Removing hydrocarbons from soil more cost effectively than other conventional thermal technologies is now further enhanced when you can create viable recycling alternatives.

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Preface
This discussion paper is intended for prospective clients seeking to assist in the further refinement of two proven technologies that offer a comprehensive solution for the disposition of contaminated soils.

Introduction
As regulations and public opinion continue to place pressure on industry leaders and other stakeholders to find an environmentally benign and less invasive solution for handling and processing of hazardous waste streams, the need for expedient and accurate remediation technology is becoming more of an issue. When faced with the opportunity to reach or exceed compliance on contaminated soil, three things seem to be of primary concern, cost, speed and future liability.

Executive Summary
This paper describes the merging of two distinct and proven technologies that afford the opportunity to remove and recover the valuable liquids from the soil and turn the remaining soil into an environmentally friendly construction product. The thermal technology described herein focuses on getting the heated air into the soil faster than conventional thermal treatment methods. The water wash process after cooling the exhaust gases affords a point in the process to affect the chemistry of the remaining liquids condensed / collected to enhance reuse and recycling of the liquids. The ability to take soils and additives to create benign bricks adds a significant value position to those stakeholders with multiple contaminants in their waste stream. The blending of these two technologies has the potential to address cost, speed and future liability.

Background
The most common methods of remediation have historically involved contaminant transfer. Transfer in this case meaning, “to move the waste stream to some else’s backyard”. This continues to be a key concern for stakeholders as they continue to deal with public pressure to treat and render waste streams environmentally benign, verses, moving the waste stream for storage in some else’s backyard.

Thermal Desorption is a long proven method of “insitu” remediation which is an expeditious alternative that eliminates the risk of future liability for stakeholders by achieving higher levels of “clean soils” with “reduced emissions” and in turn, create an opportunity to positively influence public opinion while escaping the negative pressures and impacts associated with the “transfer” technologies and processes.
The Project
To mobilize the self contained equipment to a waste generator site to process contaminated soils;

Phase One
- To remove and collect liquids from contaminated soil for recycling
- To collect operational data
- To verify and refine process flow with different contaminated soil profiles.

Phase Two
- To determine cooling process/time required to create bricks
- To determine the rehydration requirements
- To determine additives required for different soil profiles
- To test the structural integrity of the bricks (compression and shear)
- To prove the commercial viability/use and applications for the bricks
- To determine the requirements to have bricks approved for use by regulators based on specific co-contaminant levels

Permits and Licensing
We have been licensed through Alberta Environment under the Small Incinerator Code of Practice. Wherein there exists a requirement to provide the Authorities Having Jurisdiction 30 days notice prior to mobilization to the waste generator’s site.

We are in discussions with ERCB and AENV to determine the opportunity to use the bricks with contaminant levels that exceed Tier I levels under Section 21.

Product Registration

Terra-Tech Remediation Ltd. has Registration in the Province of Alberta covering the manufacture, operating and decommissioning of a small incinerator (Mobile Thermal Desorption Unit).

Figure 1 Registration Certificate
Operational Issues

Characteristics of the Target Soil

Coarse VS Fine Soils
Our technology is designed to remove hydrocarbons from soil. We can process sand, rock, dusts and clay provided they can pass through the ¾ inch sorting screen/shaker on the KAG-1000 unit. Clay can prove to be a challenge depending on the type of clay present, moisture retention and tendency to lump into larger chunks. A certain amount of clay is usually present in most sub-soils, and the KAG-1000 has proven an ability to handle this material quite efficiently.

The specifications for soil classification that we use are found in ASTM: D2487, with the sub-categories GW (well-graded gravel with sand), GP (poorly graded gravel with silt, sand, cobbles and boulders), SW (well graded sand), and SP (poorly graded sand). Combinations of these soil symbols will indicate a mixture of conditions and are the most common occurrences in nature, plus a “clay” component.

Moisture Levels
The maximum moisture content the KAG-1000 can process is subject to the concentration of hydrocarbon to water. As a rule of thumb - the soils should not be so wet as to slump. Hydrocarbons in a soil matrix tend to attach themselves to water molecules. The thermal process of our technology will evaporate the water as it vaporizes the hydrocarbons operating at 350-700 degrees Celsius.

In situations where soils do “slump” a pre-process stage is required which could include; decanters – drying soil, adding processed soils to unprocessed soils, piling unprocessed soils given there is time before the equipment arrives. Gel products, saw dust, wood chips are not desirable or required for the KAG-1000. The KAG-1000 can process these additives but they are not required to deal with soils that slump.

Distribution of Hydrocarbon Content
The KAG-1000 is unique in two ways among thermal technologies;

- First the heat chamber is not subject to spontaneous combustion with elevated hydrocarbon levels. As a result additives are not required during processing to reduce heat spiking and / or explosions in the heat chamber.
- Second, KAG-1000 will collect gas and liquid hydrocarbons versus incinerating / burning the valuable exhaust gases using a flare stack.
- Third the KAG-1000 uses a water wash cycle which may afford a new opportunity to maintain the heat chamber at a lower temperature. Using chemical additives to deal with some contaminants which evaporate / volatize at below 450 degrees Celsius.
Conventional thermal processes can be subject to heat spikes / explosions in heat chamber and the flare stack flame height can vary quite a bit as the equipment vents off the pressures created by an explosion by forcing large amounts of vapor through the system, filter bag house and eventually to the flare stack.

**Co-contaminant Levels**

Co-contaminants are undesirable when looking strictly at thermal desorption. Thermal desorption technologies will not remove inorganic substances (mercury or any inorganic substance that vaporize below 450°C are the exception) in fact the process will appear to concentrate co-contaminant levels until the soils are rehydrated. Removing heavy metals from soils can be achieved using readily available equipment and magnets. Dealing with salts and other inorganic substances in situ are where we are exploring the use, application and approval of the brick technology. Using the water wash cycle adds a new treatment option to address the chemical properties of the hot exhaust gases early in the process.

**Technical Support Team**

**Inventors & Partners**
The inventors and partners to Terra-Tech Remediation Ltd. have years of experience with thermal technologies and testing the KAG-1000. The Partners include on a technical side;

- Mr. Earl Gingras, Inventor/Operator,
- Mr. Jim Kuhnan, Steel Fabrication and Design,
- Dr. Norman Arrison, P.Eng., Ph.D., M.Sc., B.Sc. our resident scientist.

**Consultants & Business Development Team**
The consultants and business development contacts include;

- Mr. Bert MacLean, BSc, our soils handling and processing consultant,
- Mr. Doug Bremner, CGA, CMA, our financial / business advisor,
- Mr. Chris Harper, our dangerous goods has hazardous materials consultant,
- Mrs. Nicole Lundberg, ____ our project coordinator.

**Third Party Consultants**
Third party soil and stack testing has been provided through Maxxam Analytics to date include;

- Ms. Caroline P. Butler, B.B., CEPIT and
- Mr. Ron Bennington, B.Sc.

Testing on smaller samples (oil and gas drilling invert material) has confirmed the soil and stack testing / reporting meet or exceed AENV Tier I requirements.
Forecasting Outcomes
Thermal processing can be simulated in a lab retort test. Research is being done to see if there is a simple means to define the amount, type of gas and heat release point from a specific soil sample. At present retort testing has shown to provide a better understanding of the hydrocarbon VS water present in the soils.

In seeking to better define the exhaust gases we are exploring the opportunities to introduce additives through the water wash cycle to effect change in the exhaust gas from the heat chamber.

Operating Costs

Soil Profile & Costs
The soil profile will quite often contain hydrocarbons ranging from C10 to C40, the latter being to upper range of hydrocarbons. The five factors that affect the costs for thermal treatment include: soil type, moisture content, contaminant type, contaminant level and clean-up criteria.

Variable Costs
As the soil profile change from project to project it is difficult to forecast the following costs:

- Fuel consumption for cogeneration of heat
- Filter media (5 and 0.3 Micron)
- Water required to rehydrate soil

Recovery / Offsetting of Costs
The hydrocarbons collected in cooling tower (tank) can be skimmed off into a collection tank. Depending on the volume and qualities of hydrocarbon liquid collected these liquids present a new opportunity to offset operating costs for treatment. For example;

- In the case of drilling fluids - the rheology of the fluid has not been affected (S.T. Wait, 2003), all the fines and solids have been removed making it an economical choice for reuse.
- In the case of hydrocarbons such as diesel it will be possible to reuse these as a fuel; with other hydrocarbons, as a result of the thermal process, may have been upgraded and can be used in blending operations.

More research is required to explore the costs of handling and additional processing. In past convention thermal processes the exhaust gases have been incinerated adding additional costs and load to the green house gas problem. The removal of incineration as the final step, moving to recovery of the valuable gas and liquids may offer two distinct advantages;

- Ability to speak positively about the reduction on CO2 gases venting off to atmosphere and
- Possibility to reduce the overall cost to thermal processing.
The Technologies

KAG-1000PTDU Thermal Desorption Unit

Performance
This unit has proven itself in removing all contaminants (non-detectable) from the soil and condensing the valuable hydrocarbons with low emissions and high energy efficiency.

The energy efficiency gains are through patented and unique modifications to the heat generation, the heat chamber, soil conveyance, gas collection, cooling & condensing, and air emissions equipment.

Heat Generation
Cogeneration is a highly efficient means of generating heat and electric power at the same time from the same energy source. Heat is generated by cogeneration using independently controlled electric elements (100% efficiency at burner tip) and hot exhaust gases from the prime driver of the self contained electric generation unit. The patent focuses on taking the cogenerated heated exhaust air and maximizing heat transfer to the soil.

Heat Chamber
Is designed to achieve a ‘zero oxygen’ atmosphere, oxygen is displaced by engine exhaust gases creating a positive pressure environment alleviating any risk of spontaneous combustion while maximizing heat transfer to the soil.
Soil Conveyance System
Soil enters the KAG-1000 through a shaker above a hopper which has a ¾ inch sorting screen. Soil is then moved into and through the heat chamber. The heat chamber auger is perforated to ensure maximum heat contact with the soil to quickly vaporize water and the volatile contaminants from the soil. The soil is moved from the heat chamber to the exit auger. The exit auger has a glycol jacket to cool the soil. Clean warm solids are deposited into a bin / pile where samples are taken for quality assurance purposes.

Cooling & Condensing

Gases
Cooling of the hot volatile gasses exiting from the top of the heat chamber is achieved using a water cooled venturi in the insulated line running across at the top of the heat chamber. The venturi can be adjusted modestly to match the flow rate as the gas is brought to near ambient temperature before entering the cooling tower (tank). Because the KAG-1000 uses a water wash of all exhaust gases through a venturi the water can be used as a secondary cleaning process. Hydrogen peroxide could be used in the water to ensure complete destruction of any hydrocarbon molecules. Other water wash treatments can be added and afford a second or third treatment process.

Liquid &Soils
A closed glycol loop is circulated first through the cooling tower (tank) to further enhance gas scrubbing and recovery activity. Then the glycol is taken to the exit auger to cool the hot soil as it leaves the heat chamber. The glycol is cooled again by a large fan and the cycle repeats.

Gas Collection
Gas collection occurs where the near ambient gasses are drawn from the cooling tower (tank) and pass through a specially designed centrifugal separator to remove any remaining large particles from the gas. Larger particles are returned to the tank and the remaining exhaust gas is fed into a compressor as it passes thru a 5 micron bank of filters and then a final filter which is 0.3 micron producing a ‘solids-free’ exhaust from the process. Additional research is required to understand if there is added value (cost recovery) in capturing the lighter hydrocarbons (Methane, carbon dioxide and carbon monoxide for example) that presently move through the filtration media as exhaust.

Liquids Collection
Water, hydrocarbons and solid particles end up in the cooling tower (tank). Oil is skimmed off and the water is taken off near the bottom and reused in the venturi to cool the hot gases. Oil that has been skimmed off to date has shown good qualities for recycling. More research is required to understand the recycling opportunity when creating a larger unit and working on larger projects.
Air Emissions
Air emissions (stack) testing demonstrate that the KAG-1000 will clean the air primarily during Gas Collection process, utilizing cyclonic action (centrifuge) on the gasses to remove most of the particulates from the heat chamber exhaust. As a safety feature the exhaust gas is passed through a filter chamber to insure process exhaust emissions meet or exceed the guidelines as set out by the numerous clean air Acts and Regulations. Testing shows the exhaust from the process is typically water vapor, exhaust gases and light hydrocarbons that are not captured by the .3 micron filter.

Earth Brick Press - Model - TB 250

Adheres to all of Built Green™ Alberta’s Compliances, an evolving industry standard which promotes sustainable or “green building practice” to reduce the impact that building has on the environment.

Earth Brick Press Features
The Earth Brick Press increases the technical advantages of treating some waste streams in situ. The technology involves a unique design for mixing the soils with proprietary ingredients and using an automated press to compress the soils into uniform and dense bricks with dimensional accuracy.

Brick making starts with the dry clean soil from the thermal desorption unit that has been cooled and possibly rehydrated to a proper handling temperature and consistency. The soil is conveyed into a hopper on the mixer (fig 4) where precision measurements of clay, cement, proprietary powder and moisture are combined and mixed to produce a uniform “recipe”. Additives can be blended in at this point to mitigate any unsatisfactory soil characteristics such as high salt content. Additives can be blended in at this point to create different colors and / or look to the bricks. The blended soil
mixture is augured into the hopper of the earth press unit, where the precise quantity of soil is deposited in the chamber, and subjected to hyper-compression in a mould.

Hyper compression, in the range of 141 – 563 kg/cm (2000 to 8000 psi) causes a high degree of molecular adhesion, is provided by two hydraulic rams that are powered by a small gas engine. The brick mould is presently designed to make a brick that is 1.3 kg and 101 x 101 x 305 mm (29lbs - 4” x 4” x12”)

**Recycling / Reuse of Processed Solids**

Bricks created are stacked on pallets and packaged, ready for any construction project undertaken. Bricks maybe used in containment wall construction, for sound barriers to achieve noise control requirements, as paver stones for driveways, for retaining walls and landscaping, or for structural projects where conventional bricks or cement blocks are used. The bricks may be used subject to meeting the CSA standard for virtually any construction application using a “dry stack method” including residential, commercial, and public building for all load and non-load bearing functions.

The uses of these bricks have been proven in endless applications and have been used in luxury mansions, and low cost housing around the world demonstrating superior thermal characteristics and durability.

Samples of the brick will be taken at various times and subjected to a compression test for quality control and suitability for a construction material.
Conclusion
Reduce, Recycle and Reuse may lower the costs to the waste generator. Insitu recycling of the waste stream into valuable useable products is environmentally beneficial and socially responsible.

There is no longer a need:

- to bulk hazardous waste by mixing it with absorbent material;
- for the hard costs created by conventional transfer technologies;
  - transportation and
  - disposal / tipping fees
- for the soft environmental costs of undesirable and excessive VOC’s created by conventional transfer technologies;
  - evaporating light hydrocarbons from handling soils
  - exhaust from transporting soil away from the site
  - exhaust caused when bringing new fill to the site
  - exhaust from land fill and farming equipment handling operations
- for the perpetual waste tracking reports and hidden costs for monitoring of the hazardous materials;
- for the hidden costs to plan, develop and then construct and open new land fill sites and land farms to handle increasing demand.

The economic benefits of blending these two technologies may be enhanced by the benefit of ‘positive public perceptions’ and the ability to ‘give back to society’.
Bibliography


Figure 7 Wall Construction using Earth Bricks