SOIL RECYCLING FACILITY

FEASIBILITY STUDY RESULTS

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EXECUTIVE SUMMARY

1. It is feasible, economically, technically and environmentally, to implement a facility to clean contaminated soil and groundwater in the Port Industrial District (P.I.D.).

2. P.I.D. lands are contaminated with heavy metals, other inorganic contaminants such as arsenic, and with organic contaminants such as oil and grease.

3. A soil recycling facility with the capability to clean our soils, which are fine silty sandy soils, of the various contaminants in an environmentally sound manner that will result in recycling not just the cleaned soil but contaminants as well, would require use of three cleaning processes in series:
   - first, the bulk contaminated soil would be washed under high pressure, to remove the large majority of contaminants from the sand. Following this process, the clean sand, which makes up about 80% of the bulk soil volume, would be recyclable as backfill, leaving 20% of the fines as a contaminated slurry that requires further treatment.
   - second, removal of inorganics, mainly toxic heavy metals, from the contaminated slurry using a leaching process adapted from the metals mining industry, and
   - third, treatment of organic contaminants by bioremediation under controlled conditions in reactors, where the final product is a soil that is suitable for topsoil and landscaping.

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4. A full scale soil recycling facility capable of cleaning up to 300,000 tonnes per year of bulk contaminated soil should be constructed and operated in the P.I.D. by the THC. Programming the total area clean-up will be a major undertaking, requiring considerable negotiations with leaseholders and private landowners to resolve sequencing of site clean-up, groundwater management, and the costs to be charged to clients for using our treatment facility. The THC is most suitably placed to be able to successfully and efficiently negotiate the agreements necessary to effectively implement site remediation over the entire P.I.D.

5. Our study indicates that the charge-out rate per tonne that we would have to charge in order to recover our costs is highly dependent upon the amount of soil cleaned by the plant per year. For our study, we have considered two scenarios to demonstrate how our charge-out rates for soil cleaning can vary depending upon plant efficiency.

Plant Throughput per year (tonnes)	Soil Cleaning Charge per Tonne
180,000	$265
300,000	$160

6. The THC should proceed as soon as possible with implementing a demonstration plant to demonstrate the selected soil cleaning technologies. Costs to undertake a demonstration plant that would clean 6000 tonnes of contaminated soil are estimated to be approximately $4.3 million. This would include $100,000 for pump tests to model the groundwater flow direction and flow rates in the P.I.D. Some funds may be recovered from the federal and provincial governments under the DESRT Program to demonstrate viable technolgies for cleaning contaminated soil and groundwater.

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SOIL RECYCLING FACILITY
FEASIBILITY STUDY RESULTS

The Toronto Harbour Commissioners commissioned SNC Inc. to assist the Director of Engineering in preparing a study to determine whether it was feasible for the THC to construct and operate a facility to clean contaminated soil and water in the Port Industrial District. The purpose of implementing such a facility would be to remediate all the contaminated lands and groundwater within the Port Industrial District within a reasonable time period, in a manner that would be environmentally acceptable.

We also wanted to determine whether soil remediation by cleaning and recycling the soil and the contaminants could be accomplished at reasonable cost - our measure of reasonable cost being less than $200 per tonne. The cost of removing contaminated soil from the P.I.D., including excavating, hauling, disposing in a licensed landfill, and replacing the removed soil with clean fill, is currently approaching $200 per tonne.

Our study has produced some very exciting results:

- yes, the technology exists to clean our type of soils with our type of contaminants sufficiently to be able to reuse or recycle the soil once it is cleaned, and

- yes, the total remediation activity can be conducted in an environmentally safe and controlled manner, and

- yes, the soil and groundwater cleaning can be performed at a cost per tonne of contaminated soil that would be less than option of removing the contaminated soil to a licensed landfill.

Following are the details of our feasibility study findings:

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1. TECHNOLOGY

1. SOIL RECYCLING PLANT

The soil cleaning plant should apply several technologies in its total soil and water cleaning and recycling process. The complete cleaning process is outlined on the attached flow chart. A description of each cleaning technology is provided below:

Soil Washing Plant - This will be a high pressure washing system, to subject contaminated soil to a high pressure water jet to scrub contaminants off the sandy particles of soil. In this process, the full bulk of contaminated soil is washed. The cleaned sandy soil particles are larger in size than the contaminants, so it is a simple matter to separate the cleaned sandy soil from the contaminants and water. On average, P.I.D. contaminated soils that are washed in this manner will produce approximately 70% - 80% cleaned sandy particles and 20% - 30% contaminated fines in a slurry. The 70% - 80% cleaned sandy soil can be dried and reused as a backfill once it has been tested and shown to be clean, that is, that the remaining contamination is less than the limits provided by the agreed-upon decommissioning criteria for contamination in industrial use soils.

The soil washing plant will be sized to be able to wash up to 50 tonnes of contaminated soil per hour, for a reasonable annual throughput of 300,000 tonnes. Our very rough estimate of the total amount of contaminated soil in the Port Industrial District is 2.1 million tonnes. Consequently, if our wash plant worked at full capacity it could wash all the contaminated soils in a 7 year period.

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Soil washing plants of this size and capacity already exist and are operating in Germany and Holland. This is not new technology, however, it is new to North America, and it is new to combine the wash plant with other processes that actually treat the contaminants in the contaminated slurry that is produced by the washing process. In Holland and Germany, this contaminated slurry is dewatered and the contaminated sludge is disposed of in a licensed landfill. Our objective is to clean the contaminated slurry, thereby providing a complete cleaning and recycling service.

Heavy Metals Extraction Unit - Much of the contaminated soil in the P.I.D. contains inorganic contaminants. Some form of leaching process is required to remove the inorganic contaminants from soil. We discovered there are several such processes in an experimental stage of development, and only one that meets our objectives and is sufficiently advanced to be considered for pilot plant demonstration.

Much of the contaminated soil in the P.I.D. also contains significant quantities of organic contaminants. Very often, there are organic and inorganic contaminants together in the soil. When the bulk contaminated soil is washed in the soil washing pant, the contaminated slurry from the wash plant will contain increased concentrations of inorganic and organic contaminants. We expect that most of the time the concentration level of inorganics would exceed decommissioning guideline levels, and that therefore the contaminated slurry would have to be treated to remove both inorganic and organic contaminants.

We intend to utilize a biodegradation process to remove organic contaminants from the contaminated slurry. However, the presence of inorganic contaminants can adversely inhibit biodegradation of organic contaminants, and may even be toxic to the bacteria. Consequently, our treatment process requires that the inorganic contaminants must be removed from the contaminated slurry first, and the slurry can then be treated using a biodegradation process to remove organic contaminants.

We have selected a process called the Tallon-SNC Heavy Metal Extraction Process as our preferred method of removing inorganic contaminants. One of the greatest challenges in removing inorganic contaminants from soil is to remove only the toxic constituents and to leave behind the life-supporting minerals needed to support healthy plant growth. Another challenge is to use solutions to remove the contaminants that do not themselves introduce new contamination to the soil.

The Tallon-SNC process is most interesting because it has been developed to specifically satisfy these requirements within reasonable cost. The acids used to remove the inorganic contaminants are fairly weak and can be recovered for reuse in the leaching process. Residual compounds that remain after the inorganic contamination removal is complete are biodegradable and so will not interfere with the next step in the process, which is removal of the organic contaminants.

The inorganic contaminants removed from the contaminated slurry will consist mostly of heavy metals. There is at least one organization listed in the waste materials exchange directory that will accept concentrated heavy metals such as would be produced by our inorganics treatment process, so this product could be recycled. If no market existed for this material, it would have to be disposed of in a licensed hazardous waste facility at a cost in the order of $400 per tonne.

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The Tallon-SNC Heavy Metal Extraction Process has advanced beyond the bench scale testing stage and is ready for demonstration at the field level. We are confident that it will produce satisfactory results within a reasonable cost of operation. The unit to be installed in the full scale soil recycling facility would be sized to process up to 15 tonnes per hour, that is, the entire contaminated slurry stream which constitutes up to 30% of the bulk contaminated soil being processed by the wash plant.

Bioslurry Reactor - to clean the remaining organic contaminants from the contaminated slurry we have selected a bioremediation process referred to as the SNC Bioslurry reactor. This is a system of upflow reactors that provide an ideal environment for natural bacteria to digest the organic contaminants in the slurry.

The process utilizes a system of tanks (reactors), air filters and filter presses to remove the organic contaminants through digestion and then to dewater the effluent slurry. The process is totally enclosed so that all waste streams are environmentally controlled and managed.

The dried soil produced from this treatment process would be suitable for use in sod farms or for landscaping as a topsoil.

2. SOIL RECYCLING FACILITY

There are a number of components that make up the complete soil recycling facility. These are briefly described as follows:

1. <u>SITE</u>

The plantsite should be a clear area of about 4 ha (10 acres), preferably with dockwall access in an area where heavy industrial activity is occurring. A location east of the Hearn Generating Station on the south side of the ship channel would serve very well as a fixed treatment facility site. The industrial building needed to enclose the fixed facility would not be out of place with the Hearn station next door and would be well away from residential areas.

The site itself should be clean before the plant is constructed on it. This may require removal and stockpiling of contaminated soil, so there should be a contaminated soil storage site situated on another 4 ha (10 acre) site adjacent to the plantsite. We would require a special approval from MOE to operate a contaminated soil storage site. The storage area would act as a surge pile to ensure continuous supply of contaminated soil to the plant.

The clean plantsite should be lined with a membrane to prevent contaminants moving from the contaminated soil to be handled on the plantsite into the subsoil and groundwater beneath the plantsite. The entire plantsite should start clean, be clean throughout its operations, and leave its site environmentally clean when the soil cleaning plant is one day decommissioned.

2. <u>SITE FACILITIES</u>

In addition to being graded and lined, the plantsite will require services (water, sewer, gas, hydro, telephone), a surface drainage and collection system, lighting, fencing and surfacing.

Structures on the plantsite will include the main soil recycling plant, a weigh scale, a screening and crushing operation, access and parking areas, equipment storage areas, an administration building, and a complete laboratory.

Contaminated water from the soil cleaning process, plus contaminated run-off from the plantsite, will be cleaned in a plantsite water treatment facility.

Some storage facilities must also be provided, for contaminated soil to be treated, for cleaned soil awaiting tests results before it can be returned to the industrial area for reuse, for possible contaminated waste streams that cannot be treated and will be stored until they can be removed for treatment elsewhere or for disposal, for raw materials used in the treatment process, and for the inorganic contaminants removed by the cleaning process.

Some on-site equipment would be necessary such as loaders, site cleaning equipment, and dust control equipment.

3. OFFSITE FACILITIES

Although the thrust of our study was to determine the feasibility of implementing a soil cleaning facility, we found it necessary to examine certain off-site facilities as well, in order to be able to present a complete analysis of cost to clean contaminated soils as compared to removing them to a licenced landfill.

Off-site facilities relate to the management of contaminated soil and water at the source of the contaminated soil, and the facilities to excavate the soil, haul it to the plant for cleaning, and return the cleaned soil to the source location.

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Management of the contaminated groundwater within and surrounding the contaminated site is a major undertaking. For example, consider the 42 acre McColl Frontenac site south of Commissioners Street. We know that much of this area is heavily contaminated, and that the groundwater is also contaminated. Let's assume that practically the whole area is contaminated. If one was to design a system for removing (excavating) contaminated soil from this site for treatment off-site in a fixed treatment facility, the operation could be designed like an open pit mine. Groundwater collection systems would be installed for several reasons - to provide a relatively dry excavation area, and to ensure that clean soil replaced in the excavation would not become contaminated by contaminated groundwater flowing through it. Such a collection system may have to be left in place and operate until all adjacent contaminated lands are cleaned.

The contaminated water collected from the site would include contaminated groundwater and surface runoff. A surface runoff collection system would have to be installed before the excavation began, to ensure that all contaminated water related to the site would be retained on-site and treated.

The contaminated water could constitute a large volume of water, and would have to be treated before it could be discharged. Our intention is to provide a complete groundwater collection and treatment facility to accommodate complete site remediation.

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The contaminated water treatment facility would have to be designed to treat a variety of contaminants, similar to the soil recycling plant. The water would not be as heavily contaminated as the contaminated slurry and process plant water, and the treatment would be more selective - all water would not go through all the treatment processes. Depending upon how the contaminated soil excavation programme is designed, the water treatment facility at the excavation site may be developed in stages, with new components to clean new contaminants being added as they are required.

Still, the contaminated water collection and treatment facility is a major component with a major cost for construction and operation, that must be considered when determining an estimate of total site remediation costs.

Other off-site facilities would include screening and crushing operations to ensure that particles of contaminated soil are smaller than the largest acceptable size of particle that can be cleaned in the soil washing plant. Also included would be the equipment to excavate the soil and load it onto trucks, trucks to haul the soil to the cleaning plant, and trucks to haul clean soil back to the excavation, and equipment to backfill and grade the cleaned portions of the site.

4. COMPARATIVE SITE REMEDIATION COSTS

We have sized the soil washing plant to be able to wash 50 tonnes of contaminated soil per hour. At this rate, a plant operating at full capacity 24 hours per day 365 days a year could process 438,000 tonnes of contaminated soil.

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The plant operators we visited in Holland and Germany advised that, in their experience, certain allowances must be made for maintenance and repairs which reduce the total throughput of the plant. On their advice, we rate our 50 tonnes per hour plant as being capable of processing up to 300,000 tonnes per year, that is:

50 tonnes/hr x 20 hrs/day x 300 days/yr

For comparative purposes, we have considered two production scenarios:

Scenario 1 - Plant operates at full capacity of 300,000 tonnes per year.

Scenario 2 - Plant operates at 60% capacity of 180,000 tonnes per year.

Since the capital and operating costs of running the soil recycling facility are relatively fixed, the cost to treat a tonne of contaminated soil will obviously increase as the plant throughput decreases. To show the effect of this, consider the following:

(a) Plant throughput of 300,000 tonnes/year

- Plant annual costs, including off-site costs but excluding soil handling costs, equal $47.8 million
- Therefore, charge-out rate per tonne of soil cleaned = $159.33.

(b) Plant throughput of 180,000 tonnes/year

- Plant annual costs, again, at $47.8 million
- Therefore, charge-out rate per tonne = $265.56.

Obviously, it is imperative that the plant be operated at or as close as possible to full capacity at all times, to minimize the charge-out rate to clean a tonne of contaminated soil.

3. DEMONSTRATION PLANT

Our feasibility study has determined that it is feasible to implement a soil and water cleaning facility, to clean contaminated soil and water at a reasonable cost. The technologies exist, we know we have the contaminated materials, and the THC has the expertise to manage and operate the facility.

We need to demonstrate that the technologies will work within a reasonable cost under our site conditions, and to refine the actual operating costs so that we would know how much we would have to charge in order to manage and clean the contaminated groundwater and soil. To demonstrate the technologies we propose to use in our full scale plant we should build a pilot plant or demonstration plant, and clean a representative sample of soil.

Our demonstration plant should demonstrate the effectiveness of the three principal technologies:

- the soil washing plant,
- the heavy metals extraction plant, and
- the bioslurry operation.

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Unfortunately, there is no existing available soil washing plant that we could bring to our site, erect, and operate to clean a bulk sample of, say, 6000 tonnes of contaminated soil. So, if we can't bring a plant to our soil, the next best alternative appears to be to bring our contaminated soil to an existing soil washing plant, and that is precisely what we propose to do.

We propose to ship a bulk sample of 6000 tonnes to a soil cleaning plant in western Europe, either in Holland or Germany, and to have them process the sample through their facility. We would collect the contaminated slurry, and return the contaminated slurry to the P.I.D. where we would process it through the other two stages of our proposed cleaning process - for heavy metals extraction and then for bioremediation.

A bulk sample of 6000 tonnes should produce between 1200 and 1800 tonnes of contaminated slurry. The bulk sample could be excavated and shipped abroad for processing while the remainder of the demonstration plant is being assembled. By late summer or early fall we should be ready to begin processing the contaminated slurry, to demonstrate the effectiveness of our selected technologies.

We estimate the costs of conducting a demonstration to clean a bulk sample of 6000 tonnes of contaminated soil to be as follows:

(1) bulk sample treatment:
- includes excavation, shipping, cleaning and returning possibly <u>all</u> soil and contaminated water to Toronto, complete $1,900,000

(2) processing up to 1800 tonnes of contaminated slurry for heavy metals extraction, complete $ 800,000

(3) processing up to 1800 tonnes of contaminated slurry by bioremediation to remove organics, complete $ 600,000

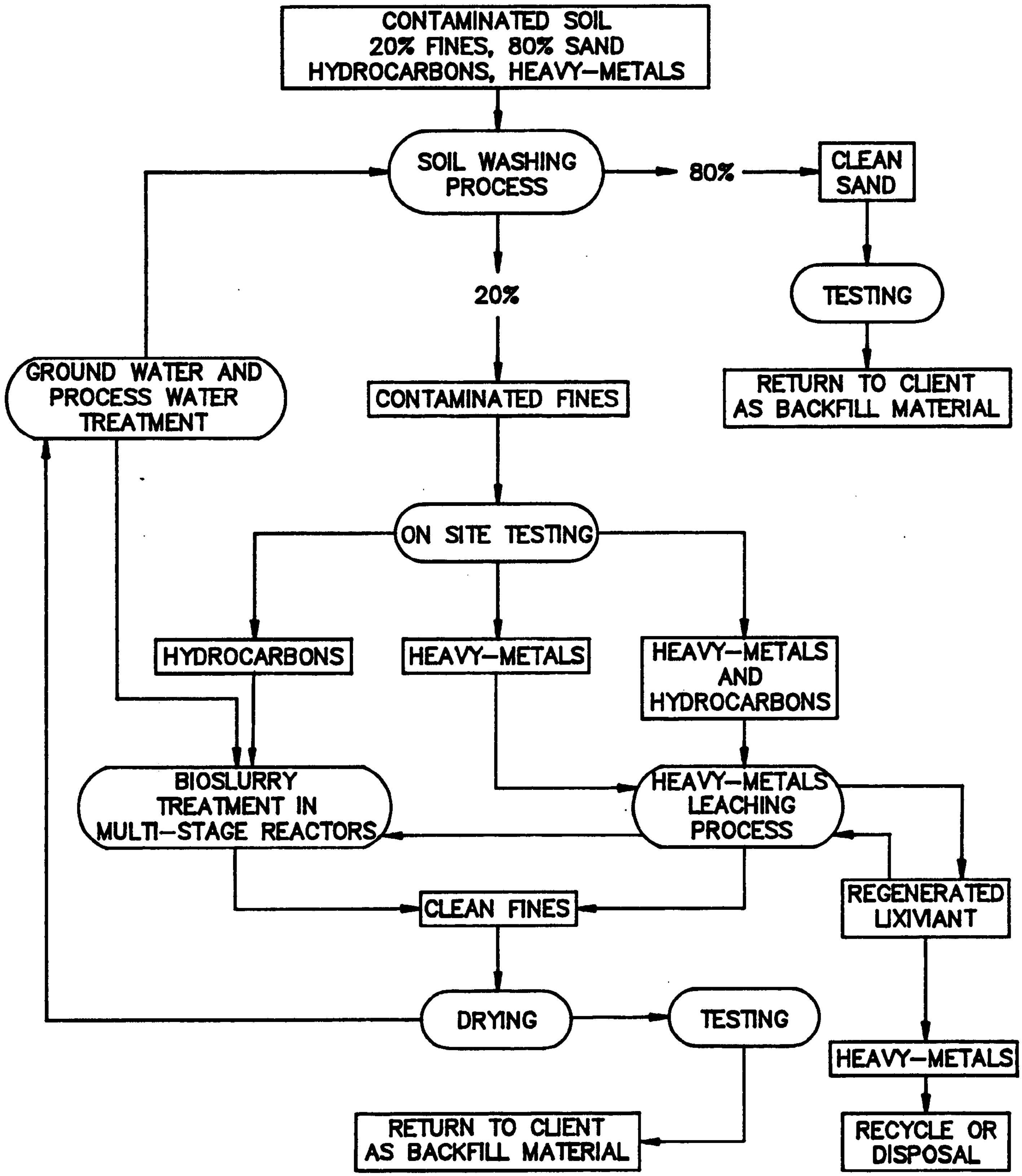
(4) ancillary costs, including consulting fees, THC costs, site preparation and groundwater pump tests and modeling, public affairs programmes, regulatory approvals and contingency $1,000,000

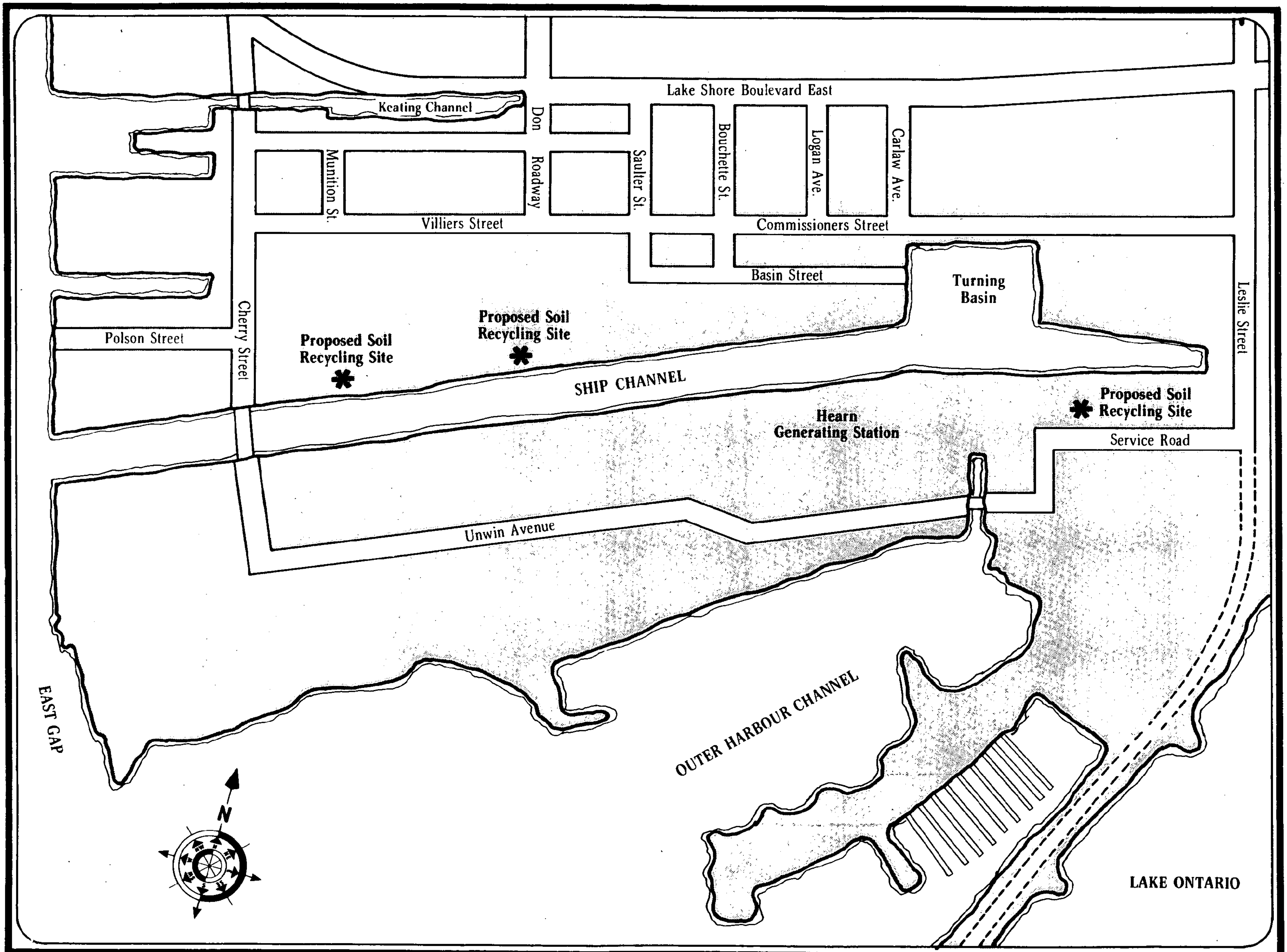
TOTAL ESTIMATED DEMONSTRATION PLANT COST $4,300,000

We note that the federal and provincial governments have a programme called the "Development and Demonstration of Contaminated Site Remediation Technology (DESRT) Program" whereby funds are available to demonstrate environmentally and economically viable technologies that will effectively clean contaminated soil and groundwater. The funding is shared 50-50 between the two levels of government. The programme is just beginning and there have been no approved projects in Ontario up to this time. Our demonstration project should be eligible for partial funding under the DESRT Program.

THC's cost to construct and operate the demonstration plant should be recovered in the charge-out rates to be charged to clients to clean contaminated soil and water in the full scale soil recycling facility.

PROPOSED SOIL TREATMENT FLOW - CHART
THC - FIXED TREATMENT FACILITY
SCENARIO 1





Lake Shore Boulevard East
Keating Channel
Don Roadway
Munition St.
Saulter St.
Bouchette St.
Logan Ave.
Carlaw Ave.
Villiers Street
Commissioners Street
Basin Street
Turning Basin
Leslie Street
Polson Street
Cherry Street
Proposed Soil Recycling Site
Proposed Soil Recycling Site
SHIP CHANNEL
Proposed Soil Recycling Site
Hearn Generating Station
Service Road
Unwin Avenue
OUTER HARBOUR CHANNEL
EAST GAP
N
LAKE ONTARIO