3.0 POTENTIAL FOR PILOT-SCALE OPERATION

Based on the results of the Phase I work, the FBT has good potential for demonstration as an effective treatment for harbor sediment. Although BioSafe is not currently planning to further develop the process, it still holds promise as an effective treatment method. The following section is a projected pilot test program for the process.

3.1 PILOT-SCALE CONFIGURATION AND PROCESSING RATES

BioSafe's recommendation to piloting the full FBT process would be based on using the existing Phase I FBT unit as the first stage of a demonstration unit that will meet all requirements of the Phase II program. The bulk of work in Phase II would be designing and fabricating a second stage that could be incorporated into the process such that the resulting unit will:

- Be skid-mounted and transportable;
- Be capable of processing as-received sediment (70 % moisture) at a rate of 100 to 125 pounds-per-hour on a continuous basis;
- Produce a solid product suitable for unrestricted disposal;
- Produce a Lo-Btu gas that can be combusted as fuel for the process; and
- Produce a clean water stream that can be reused to generate steam for process use.

Process Description

Figure 3.1-1 is a process flow diagram showing the equipment as well as basic instrumentation of the full FBT process for this program. The FBT process uses two stages or fluid beds in series. The first stage is essentially that unit fabricated for Phase I, however, it would require modification to allow an increased throughput by:

1. Installing indirect heating tubes in the fluid bed, and
2. Incorporating a dual feed system that can use a screw feeder or progressive cavity pump.

The first stage will be fluidized using superheated steam at 1400 °F. Feed will be introduced into the hot fluidized bed and temperature will be maintained by burning a fuel such as natural gas (supplemented by the LoBTU gas that the process produces) and then passing the hot combustion gases through tubes immersed in the bed. Combustion gases do not come into contact with the material being treated. In addition, the external electric heaters that were used in Phase I will remain in-place to minimize heat loss and as supplemental heat sources.

The volatile organic materials in the feed have boiling points in the range of 180 to 1200°F and volatilized ("steam stripped"). These hot gases exit the fluidized bed with the steam and vaporized water. The majority of entrained solids are released in the freeboard volume of the vessel. Smaller entrained particles are conveyed by the vapor velocity into a cyclone where particles larger than 1 micron are collected. In operation, the necessity of this cyclone

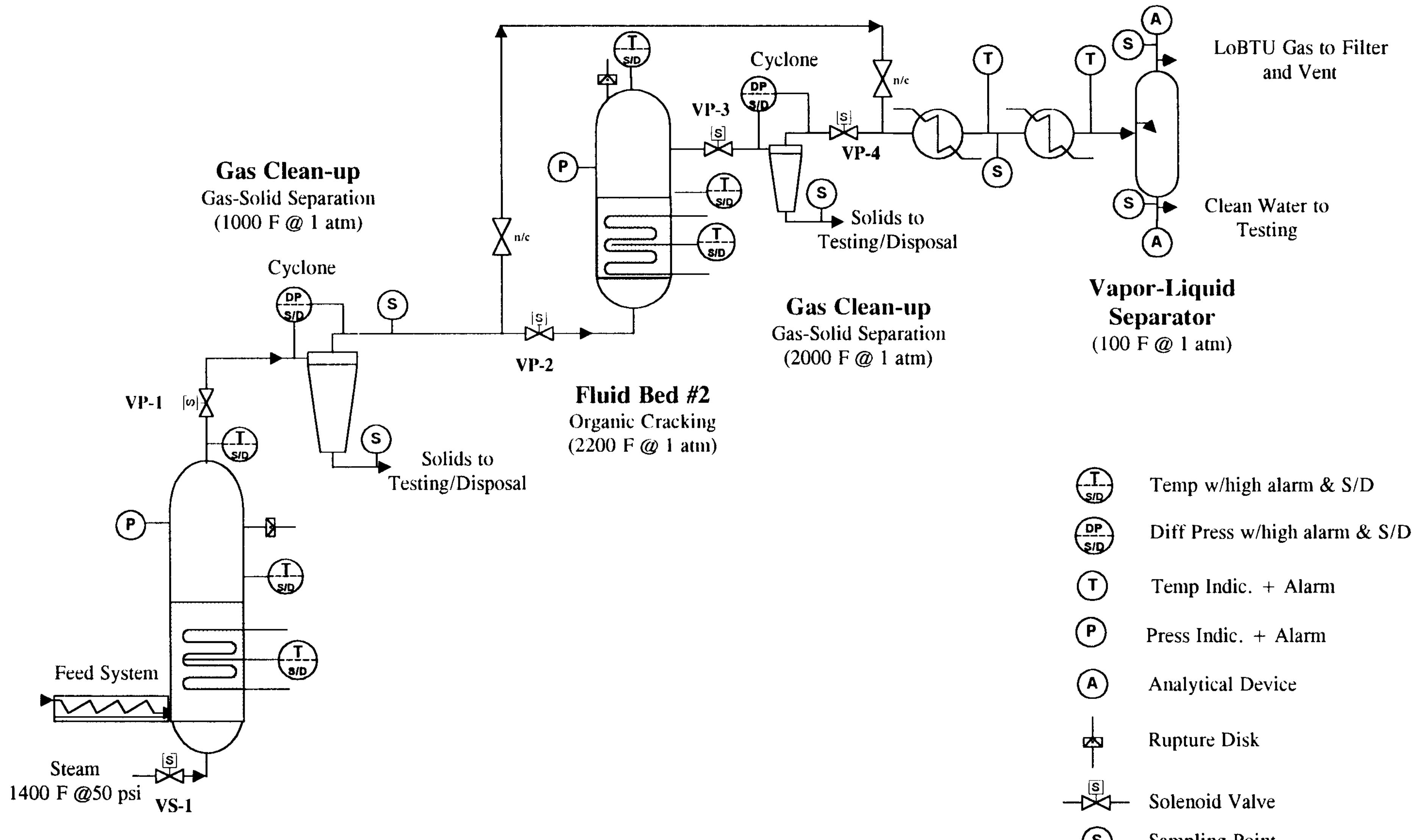

FIGURE 3.1-1

BioSafe FBT Process

Full Pilot-scale Demonstration Unit

separation will be evaluated. Ash that builds up in the fluid bed is recirculated in a adjoining standpipe with a predetermined amount removed continuously using a rotary valve. This is similar to a blowdown stream that is removed from a cooling tower. The solids are cooled and represent the solid product from the process that is clean for disposal. Options for the ash/inerts include use as clean fill, concrete aggregate, cover material, agricultural material or beach nourishment.

The vapor from the outlet of the first fluidized bed (organic vapor, water and dust) enters the second atmospheric fluid bed where they are "cracked" at about 2200°F to yield the components of the LoBTU gas. This fluid bed is similar in design to the first stage, but the steam organic vapor enters the bottom of the bed as the fluidization medium, and is heated to 2200 °F where the complex organic materials are cracked to carbon monoxide, carbon dioxide, hydrogen and similar materials. Heat to the bed is provided indirectly by circulating combustion gas through tubes that are immersed in the bed. Again, the heating is accomplished indirectly - no combustion products are in direct contact with the material being processed.

Within the second stage fluid bed, the mixture is in equilibrium in the water-gas shift reaction:

$$H_2O + CO = CO_2 + H_2$$

The gross excess of water will drive the reaction to the production of Hydrogen which enhances the fuel value of the cracked gas. The hot cracked gas exits the fluidized bed with the steam and vaporized water. The majority of entrained solids are again released in the freeboard volume of the vessel. Smaller entrained particles are conveyed by the vapor velocity into a cyclone where particles larger than 1 micron will be collected. Collected solids will be removed from the cyclone on a continuous basis. The solids will be collected and analyzed and represent a second clean solids stream for disposal.

Following the solids removal, the gas steam mixture is cooled and the water fraction condensed and collected. The organic portion which remains a vapor is the LoBTU gas (heating value of approximately 400 to 500 BTU/scf vs. 1,000 BTU/scf for natural gas) which can be recycled as fuel and burned along with natural gas in the combustion system which supplies heat to the tubes immersed in the fluidized bed. The water is highly pure distilled water which is reused to generate steam that is used in the process.

Safety devices/interlocks

The FBT would be computer controlled and incorporate a variety of remote sensing devices that will be alarmed and interlocked to ensure that the system automatically shuts down in the event of unplanned transients.

Figure 3.1-1 shows several of the automatic safety features that ultimately prevent the system from unexpected temperature and pressure transients that may cause injury to operators, initiate an unplanned discharge, or damage equipment. The major focus of the safety devices are to prevent the thermal transients (temperature excursions) that increase stresses on equipment. The FBT system is protected by interlocking several key thermocouples such that they can initiate a plant shutdown. There are six thermocouples that are interlocked in this matter. They are located in the fluid beds and discharge lines and will detect any abnormal increases in temperature. The temperature shutdowns for FBT 1 will be at 1600 °F (normal operating is 1200-1400), and FBT 2 will be set to initiate an emergency shutdown at 2500 °F (normal operating is 2000-2200).

Automatic shutdowns can also be initiated by excessive differential pressure across the cyclone. This serves as an indication that the solids separation device is plugging, and if no action were taken, the fluid beds would pressurize. At this time the system will be set initiate a shutdown when the differential pressure exceeded 5 psig. During operations, this setpoint will be reevaluated based on empirical data to determine the proper setpoint.

The operator also has the ability to initiate an automatic shutdown by the initiation of a single switch if, in their judgment, the unit is approaching an unsafe condition.

As a fail-safe measure, each fluid bed is equipped with a mechanical rupture disk that will vent the system in the event of a pressure buildup.

Feed system/Introduction of hazardous waste material

The FBT unit will be fed from a day tank/silo that is filled prior to beginning a test, and as required during operations. The tank/silo will be a stainless steel unit with a removable top that is fitted with a carbon filtered vent. The tank will be filled with an appropriate amount of feed material that has been measured in the laboratory area.

The operator measuring and transferring the feed materials will use appropriate personal protective equipment.

Two feed systems will be used. When processing soils, or other dryer materials, the day tank/silo will provide direct connection to a screw conveyor. In tests with wetter sludge-like materials the day tank/silo will be connected directly to the suction of a progressive cavity pump. In both cases, the tank/silo will be directly coupled to the mechanical device, and essentially be a live bottom unit.

3.2 PHYSICAL REQUIREMENTS

BioSafe's approach would be to fabricate a modular skid mounted pilot unit that can initially be tested in our own facility. Upon completion of check-out testing, the unit would be transported to an indoor facility at the site for the demonstration testing campaign.

Space

The BioSafe pilot FBT demonstration unit would be skid mounted, and transportable on conventional overland trucks. The operational process is contained on two skids that measure

8 feet by 30 feet. These skids are 8 feet high rigged for transport, but will require 20 feet of overhead for operation. Figure 3.2-1 is a layout of the operational process.

In addition to the process skids, additional space will be required for feed and effluent storage tanks. Based on holding the full 25 cubic yards of sediment, approximately 1,000 ft^2 of floor space will be required.

Utilities

The FBT unit will require the following utilities:

ITEM	AMOUNT	REMARKS
Natural Gas	1000 cubic feet/hour	Maximum usage
Electricity 450 v 3 Phase	600 amps	All resistive load
Electricity 240 v 3 Phase	20 amps	All resistive load
Electricity 120 v	600 amps	
Cooling Water	100 gpm	Can be closed loop

BioSafe's pilot plant will be equipped with all necessary distribution and control panels. It only requires single power feeds at the specified voltages.

BioSafe's FBT uses a natural gas fired heater that will require venting to the outdoors. This would be a normal chimney from a natural gas furnace, and require a minimal permitting effort.

3.3 Environmental Health & Safety

BioSafe's FBT process is totally enclosed, and will not require any special Health & Safety measures/procedures during normal operations other than those in any industrial environment utilizing rotating and heated equipment.

The only potential unique hazards are associated with the second stage fluid bed operation at high temperatures, and the loading and unloading of raw sediment. The latter is assumed to be the responsibility of others.

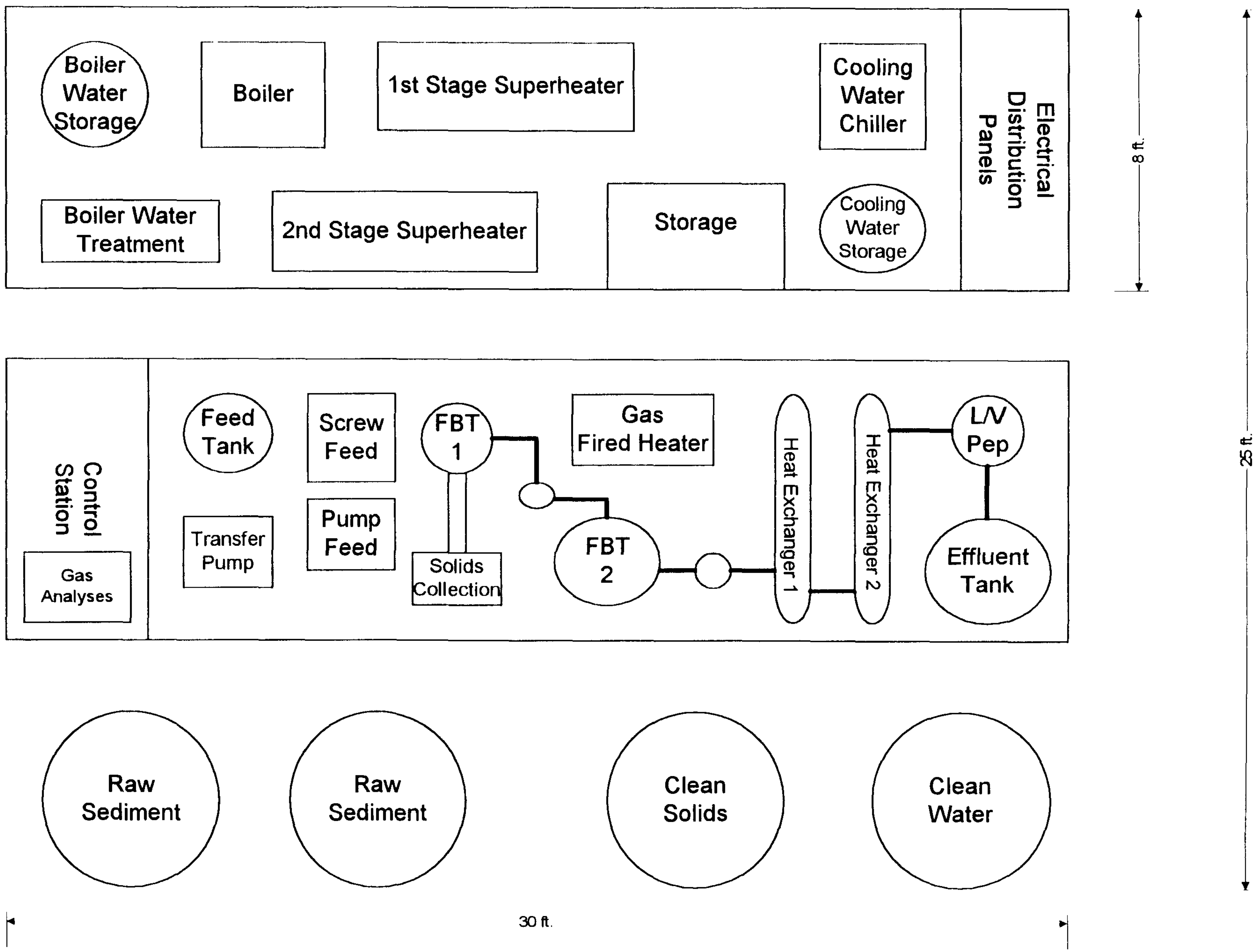

Figure 3.2-1
BioSafe FBT Pilot Demonstration Layout

3.4 Residue Management

The FBT will have the following discharges during operation at a nominal feed rate of 100 pounds-per-hour of as-received sediment (not dewatered):

MATERIAL	GENERATION RATE (per hour)	COLLECTION METHOD	DISPOSITION
Solids	20 pounds	Removed from cyclone	Tested for organic materials and metals then disposed as appropriate
LoBTU gas	10 pounds	Collected from vapor-liquid separator	Continuously monitored for CO, H_2, CO_2, CH_4, and C_2+. Grab samples are taken. The gas is used as an external fuel in the process.
Water	70 pounds	Collected from vapor-liquid separator	Held in poly tank until cleared for sewer or sent to treatment
Flue Gas (from fired heaters)	8000 cubic feet	Vented through chimney	Vented

The FBT process will generate two residual streams that will require disposal. Our intent is the following:

Solids Material that is recovered from the first fluidized bed will be analyzed for organic contaminants and metal ions. It is not expected that any organic materials will be present. However, most of the metals will remain in the solid material, and analyses will be conducted to determine the proper disposal method. The worst case is that the residual solids will be have to be disposed of in a restricted landfill. Over the course of the performance test, approximately 4,000 kilograms of solids will be generated.

Liquids The bulk of the liquid generated will be condensed steam that will be recycled as boiler feed water. During steady state, it is expected that approximately 8 gallons-per-hour of water will be discharged. This material will be collected, sampled, and treated if necessary (to adjust pH) and discharged.

3.5 Pre-Treatment Requirements

The BioSafe FBT process is robust in that it can process a variety of feedstocks. The only limitation is the ability to convey the material into the first stage fluid bed. Once in the bed, the moisture content will only create more steam within the system, and therefore will only impact the energy usage. At the current time, the expense and potential complications of a dewatering process, and the associated treatment of the filtrate, outweigh the fuel savings that may be realized.

BioSafe's would fabricate the pilot demonstration unit with both a screw feeder and a progressive cavity pump. Having both feed systems will allow the FBT to feed and process virtually any feed.