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# Characterization Report to Support the Phytoremediation Efforts for Southern Sector, Savannah River Site, Aiken, South Carolina



by
K. M. Jerome
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

J. L. Simmons

D. G. Jackson

B. B. Looney

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## SUMMARY

In February, 1999, we conducted a small-scale characterization effort to support future remediation decisions for the Southern Sector of the Upper Three Runs watershed. The study concentrated on groundwater adjacent to the seepline at Tim's Branch above and below Steed's Pond. The primary compounds of interest were the volatile organic contaminants (VOCs), trichloroethylene (TCE) and tetrachloroethylene (PCE). Due to the site topography and hydrogeology, samples collected north of Steed's Pond were from the M-Area (water table) aquifer; while those locations south of Steed's Pond provided samples from the Lost Lake aquifer. Results of the study suggest that the leading edge of the A/M Area plume in the Lost Lake aquifer may be approaching the seepline at Tim's Branch below Steed's Pond, south of Road 2. Neither TCE nor PCE were detected in the samples targeting the seepline of the water table aquifer. The concentrations found for both TCE and PCE associated with the Lost Lake aquifer outcrop region were slightly above the detection limit of the analytical instrument used. The findings of this study are consistent with the conceptual model for the organic contaminant plume in the A/M Area of the Savannah River Site (SRS) -- the plume in the Southern Sector in known to be depth discrete and primarily in the Lost Lake Aquifer. The sites with detected VOCs are in the most upstream accessible reaches of Tim's Branch where water from the Lost Lake Aquifer crops out. Additional characterization efforts should be directed near this region to confirm the results and to support future planning for the dilute-distal portions of the A/M Area plume. These data, combined with existing groundwater plume data and future characterization results will provide key information to estimate potential contaminant flux to the seepline and to assess the effectiveness of potential clean-up activities such as phytoremediation.

## BACKGROUND

*Goal*: To determine if contaminants (TCE, PCE) are present in groundwater adjacent to the seepline at Tim's Branch.

*Conceptual Model*: The shallow groundwater zones (i.e., M-Area and Lost Lake Aquifers) in A/M Area discharge to the seeplines adjacent to Tim's Branch and Upper Three Runs creek. The bulk of the chlorinated solvent plume in A/M Area is located in these aquifer zones. Source control and remediation is currently being addressed using conventional pump & treat technologies coupled with vertical recirculation wells to address those portions of the plume that are greater than 500 ppb TCE. To address the low concentration, high volume portion of the plume that exists between the deployed recirculation wells and the plume boundary, less aggressive clean up methods such as phytoremediation technologies are planned. These technologies utilize reductive dechlorination and/or uptake/destruction processes that are provided in the root zone of certain species of trees. These species can either be indigenous to the ecosystem or introduced and managed based upon the influx of contaminants. Due to the location of the regional drainages and elevated topography, A/M Area is characterized by a strong downward gradient with most of the flow in the M-Area Aquifer moving vertically into the Lost Lake Aquifer. As the plume migrates towards the south in the Lost Lake aquifer, the contaminated interval is present in the lower portion of the Lost Lake Aquifer. This aquifer outcrops towards the southeast along Tim's Branch and along Upper Three Runs creek to the south. This outcrop occurs in regions where the Green Clay confining unit is eroded and is consistent with the southward and eastward decrease in topography observed in A/M area. Figure 1 illustrates the groundwater flowpath associated with typical flow near a seepline. To effectively assess and implement phytoremediation efforts, it is necessary to collect preliminary samples at locations that provide data on the delivery of the plume, but that are not already significantly influenced by the root zone (rhizosphere). Non-conservative contaminants, such as TCE and PCE, in the root zone can be broken down or taken up by the plants/tree. For example, Walton and Anderson (1990), documented degradation of $^{14}C$ labeled TCE in SRS soils by microorganisms associated with root zones of native pine trees. Thus, groundwater concentration data collected within the root zone alone will not provide sufficient measure of the presence of contaminants and whether the location is appropriate to conduct phytoremediation efforts. If samples are clean, it is not possible to say whether the plume has not arrived, or if the contaminants were destroyed or removed.

## FIELD ACTIVITIES

*Initial Activities to Identify Sampling Strategy*: An initial reconnaissance was made on January 8, 1999 in the area immediately above and below Steed's Pond. The area selected was based on the proposed location identified by the Environmental Restoration Department and by data available on the area where the Green Clay does not exist. Visual inspection of the area indicates that south of Steed's Pond the Green Clay is not present. This area is very sandy, similar to the materials of the lower Lost Lake aquifer and the surface elevation is consistent with the elevation of this aquifer. Thus, it can be concluded the groundwater outcropping at the seepline would be from the Lost Lake aquifer. Based on the surface elevation and the soils present at locations immediately above Steed's Pond it is concluded the Green Clay is present in this area and that water outcropping to the seepline would be from the water table aquifer and not the Lost Lake aquifer. Based on this reconnaissance and the information that TCE and PCE would be present in the Lost Lake aquifer, sampling locations were chosen as follows: four locations above Steed's Pond and seven locations below Steed's Pond south of Road 2. These locations are shown in Figure 2. The sample locations were selected near the toe of the escarpment leading to a broad relatively flat floodplain adjacent to the creek. While such topography is ideal for possible phytoremediation, groundwater collected from the selected sites would be relatively unimpacted by the root zone of the native trees in the floodplain. The locations above Steed's Pond are approximately 100 feet apart; while the locations below Steed's Pond are approximately 300 feet apart.

*Collection of Water Samples*: Field activities were initiated on February 9, 1999 and were completed on February 23, 1999. Samples were collected in an area where depth to groundwater is approximately 5 feet. The samples were collected at eleven locations at depths of 15 and 20 feet. This allowed collection of samples in an area approximately 50-200 feet from the actual seepline. At most locations, a wooded

terrestrial ecosystem is present between the sample location and the seepline/stream. Further, this sampling strategy allowed collection of water from below the root zone and thus maximized the probability of detecting plume arrival without confounding effects of destruction or uptake. We collected water samples using a small track mounted coring rig provided by Gregg In Situ. The rig was used to push the core barrel similar to CPT and was also capable of vibrating the core barrel. Attached ahead of the core barrel is a sampling tool that consists of a solid tip and a retractable sleeve. Upon reaching the desired depth the sleeve is pulled back allowing water from the adjacent zone to enter the chamber where it is removed using a 0.5 inch bailer. Seven and a half milliliters (7.5ml) of sample are transferred into 22 ml headspace vial and sealed with a crimped septum top. Duplicate samples are collected at each depth for all samples. Ten percent (10%) of the duplicate samples are analyzed as a quality control check. Samples are kept on ice while in the field and transferred to a refrigerator at the end of each day.

*Analysis of Samples*: Each water sample is analyzed on a HP 5890 Series gas chromatograph (GC) equipped with flame ionization detector (FID) and electron capture detector (ECD). Equilibrated headspace gas is sub-sampled and transferred to the GC using an automated headspace sampler. Equivalent water concentrations are calculated using the appropriate detector (ECD for low concentrations, FID for high concentrations). The gas chromatograph is calibrated using certified solvent mixtures in methanol diluted to specific concentrations. Standard concentrations used are 3, 5, 10, 50, 250, 500, and 1000 ppb (µg/l). The standards are analyzed for vinyl chloride, freon-11, freon-113, 1,1-DCE, trans-DCE, cis-DCE, 1,1,1-TCA, $CCl_4$, TCE, and PCE.

**RESULTS**

Table 1 provides the analytical results of the water samples collected for this study. The results measured the presence of TCE and PCE near the detection limits of the analytical equipment (0.001 ppm) in two locations (sample locations 5 and 6) which are adjacent to each other at elevations between 161 ft msl and 151 ft msl. 1,1,1-Trichloroethane was also identified, but not quantified, at these two locations. These locations, as shown in Figure 2, are below Steed's Pond south of Road 2 in soils that based on observation and depth would indicate the Lost Lake aquifer. No VOC compounds were identified at the other 9 sampling locations. Hydrocarbons of low molecular weight were detected but not quantified by the FID. These compounds were not detected by the ECD.

**DISCUSSION:**

The area where this study was conducted is a minimally disturbed area. The only infrastructure into the area is a dirt road than runs adjacent to all sampling locations, a single well cluster, MSB50, and a power line. We chose the small track-mounted vehicle over the conventional drill rigs or CPT truck because we wanted to minimize any impact to this area from our activities. Figure 3 is a photograph of one of the sample locations. From the photo it can be seen that the small track-mounted vehicle can set up at the locations with minimal disturbance to the site. This was the case for all the locations. All locations were heavily vegetated, except for location 5 that was located adjacent to the dirt road, as shown in Figure 2.

The results of the GC analysis indicate concentrations of TCE and PCE near the detection level of the GC being used. The presence of trace TCA was also indicated, but was not quantified. Dichloroethene (DCE), a compound indicative of reductive dechlorination of TCE and PCE, was not identified in any of the samples. Also seen in the chromatographs were peaks indicating hydrocarbon compounds generated from organic breakdown of plant/vegetative matter, as would be expected in marshy, wetland type areas. The presence of hydrocarbons indicates a carbon source, if for instance co-metabolic processes were chosen as part of the treatment system.

The sampling locations are in the water table aquifer (samples SSL-1 through SSL-4) and in the Lost Lake aquifer (samples SSL-5 through SSL-11). Samples SSL-5 and SSL-6 were the ones in which TCE, PCE and TCA were identified. These sample points are in the most upstream accessible reaches of Tim's Branch where the Lost Lake aquifer is expected to crop out. No VOC contaminants that our method analyzes for were detected in the water table aquifer samples. The presence of TCE and PCE at such low levels may indicate the leading edge of the groundwater plume is reaching the seepline. Figure 4 is one

possible representation of the movement of the plume towards the seepline in the Lost Lake aquifer. Confirmatory sampling should be conducted to verify this finding.

Table 1. Analytical Results of Water Samples Collected for Characterization of Groundwater Adjacent to Seepline for Tim's Branch Located Adjacent to Steed's Pond

| Sample ID | Elevation (ft msl) | Water Concentration (ppm) | | | Compounds Identified but not Quantified |
|---|---|---|---|---|---|
| | | TCE | PCE | DCE | |
| SSL-0101 | 196 | <0.001 | <0.001 | <0.001 | |
| SSL-0102 | 191 | <0.001 | <0.001 | <0.001 | |
| SSL-0201 | 194 | <0.001 | <0.001 | <0.001 | |
| SSL-0202 | 189 | <0.001 | <0.001 | <0.001 | |
| SSL-0301 | 196 | <0.001 | <0.001 | <0.001 | |
| SSL-0302 | 191 | <0.001 | <0.001 | <0.001 | |
| SSL-0401 | 196 | <0.001 | <0.001 | <0.001 | |
| SSL-0402 | 191 | <0.001 | <0.001 | <0.001 | |
| SSL-0501 | 161 | **0.001** | **0.002** | <0.001 | Trichloroethane (1,1,1-TCA) |
| SSL-0502 | 156 | <0.001 | <0.001 | <0.001 | |
| SSL-0601 | 156 | **0.002** | **0.004** | <0.001 | Trichloroethane (1,1,1-TCA) |
| SSL-0602 | 151 | **0.002** | **0.005** | <0.001 | Trichloroethane (1,1,1-TCA) |
| SSL-0701 | 156 | <0.001 | <0.001 | <0.001 | |
| SSL-0702 | 161 | <0.001 | <0.001 | <0.001 | |
| SSL-0801 | 165 | <0.001 | <0.001 | <0.001 | |
| SSL-0802 | 160 | <0.001 | <0.001 | <0.001 | |
| SSL-0901 | 158 | <0.001 | <0.001 | <0.001 | |
| SSL-0902 | 153 | <0.001 | <0.001 | <0.001 | |
| SSL-1001 | 158 | <0.001 | <0.001 | <0.001 | |
| SSL-1002 | 153 | <0.001 | <0.001 | <0.001 | |
| SSL-1101 | 162 | <0.001 | <0.001 | <0.001 | |
| SSL-1102 | 157 | <0.001 | <0.001 | <0.001 | |

## REFERENCES

Walton, B. T. and T. A. Anderson, 1990, *Applied and Environmental Microbiology*, 56:1012-1016. See also: Anderson, T. A. and B. T. Walton, 1992, *Comparative Plant Uptake and Microbial Degradation of TCE in the Rhizospheres of Five Plant Species: Implications ofr Bioremediation of Contaminated Surface Soils*, ORNL/TM-12017, Oak Ridge National Laboratory, Oak Ridge TN.

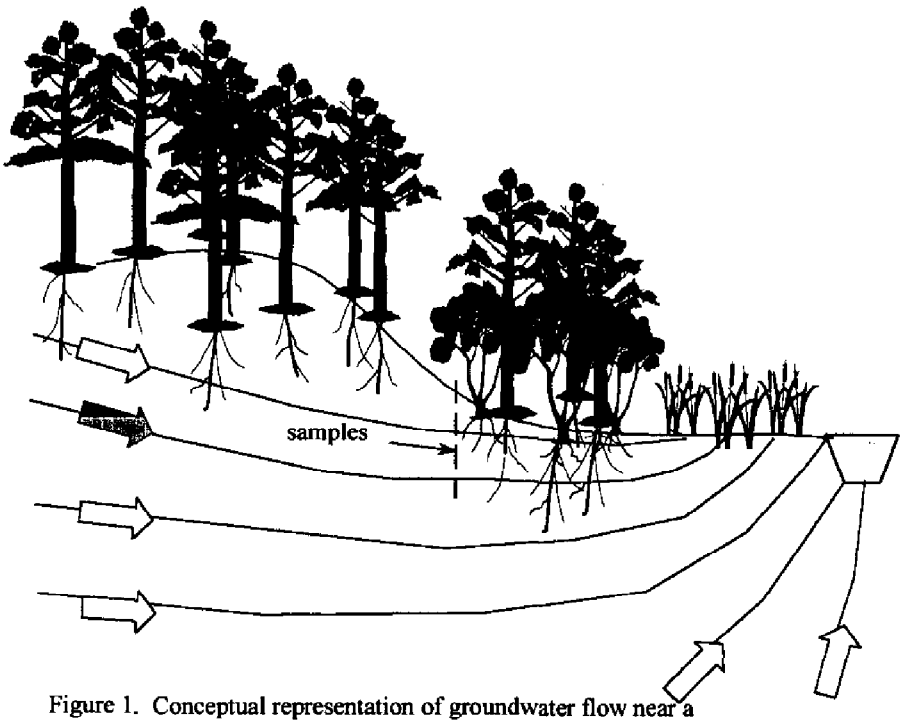


Figure 1. Conceptual representation of groundwater flow near a seepline. (Drawing not to scale.)

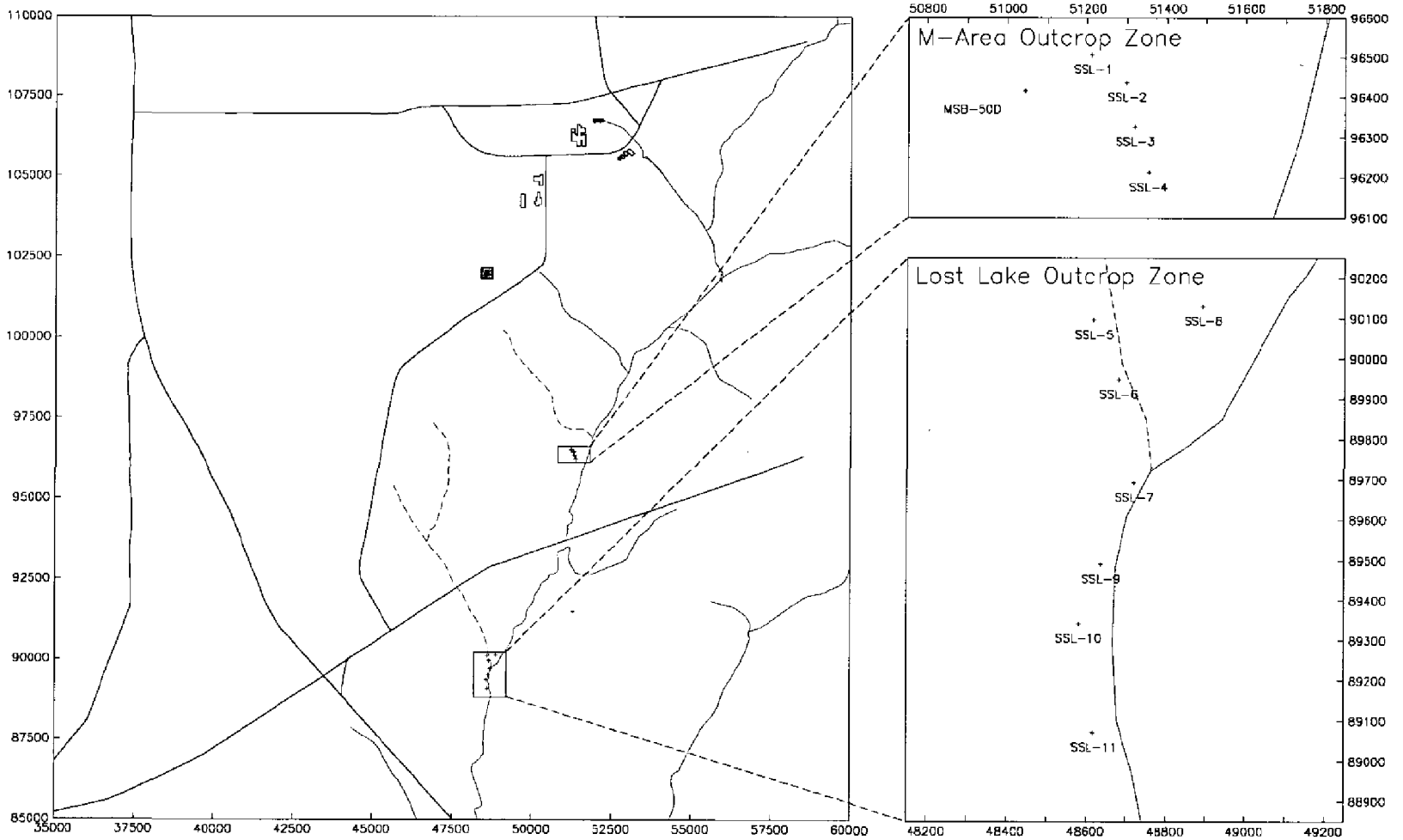


Figure 2: Location of Southern Sector Seepline Samples

Figure 3: Geo-Track Rig being used to Collect Water Samples near Projected Outcrop Regions along Tim's Branch

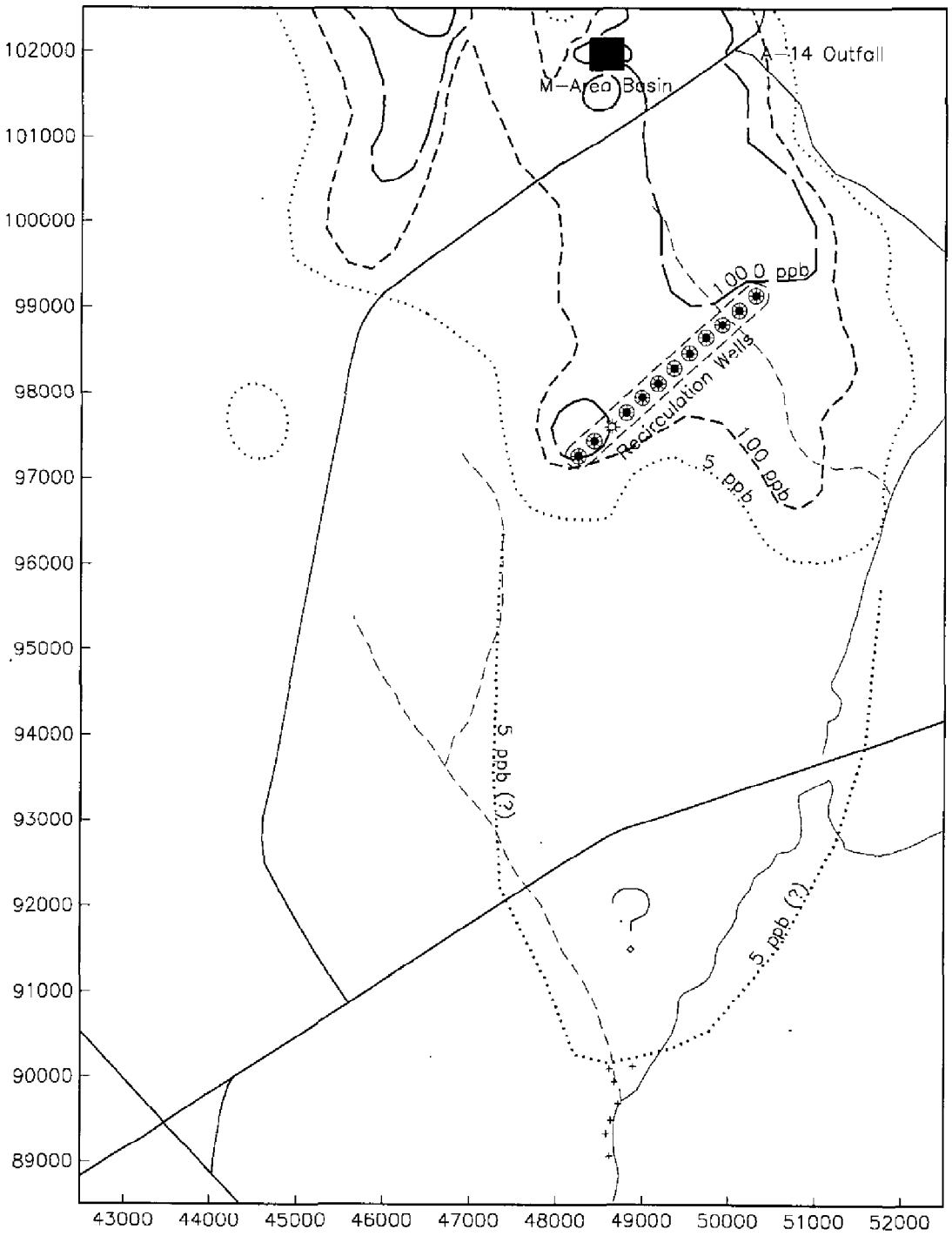


Figure 4: Conceptual Lense of TCE in the Lost Lake Aquifer.

# APPENDIX A

## Sampling Location Coordinates

Table A-1. Coordinates for Southern Sector Seepline Characterization Study

| | Site Coordinates | |
|---|---|---|
| Sample ID | Northing | Easting |
| SSL-1 | 96506.4 | 51210.8 |
| SSL-2 | 96437.0 | 51298.3 |
| SSL-3 | 96326.2 | 51318.7 |
| SSL-4 | 96212.4 | 51353.8 |
| SSL-5 | 90097.0 | 48617.9 |
| SSL-6 | 89948.8 | 48679.6 |
| SSL-7 | 89693.3 | 48720.2 |
| SSL-8 | 90130.7 | 48892.4 |
| SSL-9 | 89491.1 | 48636.9 |
| SSL-10 | 89342.8 | 48582.0 |
| SSL-11 | 89071.8 | 48618.1 |