaavaselostuksessa. Ensimmäinen luku tarkoittaa asemakaavan numeroa ja toinen luku viittaa siihen ohjeistoon, joka koskee kyseistä tonttia tai tontteja.

YLEISMÄÄRÄYS KOSKEE KORTTELIA 4538:

Ennen alueella tapahtuvaa rakentamista on huolehdittava siitä, että saastunut maaperä on poistettu ympäristösuojeluviranomaisten hyväksymien käsittelysuunnitelmien mukaisesti.

POISTETTAVAT ASEMAKAAVAMERKINNÄT JA -MÄÄRÄYKSET:

	Teollisuuskortteli, jonka saa jakaa 1.500m2 suuruisiksi tonteiksi. Tontista saa käyttää rakentamiseen enintään 1/2, jos kaikki tontilla olevat rakennukset täyttävät ainakin PL 4§:n B-luokan vaatimukset, muussa tapauksessa saa tontista käyttää rakentamiseen enintään 1/3, jolloin kaksikerroksinen rakennus saa olla pinta-alaltaan enintään 200 m2 ja yksikerroksinen enintään 300 m2. Ullakkoa ei saa käyttää varastoimiseen eikä työhuonetiloihin. Ulkovarastointiin saa käyttää enintään 1/2 rakentamattomaksi jäävästä tontin osasta. Tonteille saa rakentaa tehdas- ja varastorakennuksia sekä erillisen asuinrakennuksen sellaista henkilökuntaa varten, jonka alituinen läsnäolo on tehtaan toiminnalle välttämättömän tarpeellinen. Asuinrakennuksen on täytettävä ainakin PL 4§:n DI-luokan vaatimukset. Rakennukset ja ulkovarastot on sijoitettava vähintään 6 m päähän naapuritontin rajasta ja palosolaan on istutettava lehtipuita. Teollisuusrakennusten keskinäisen etäisyyden samalla tontilla on oltava vähintään 8 m ja etäisyyden asuinrakennuksesta vähintään 20 m. Teollisuus- ja varastorakennusten räystäskorkeus saa olla enintään 12 m ja asuinrakennuksen enintään 5 m.
	Rakennukset on maalattava kaupungin julkisivulautakunnan hyväksymien värimallien mukaisesti.
	Puisto tms. alue.
	Eri asemakaavamääräysten alaisten tontin osien välinen raja ja rakennusraja.
2	Tontin numero.
	Istutettava tontin osa.
	Viemäriä varten rakentamattomaksi jätettävä tontin osa.

YMPÄRISTÖN ASEMAKAAVAMERKINTÖJÄ JA -MÄÄRÄYKSIÄ:

AR-11	Rivitalojen ja muiden kytkettyjen rakennusten korttelialue.
AR20	Rivitalojen ja muiden kytkettyjen rakennusten korttelialue.
AO18	Enintään kahden perheen rakennusten korttelialue.
	Asunto- ja liikekortteli.
AL-1	Liikerakennusten korttelialue.
TY-6	Ympäristöhäiriöitä aiheuttamattomien teollisuusrakennusten korttelialue.
TTVL4	Yhdistettyjen teollisuus- ja varastorakennusten korttelialue.
	Pienteollisuuskortteli.
VL-8	Lähivirkistysalue, jonka hoitotoimenpiteissä on kiinnitettävä huomiota alueen toimivuuteen suojaviheralueena.
ax	Eritasoisen liikennejärjestelyn alue.

MUUTETAAN 18.06.1981 VAHVISTETTUA ASEMAKAAVAA NRO 5596 ja
MUUTETAAN 29.06.1959 " " 1196.

TÄHÄN ASEMAKAAVAKARTTAAN LIITTYY ASEMAKAAVAN SELOSTUS JA HAVAINNEPIIRROS.

TÄMÄN ASEMAKAAVAN ALUEELLA TONTTIJAKO LAADITAAN SITOVANA JA ERILLISENÄ.

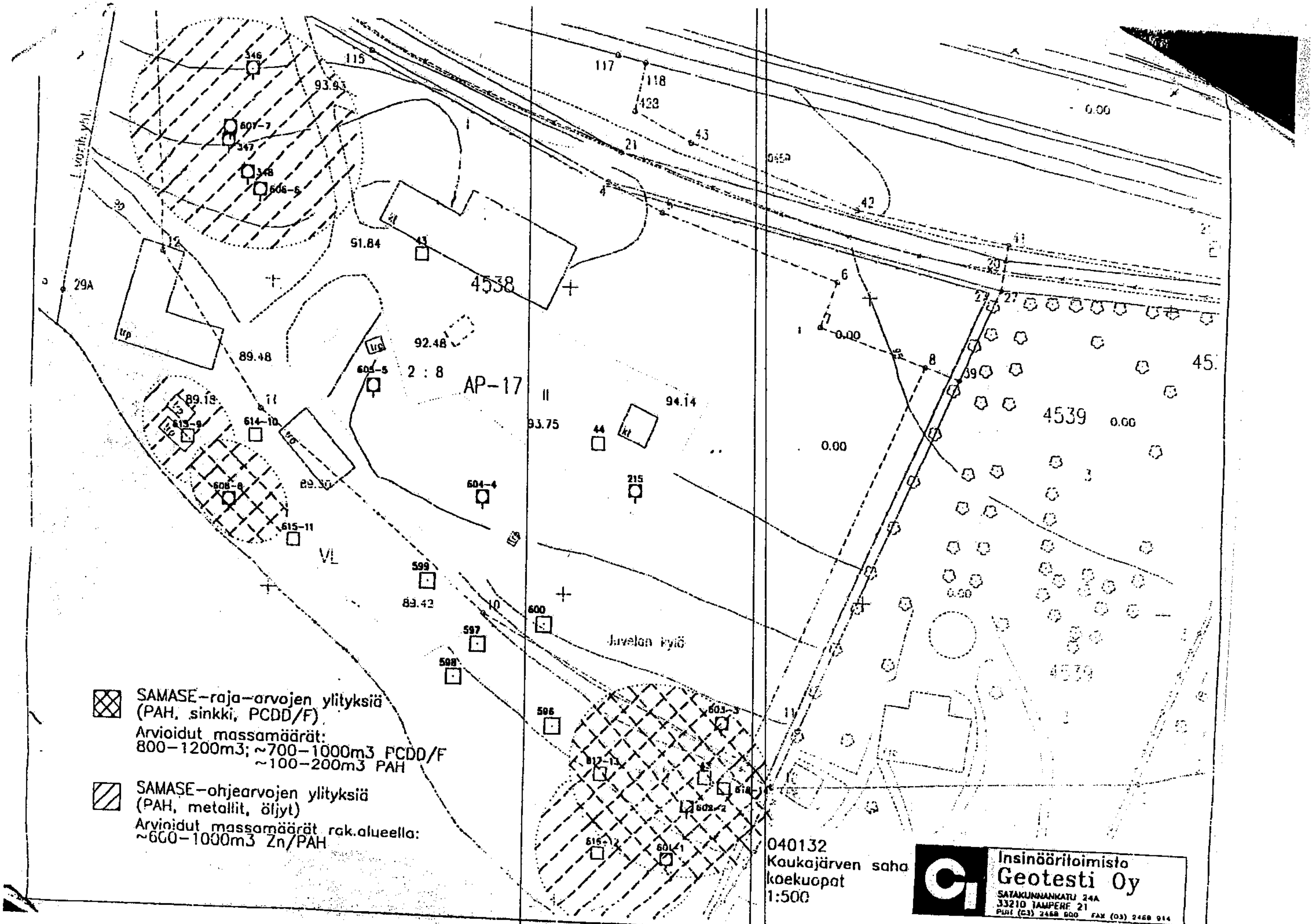
ASEMAKAAVAEHDOTUS PERUSTUU POHJAKARTTAAN, JOKA TÄYTTÄÄ 1.1.2000 VOIMAAN TULLEEN KAAVOITUSMITTAUSASETUKSEN (1284/1999) VAATIMUKSET.
Tampereella 11. pnä joulukuuta 2001.

Kiinteistöinsinööri [signature]

1:1000 0 10 20 30 40 50 100 150

Tampereen kaupunki ympäristötoimi kaavoitusyksikkö
ASEMAKAAVA: VEHMAINEN korttelit nro 4539/osa, 4540 ja 4541/osa ja katualuetta.
ASEMAKAAVAN MUUTOS: VEHMAINEN kortteli nro 4539/1 ja 2, katu- ja puistoal.
Muutoksella muod. korttelit nro 4538, 4539/osa, 4540, 4541, katu-, virk.- ja erityisal.

Tark. 04.03.2002 Tark. 04.12.2001 Pvm. 14.06.2001	Mikko Järvi asemakaava-arkkitehti	Suunnittelija ILKKA KOTILAINEN Piirtäjä J. GRÖNLUND Kartta nro 7731 KV hyv. 30.10.2002 Ark. nro 94059 atk/vid



SAMASE-raja-arvojen ylityksiä (PAH, sinkki, PCDD/F)

Arvioidut massamäärät: 800–1200m3; ~700–1000m3 PCDD/F ~100–200m3 PAH

SAMASE-ohjearvojen ylityksiä (PAH, metallit, öljyt)

Arvioidut massamäärät rak.alueella: ~600–1000m3 Zn/PAH

040132
Kaukajärven saha
koekuopat
1:500

Insinööritoimisto
Geotesti Oy
SATAKUNNANKATU 24A
33210 TAMPERE 21
PUH (03) 2468 900 FAX (03) 2468 914

KAUKAJÄRVI OLD SAWMILL

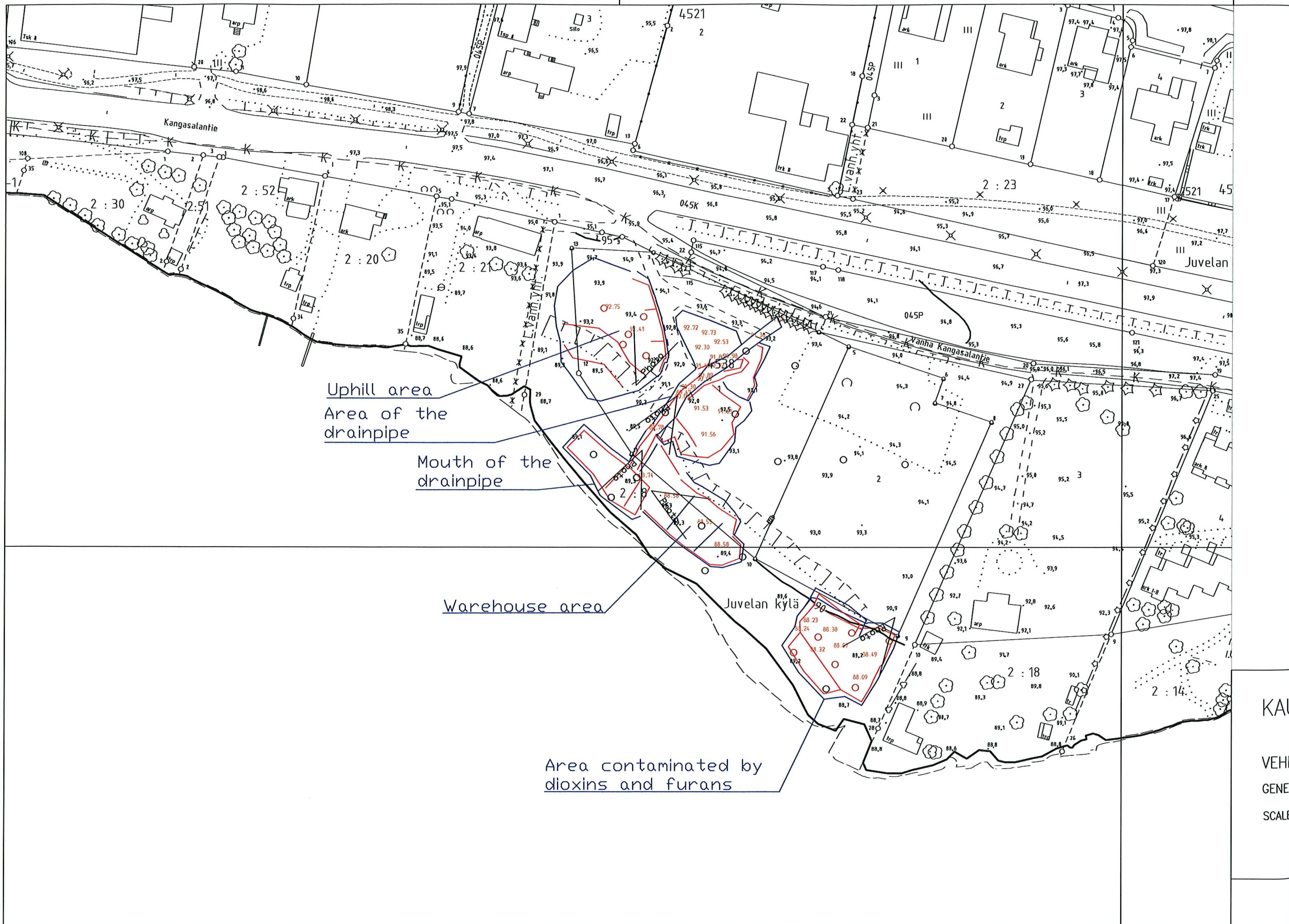
Drawer	PETRI JOKINEN
Date	3rd February 2005

VEHMAINEN DISTRICT

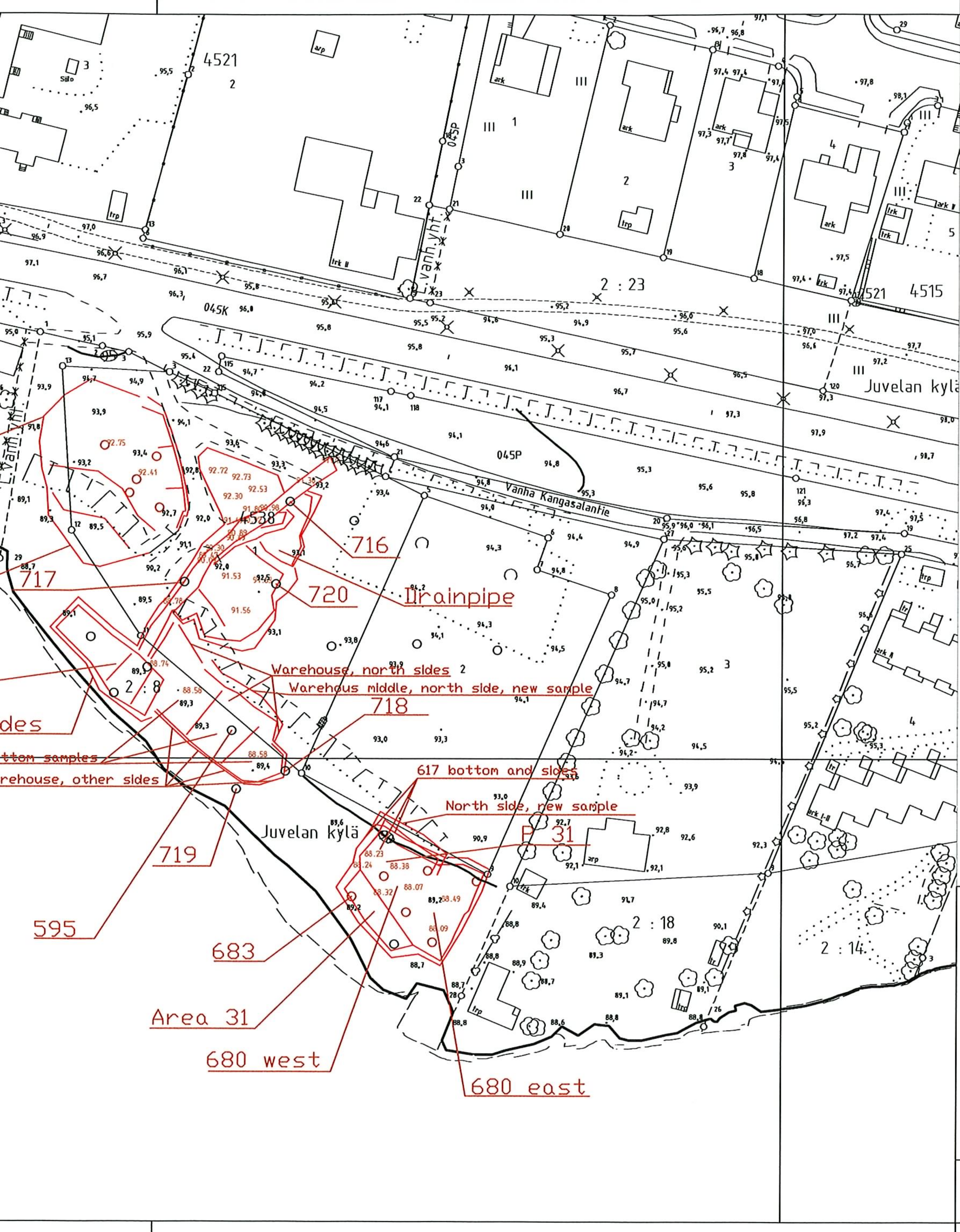
GENERAL MAP OF THE EXCAVATED AREAS

SCALE 1:1000

CITY OF TAMPERE
MUNICIPAL SERVICES



Uphill area
Area of the drainpipe
Mouth of the drainpipe
Warehouse area
Area contaminated by dioxins and furans
Kangasalantie
Vanha Kangasalantie
Juvelan kylä
Juvelan
2 : 30
2 : 52
2 : 51
2 : 20
2 : 21
2 : 23
2 : 18
2 : 14
4521
KAU
VEHM
GENEF
SCALE



KAUKAJÄRVI OLD SAWMILL

VEHMAINEN DISTRICT

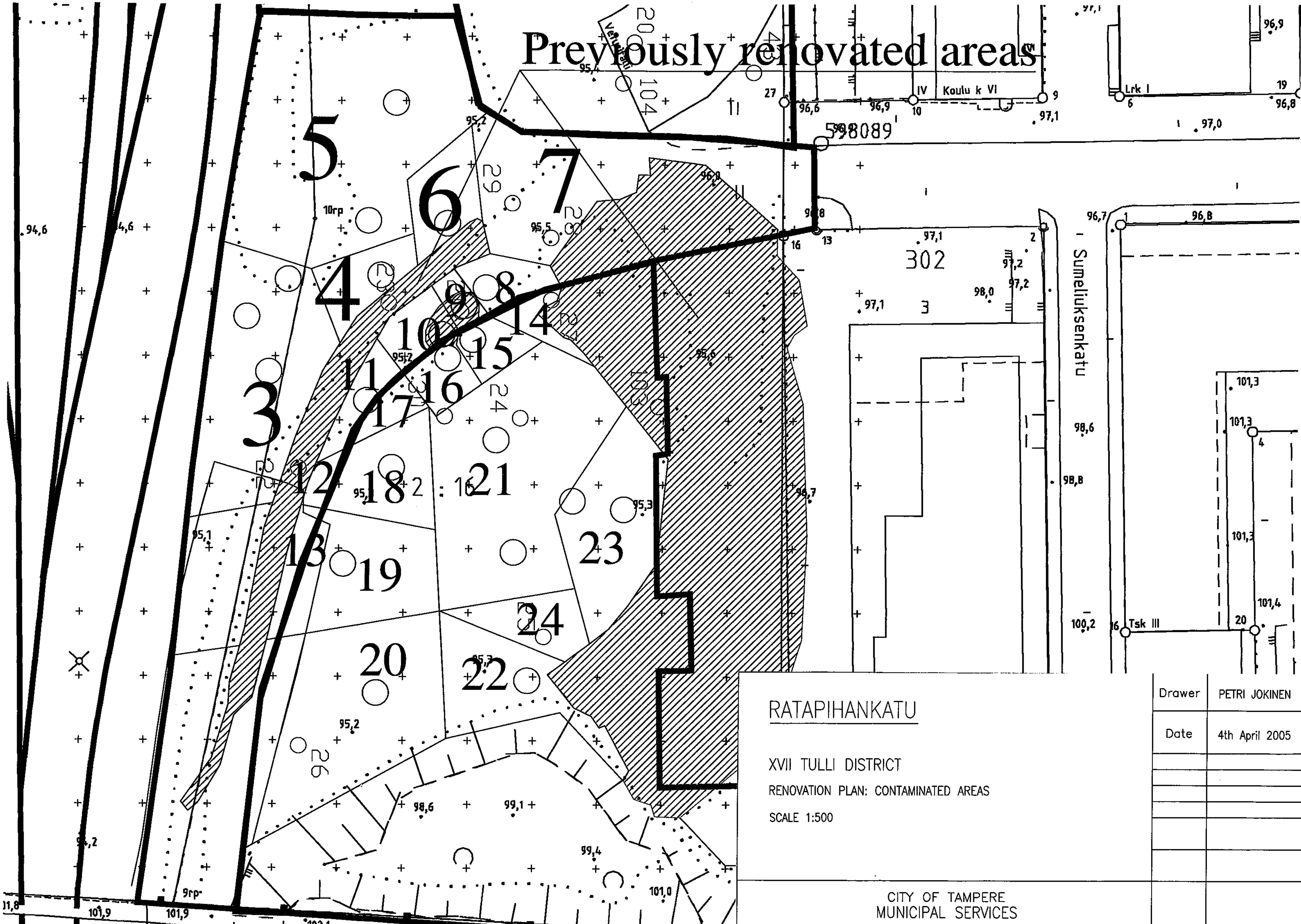
SAMPLE MAP

SCALE 1:1000

Drawer	PETRI JOKINEN
Date	3rd February 2005

CITY OF TAMPERE
MUNICIPAL SERVICES

Kangasalantie
Vanha Kangasalantie
Juvelan kylä
Park, north
Park, south
P30, area
P30, sides
Warehouse, bottom samples
Warehouse, other sides
Warehouse, north sides
Warehous middle, north side, new sample
716
717
718
719
720
Drainpipe
595
683
Area 31
680 west
680 east
617 bottom and sides
North side, new sample
P 31
KAU
VEHM
SAMPLE
SCALE


Previously renovated areas
3
4
5
6
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11
12
13
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16
17
18
19
20
21
22
23
24
Sumeliuksenkatu
Koulu k VI
598089
302
Lrk I
Tsk III
RATAPIHANKATU
XVII TULLI DISTRICT
RENOVATION PLAN: CONTAMINATED AREAS
SCALE 1:500
Drawer
PETRI JOKINEN
Date
4th April 2005
CITY OF TAMPERE
MUNICIPAL SERVICES