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September 2, 1998

E/98/1327
962-1853C

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Contaminated Sites Remediation Program
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RECEIVED
SEP - 8 1998
By________________

Attention: Ms. Sally Schlichting

RE: SVE/IAS PILOT TEST, SKAGWAY, ALASKA

Dear Sally:

Introduction

Golder Associates Ltd. (Golder) conducted a pilot test study at the White Pass Maintenance Shops (Shops) in Skagway, Alaska to evaluate the feasibility of remediating the groundwater at the Shops using air flushing technologies, specifically soil vapor extraction (SVE) and in situ air sparging (IAS).

Soil vapor extraction involves forcing air through an unsaturated soil by using either pressure and/or vacuum. SVE operates on the principle that volatile and semi-volatile compounds readily partition into the gas phase, which is then extracted. Two removal mechanisms are possible with SVE: evaporative recovery and biodegradation. The contaminants are evaporated and transported with the induced air. SVE systems also supply oxygen to the soil, which in turn enhances biodegradation.

Air sparging involves injecting air directly into the saturated subsurface below or within the contaminated zone. As the air travels through the contaminated zone the contaminant is volatilized into the air. The air then travels upwards through the groundwater zone where SVE is used to capture the vapors. Also, addition of air to the subsurface permits aerobic biodegradation of petroleum hydrocarbons.

Contaminants of concern at the Shops include chlorinated hydrocarbons (trichloroethylene, TCE and tetrachloroethylene, PCE) and hydrocarbons (benzene). These compounds are all volatile, indicating that IAS should be effective at remediating the groundwater. In order to determine the effectiveness of IAS, combined with SVE, a pilot test at the Shops was conducted. The following outlines the methodology used and results of the pilot test.

Pilot Test Setup

The pilot test area at the Shops site was conducted in the area around MW97-6, which consists of both a 30-ft and 50-ft well (see Figure 1). Both wells are individually screened over a 5-ft length. An area approximately 24 ft by 24 ft, centered on MW97-6, was covered with a tarp to limit surface airflow to and from the soil (see Figure 2). The tarp was sealed around the wells and the edges were secured using approximately six inches of soil. A 3-ft slotted SVE well was installed to a depth of 5 ft next to MW97-6 (the air sparging well). The SVE well was backfilled with cuttings and a 1 to 2 ft bentonite seal to the ground surface.

Vapor probes, for monitoring purposes, were driven into the ground at approximately 3 ft spacings. Due to the gravelly nature of the subsurface soil, the vapor probes varied from 0.5 ft to 2.5-ft in depth. Figure 2 presents a schematic of the pilot test layout.

A 5-hp blower was used to induce a vacuum on the subsurface. The blower was equipped with a "knock-out" drum to collect any water removed along with the vapor. The blower had a capacity of approximately 150 scfm (standard cubic feet per minute). An air compressor was used to inject air into MW97-6 at a pressure of approximately 25 psi (pounds per square inch).

In order to determine the radius of influence of the air sparging well and SVE well, helium was injected along with the air as a tracer. The tests were conducted by injecting helium into the sparge air and using a helium detector at the vapor probe monitoring points to determine the radius of influence of the sparge air. Once the radius of influence was determined the SVE blower was used to collect the injected air and helium. The influence of the SVE system was determined by the disappearance of helium at the vapor probe monitoring points.

Tests were conducted on the 30 ft and 50 ft wells at MW97-6. Upon completion of the test at MW97-6, the SVE blower was also connected to MW97-1 (see Figure 1) to determine the effectiveness of the 5-hp blower at removing vapors from a 15-ft well. Results of all tests are summarized below.

Test Results: Radius of Influence

As seen on Figure 2, helium (in % He) was detected in all vapor probes when sparging in the 30-ft well, indicating a good distribution of air in the subsurface. The radius of influence for the 30-ft well is at least 12 ft (half of the tarp length).

Figure 3 shows the radius of influence for the 50-ft well. Additional vapor probes were installed for this test since it was anticipated the deeper well would have a larger radius of influence. As indicated on the figure the helium was detected as far as VP-19, which was approximately 25 ft from MW97-6. Again, the helium was reasonably uniformly distributed through out the area surrounding MW97-6.

Figures 4 and 5 present schematics of the airflow pathways for both the 30-ft and 50-ft wells, respectively. The zone of the sparge air from the 50-ft well is considerably wider than the 30-ft well and therefore influences a considerably larger zone of groundwater.

Test Results2: SVE

When the SVE blower was turned on during the 30-ft and 50-ft well tests the helium at all vapor probes, within the tarp area, decreased until there was no helium present. This indicates that all the air injected was recovered by the SVE system. A conceptual diagram of this, for the 50-ft well, is shown on Figure 6. The SVE blower also captured the sparge air from the vapor probes located off the tarped area, indicating the ease of airflow within the unsaturated zone at the Shops.

A plot of the organic vapors recovered during the SVE test at MW97-1 is shown on Figure 7. The recovery of hydrocarbon vapors from just the unsaturated zone suggests enhancing the SVE system with IAS would effectively remove organic vapors from both the unsaturated (SVE) and saturated (IAS) zones of the subsurface.

Full-Scale Design

Based on the results of the above pilot tests, 60-ft deep air sparging wells, with 5-ft screens, at 25-ft spacings are proposed to address the subsurface contamination at the Shops. This configuration will allow the maximum amount of groundwater to be treated while providing a realistic engineering and economical solution to the current subsurface contamination.

Installing wells deeper than 60-ft would require relatively large air pressures to inject the sparge air, which could result in the well being "lifted out" of its borehole. Based on the 50-ft well pilot tests, a spacing of 25 ft would ensure adequate coverage of the groundwater zone by the sparge air.

SVE wells are proposed in between every second sparge well at a depth of 5 ft. Based on the SVE pilot test results, air moves easily through the unsaturated zone and therefore half as many SVE wells are required compared to the sparing wells.

Based on our previous discussions and favorable test results, we have begun installation of a series of SVE/IAS wells in the area shown on Figure 1 in order to expedite remedial activities at the Shops. The wells will be installed as described previously. A detailed mechanical and layout design of the final system will be provided once the installation is complete. However, for you information, the system will take into account the climate (*i.e.*, freezing temperatures), current and planned future activities at the Shops, and applicable regulations (i.e., filters for off gas emissions).

Closure

We appreciate your assistance in speeding the implementation of the SVE/IAS system at the Shops by providing verbal approval for us to proceed while our drilling equipment is at the site. We would also appreciate your written approval for construction of this system, as well as further comments or concerns that you may have based on the results described in this report. If you have any questions, please contact either myself at (604) 298-6623 or Gary Hamilton at either (604) 298-6623 or (867) 633-7780.

Yours very truly,

GOLDER ASSOCIATES LTD.

Diane Grady, Ph.D.
Project Hydrogeologist / Engineer

DEG/vw
962-1853C

cc: Mr. Fred McCorrison - White Pass
Mr. Robert Ward – City of Skagway

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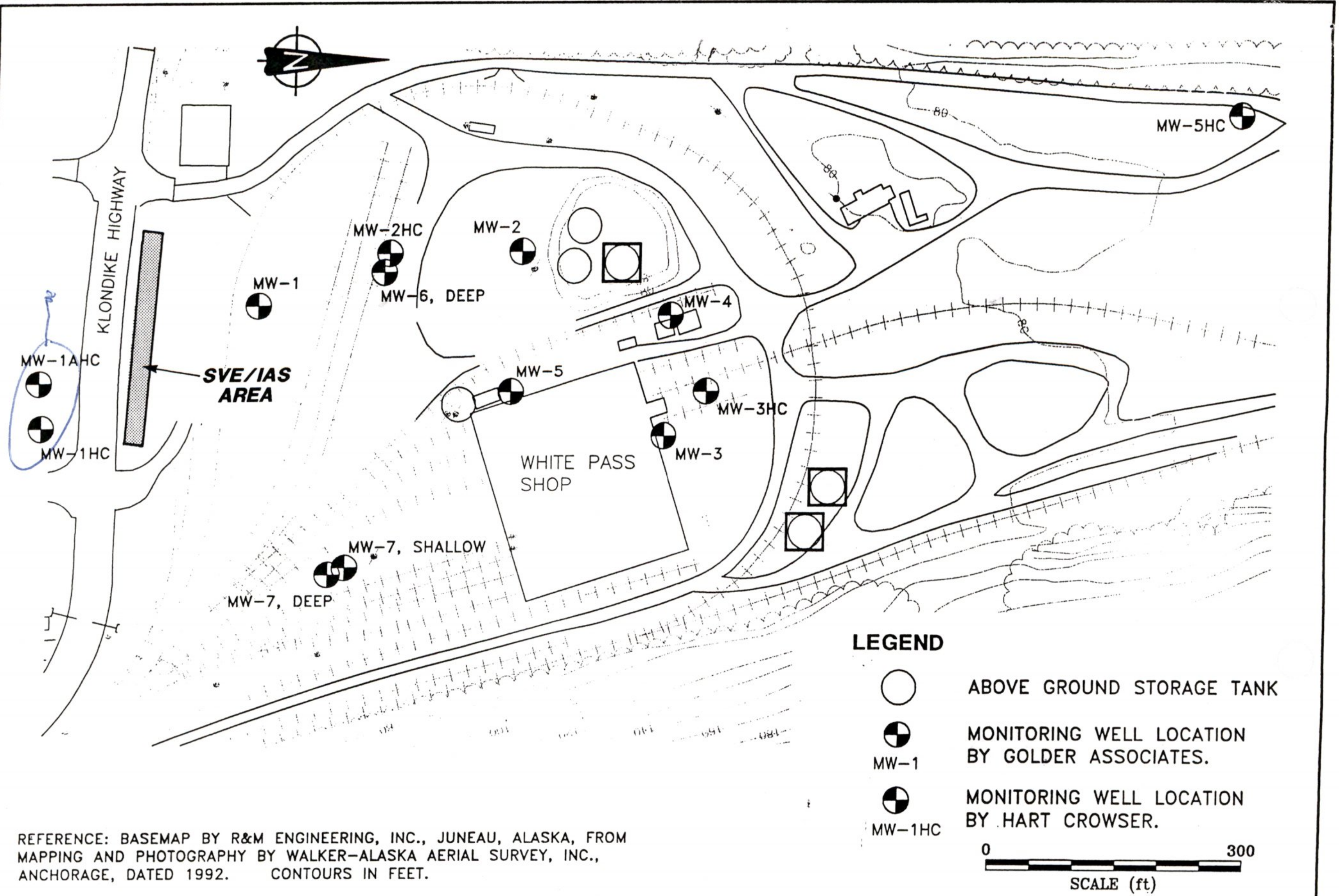
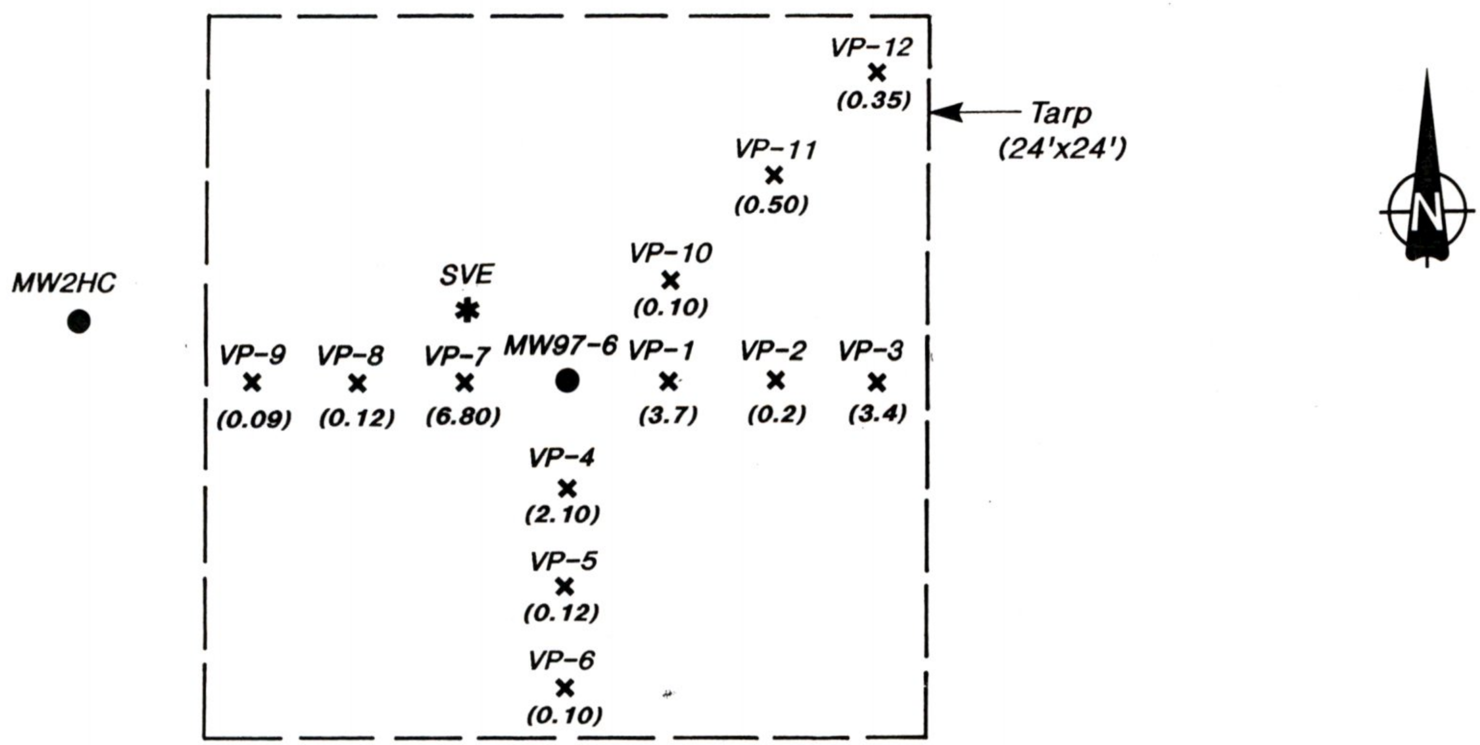


REFERENCE: BASEMAP BY R&M ENGINEERING, INC., JUNEAU, ALASKA, FROM MAPPING AND PHOTOGRAPHY BY WALKER-ALASKA AERIAL SURVEY, INC., ANCHORAGE, DATED 1992. CONTOURS IN FEET.

Project No.: 972-1853A Drawn: s.s.s Reviewed: D.E.G. Rev.: 30-DEC-97	Golder Associates	SITE PLAN	Figure 1



Legend:

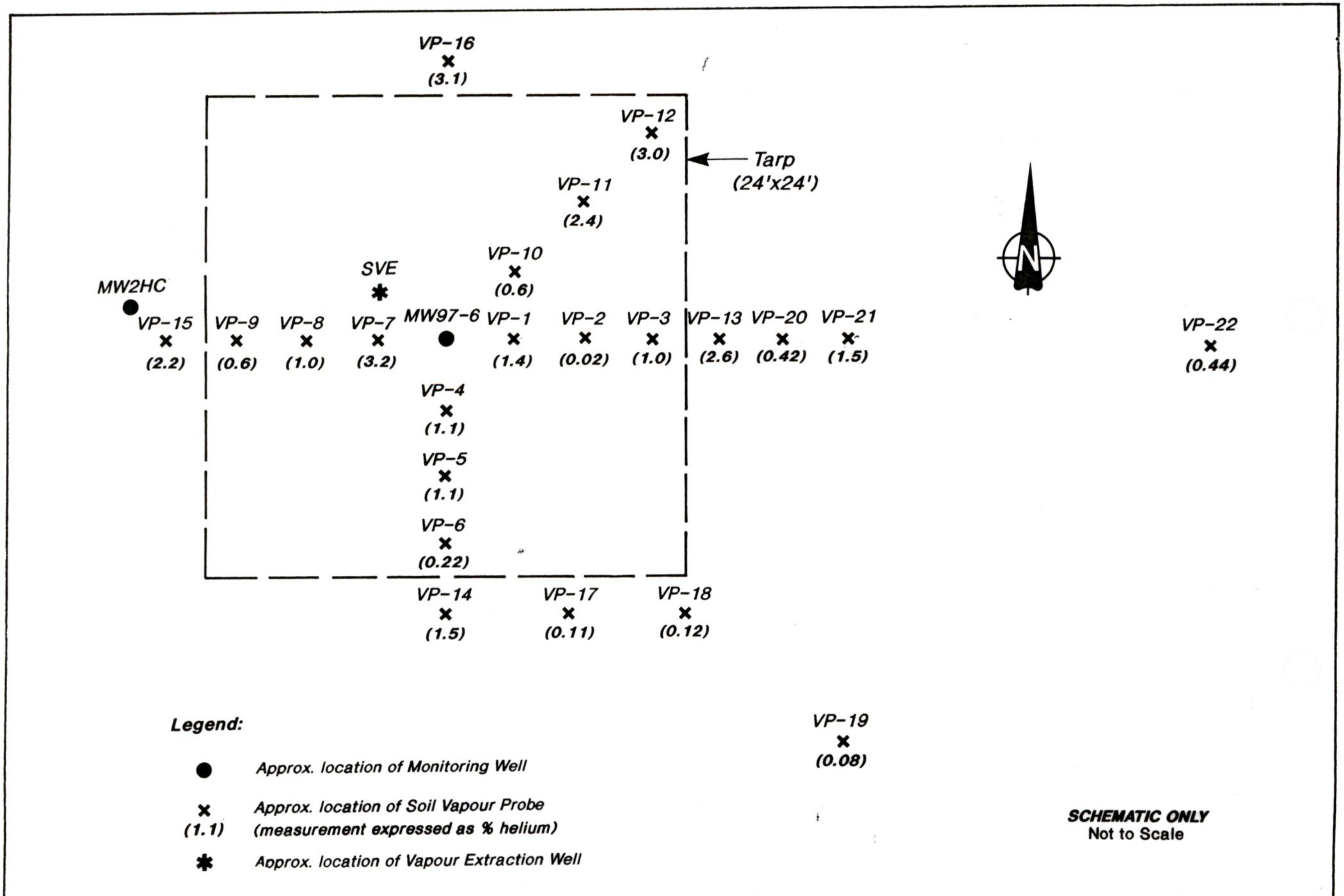
● *Approx. location of Monitoring Well*

✖ (2.10) *Approx. location of Soil Vapour Probe (measurement expressed as % helium)*

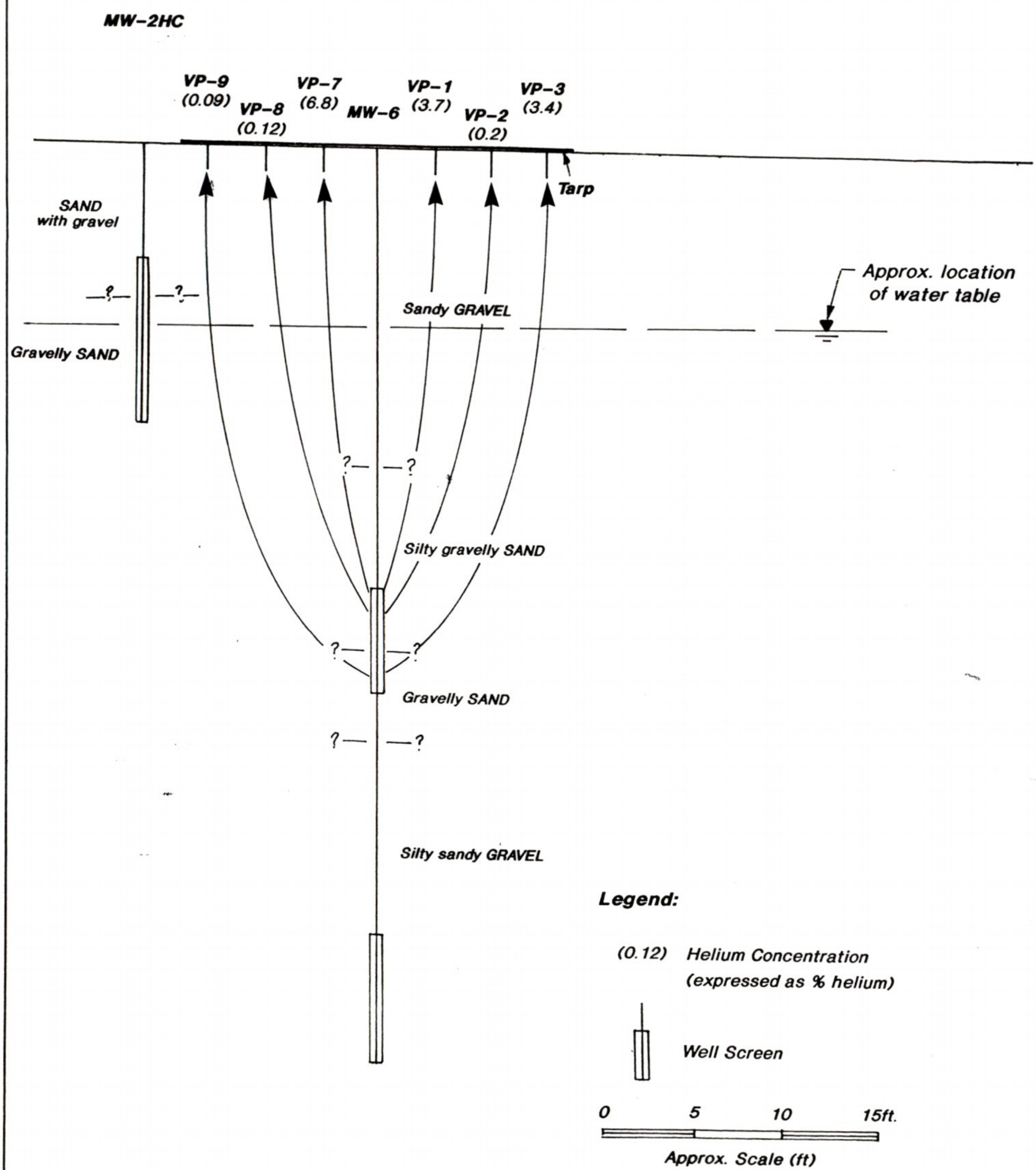
✱ *Approx. location of Vapour Extraction Well*

SCHEMATIC ONLY
Not to Scale

Project No. 962-1853 Drawn BAD Reviewed J.H. Date Aug. '98	Golder Associates	**HELIUM TRACER TEST – 30 FOOT WELL SKAGWAY, ALASKA**	Figure **2**



Project No. 962-1853 Drawn BAD Reviewed J.H. Date Aug. '98	Golder Associates	**HELIUM TRACER TEST – 50 FOOT WELL** **SKAGWAY, ALASKA**	Figure **3**



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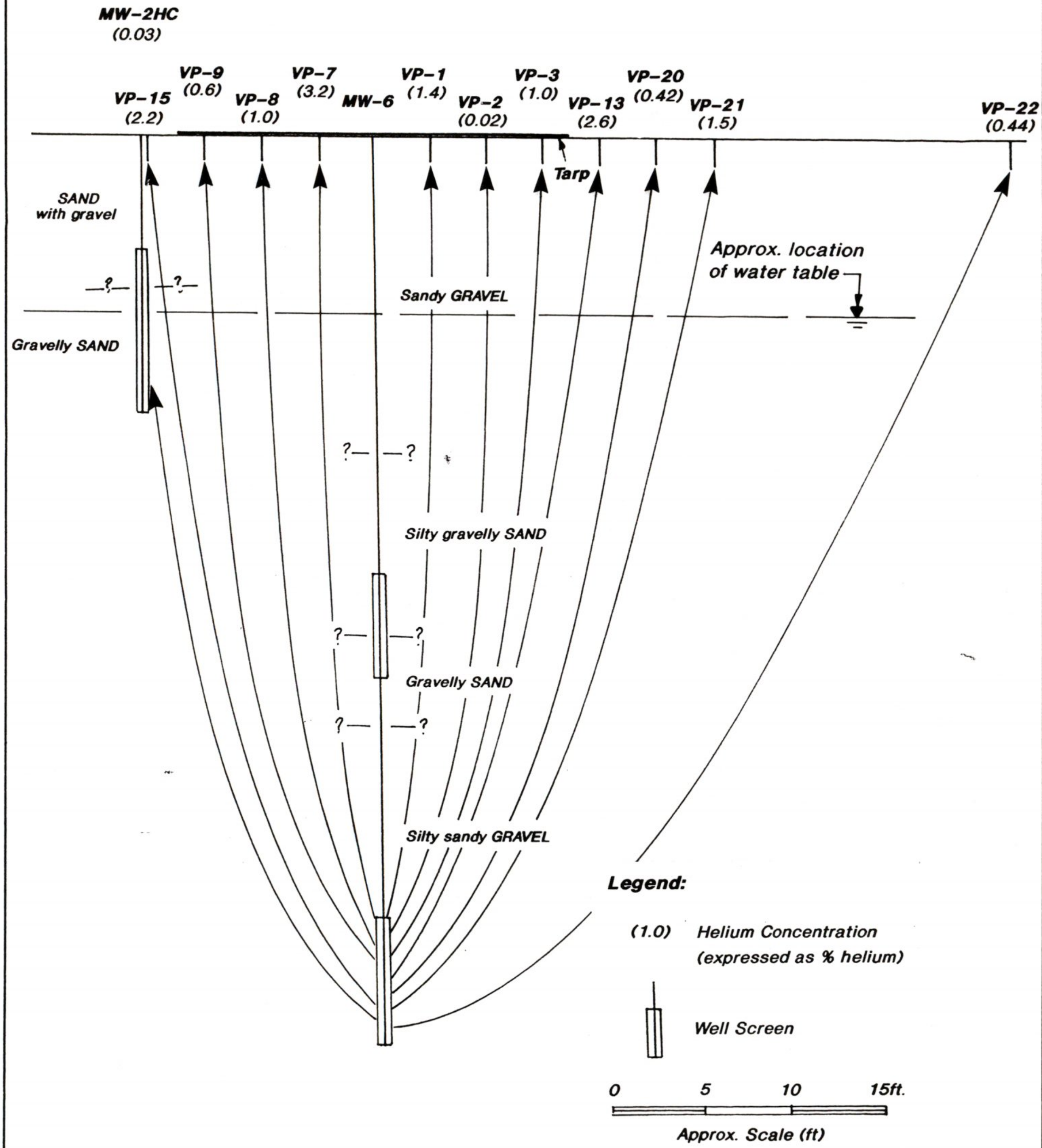
CONCEPTUAL DIAGRAM OF AIR AND HELIUM FLOWPATHS – 30 FOOT WELL

Figure **4**



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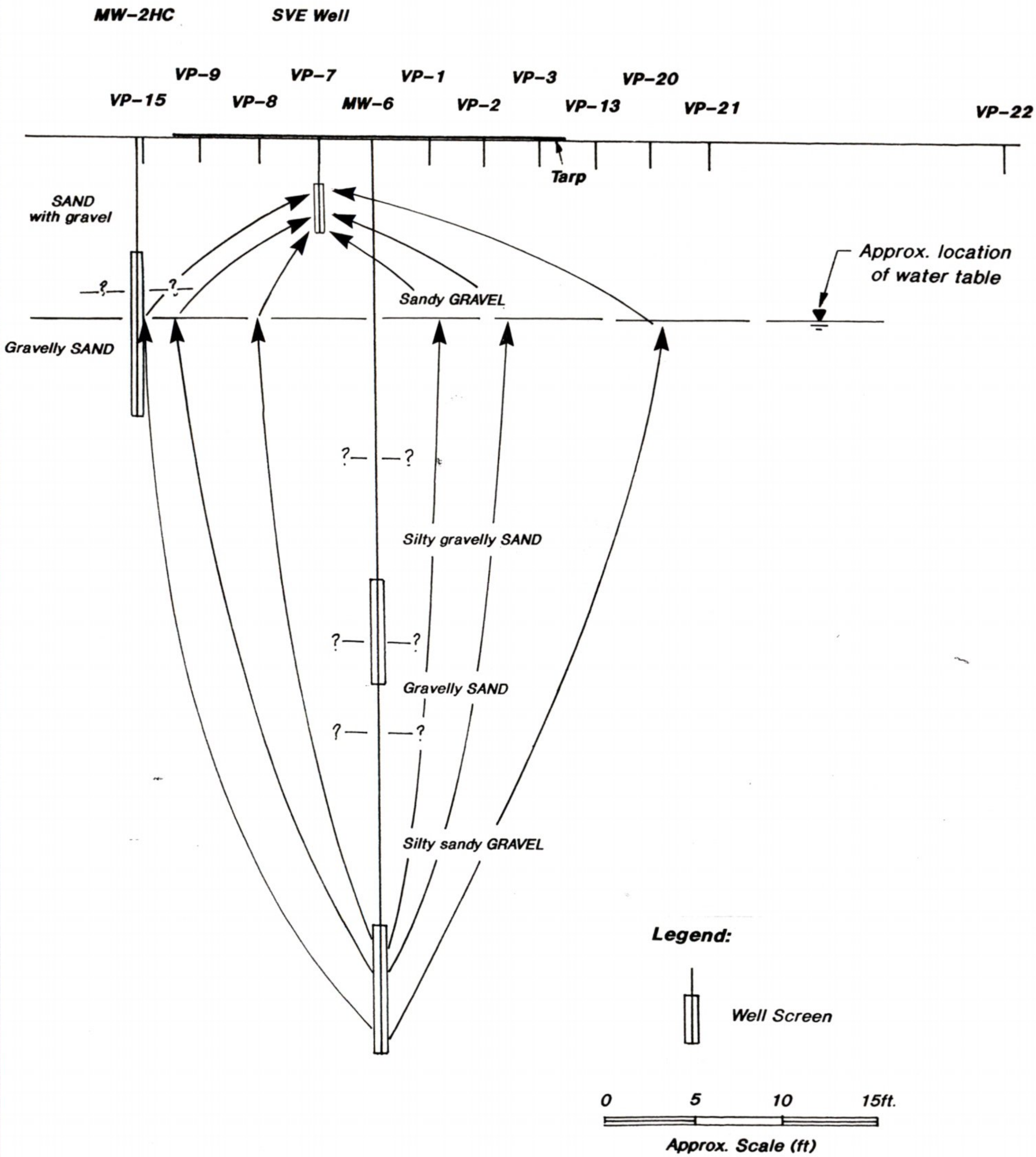
CONCEPTUAL DIAGRAM OF AIR AND HELIUM FLOWPATHS – 50 FOOT WELL

Figure 5



Project No. 962-1853 Drawn BAD Reviewed J.H. Date Aug. '98

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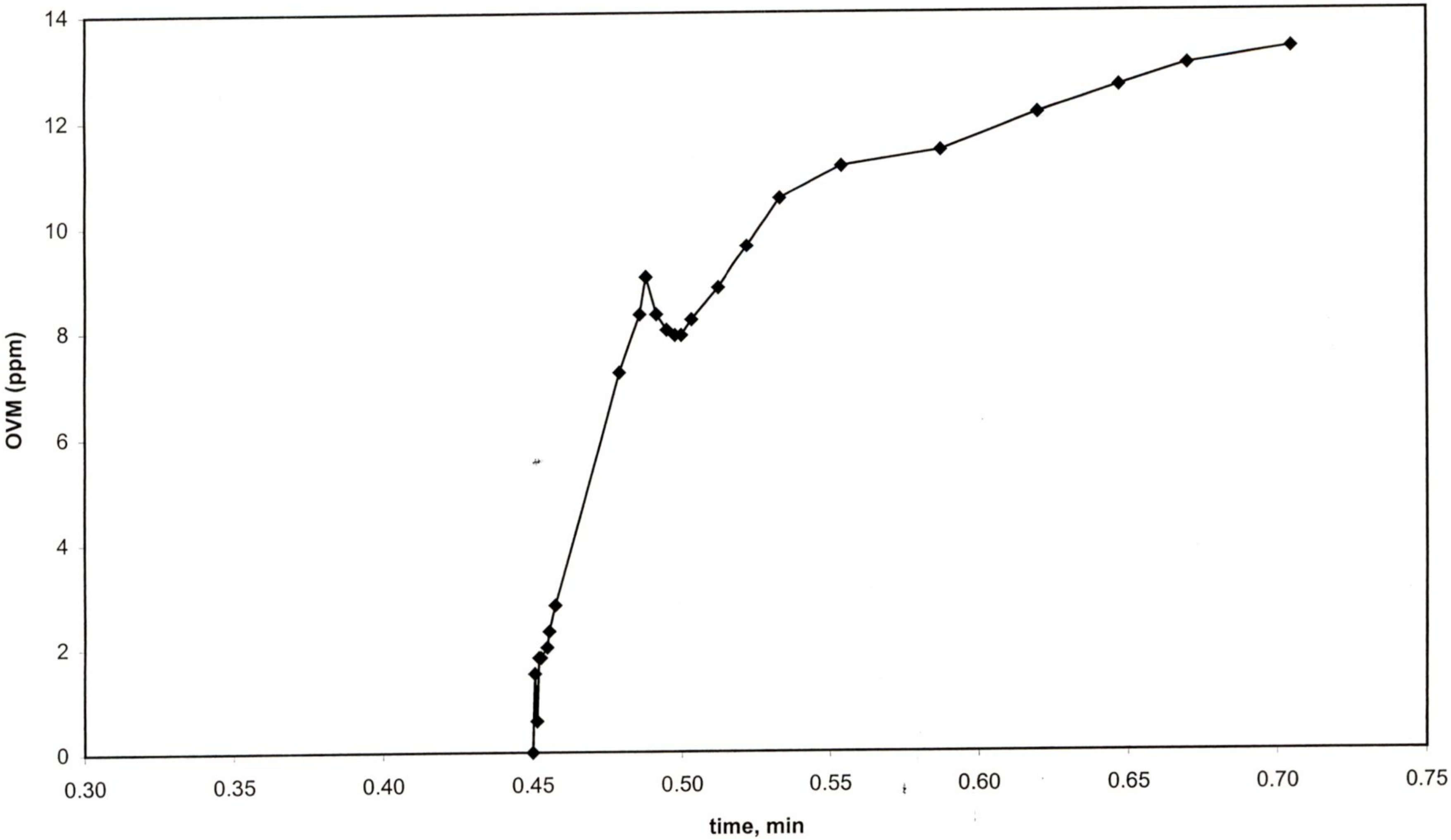
CONCEPTUAL DIAGRAM OF AIR AND HELIUM FLOWPATHS – 50 FOOT WELL TO SOIL VAPOUR EXTRACTION WELL

Figure 6

MW97-1
Organic Vapor Concentration vs. Time



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