Design of a Unique Groundwater Pumping System for Use in Flammable Environments

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September 2, 2010

Class I, Division 1 electrical hazard

Class I, Division 1 – a location in which ***ignitable concentrations*** of flammable gases or vapors may exist under normal operating conditions; or because of repair or maintenance operations or leakage; or because of breakdown or faulty operation (see 29 CFE 399).

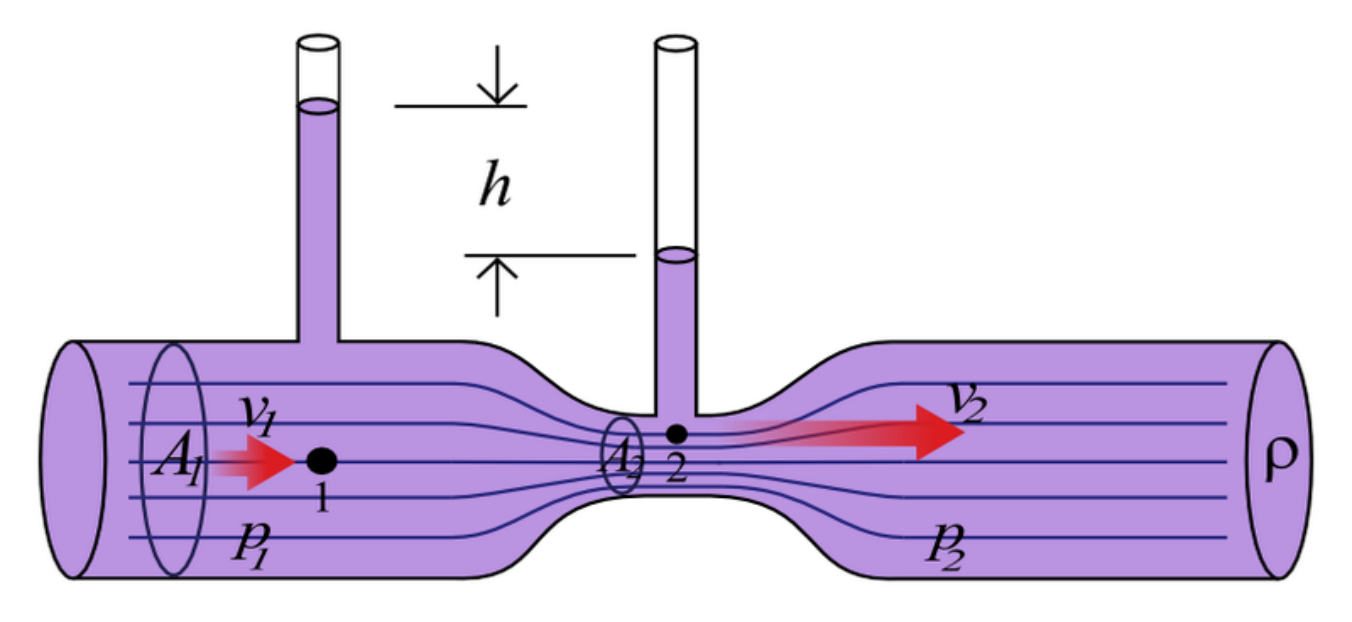
"Some typical Class I locations are petroleum refineries, and gasoline storage and dispensing areas; dry cleaning plants where vapors from cleaning fluids can be present; spray finishing areas; aircraft hangars and fuel servicing areas; and utility gas plants and operations involving storage and handling of liquefied petroleum gas or natural gas." (Memo from the OSHA Office of Training and Education, May 1996)

Class I, Division 1 equipment

- Equipment is certified by various independent agencies for use in Class I, Division 1 environments. These certifications include:
  - Intrinsically Safe – an electrical device that is ***incapable of causing an ignition*** of the prescribed flammable gas, vapor, or dust, regardless of any spark or thermal effect that may occur in normal use, or under any conditions of fault likely to occur in practice.
  - Explosion Proof – an electrical device designed with an enclosure ***capable of withstanding***, without damage, an explosion within it of a specific gas, fiber, or dust.

Given the standards that must be met, Class I, Division 1 equipment is expensive. To reduce the cost of liquid recovery in such an environment and increase the safety associated with this operation, a unique pumping system can be used that locates all electrical equipment outside of the Class I, Division 1 zone. This system can be designed with flexibility in its ability to recover oil, refined product, contaminated groundwater, and other liquids from the impacted area.

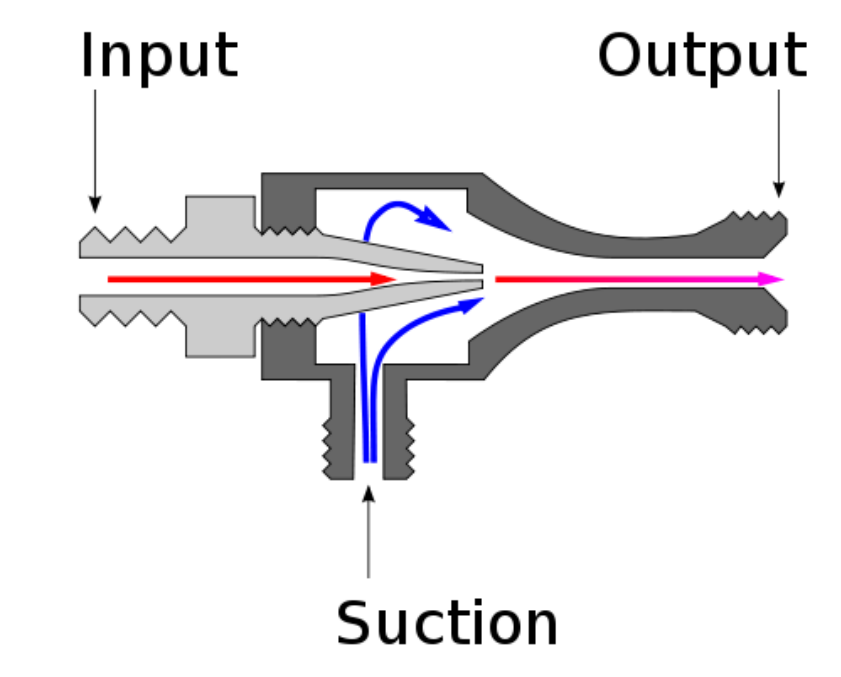
The system is based on the Venturi effect.



$$P_1 - P_2 = \rho/2\,(v_1^2 - v_2^2)$$

The fluid velocity increases at point 2 to satisfy the continuity equation, while the pressure decreases at that point due to conservation of energy.

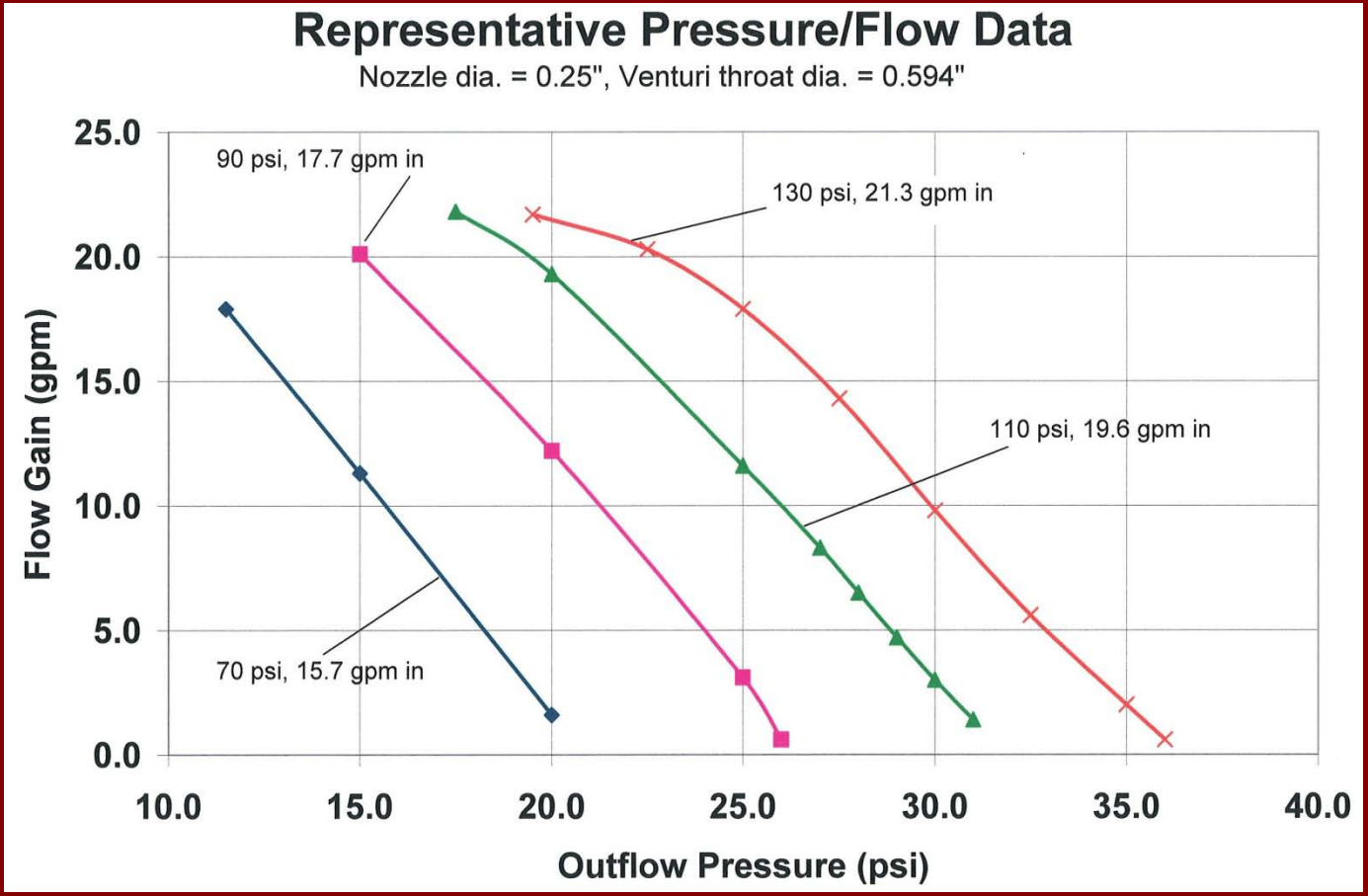
This concept governs the operation of eductor pumps.



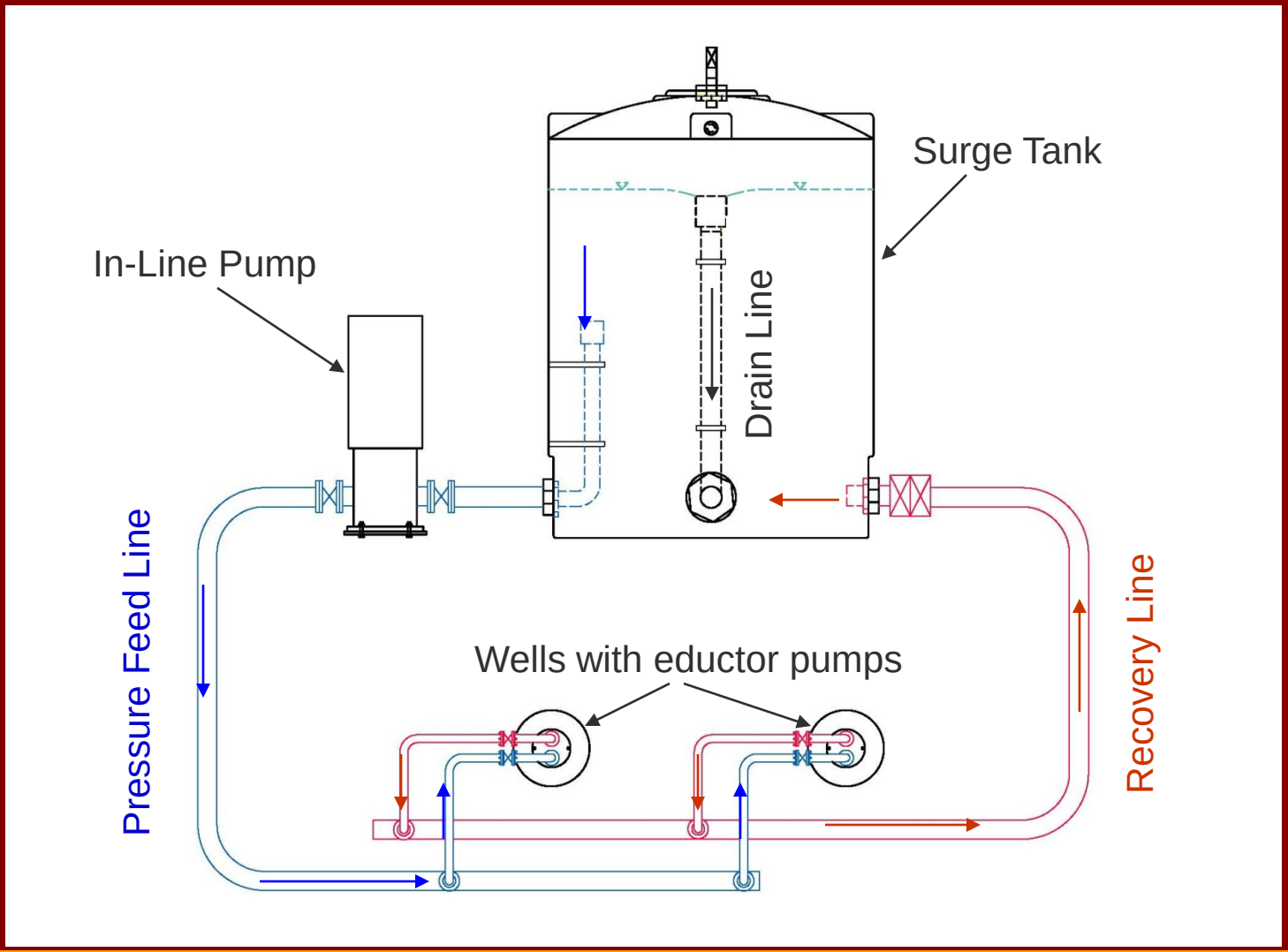
The pressure drop across the nozzle and Venturi restriction creates a vacuum that draws fluid through the suction line into the flow stream.

Source: Egmason, 2010

A unique relationship exists between eductor nozzle diameter, Venturi throat diameter, fluid pressure, and the gain in flow rate. This is determined by bench testing.



Pumping system components

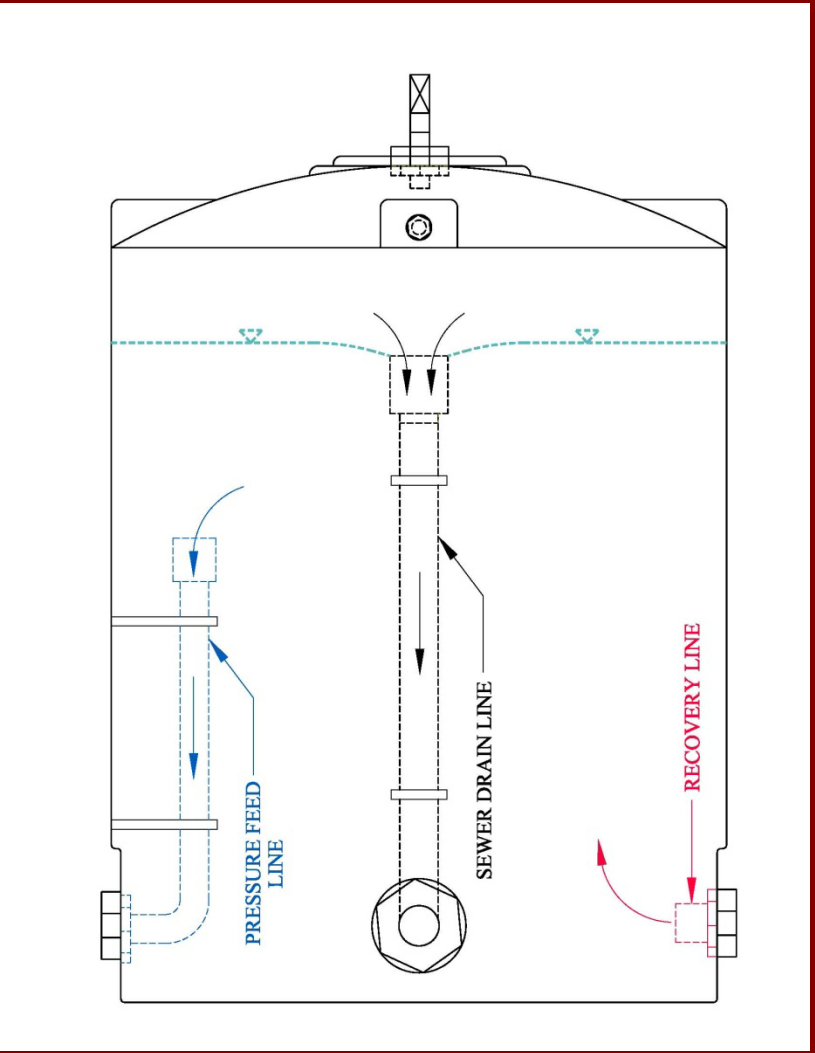


System operation

- After the wells and equipment have been installed, the surge tank is filled with water.
- Additional makeup water should only be needed to compensate for leaks.

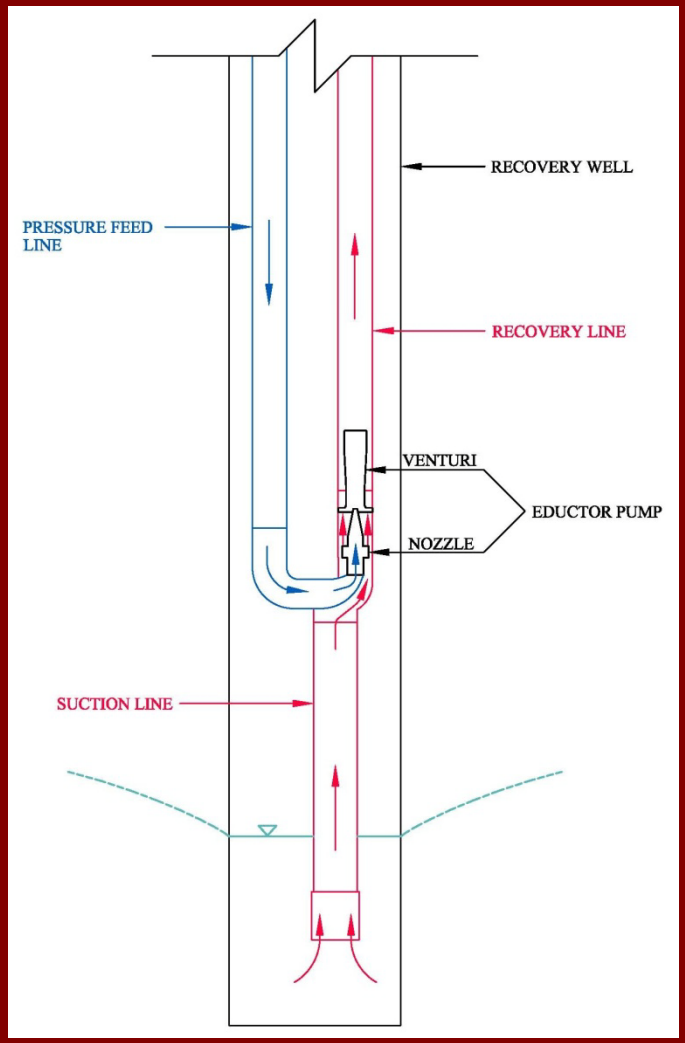
System operation (cont.)

- The system operates by drawing water from the surge tank through a pipe whose inlet is set at an elevation below expected free-phase product.
- The water is pumped through the pressure feed line by the in-line pump.



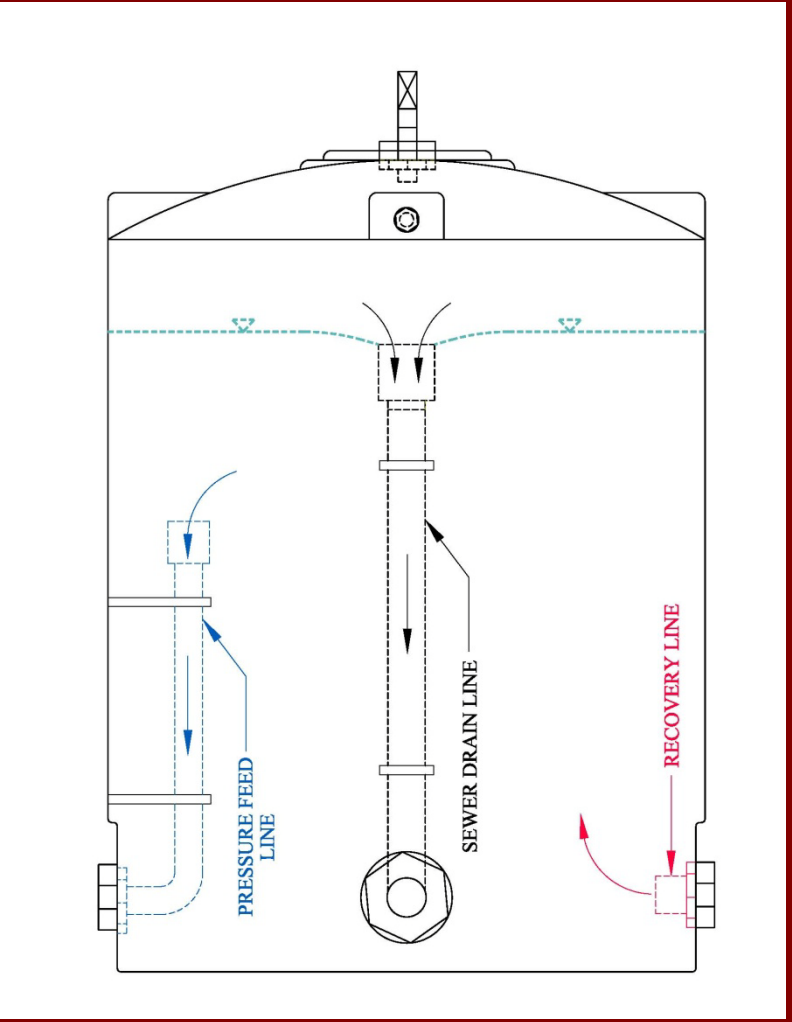
System operation (cont.)

- The pressurized water flows through an eductor pump installed in each well.
- As the feed water flows through the eductor pump, the pressure drop creates a vacuum that draws water from the well into the recovery line.



System operation (cont.)

- The well water is carried through the recovery line back to the surge tank.
- Overflow from the surge tank is discharged for treatment.



System advantages

- All electrical power sources can be located remotely from flammable areas, allowing compliance with Class I/Division 1 electrical standards.
- The system requires only one pump to operate, thereby lowering equipment and power costs.
- No moving parts are located downhole, thereby minimizing maintenance issues.
- The system is not affected by pumping air from a dewatered well.
- Many well points can be operated on the same system.
- Recovery flows can be easily set and adjusted.

Maintenance issues

- Each well can be valved, allowing work on individual wells without shutting down the entire system.
- Depending on the well design, it may be necessary to take extra care to keep debris out of the system.
- No significant maintenance is required beyond addressing normal wear.

Case History – Petroleum Refinery in northern Utah

- In operation since 2002 with no major problems
- 9 wells installed in a tank field to recover product and contaminated groundwater
- 25 HP pump
- ~250 gpm total flow
- 25-75 gpm (typical) recovered to an on-site wastewater treatment plant

Thank you