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Environmental Restoration Program

OPERABLE UNIT 1
REMEDIAL INVESTIGATION REPORT

MOUND PLANT
MIAMISBURG, OHIO

Volume I – Text

May 1994

Final

U.S. Department of Energy
Albuquerque Operations Office

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U.S. DOE MOUND PLANT
RI/FS
OPERABLE UNIT #1, AREA B
REMEDIAL INVESTIGATION REPORT
NOVEMBER 1993

U.S. EPA COMMENTS

GENERAL COMMENTS

1. Section 4 is extremely lengthy and contains a large of information, including data. This section is difficult to follow, especially Section 4.3. Can the most appropriate information be included in this section, rather than all available information.

   We agree that Section 4 is lengthy and contains a large amount of information. Very little of the basic data from the OU 1 Additional Field Work is published elsewhere, so it must be incorporated into the RIR in some manner. For the Draft, we had attempted to move all possible data to the appendices to improve readability. For the Draft Final, we have reorganized section 4.2, further simplified section 4.3 and moved additional data to the relevant appendix.

2. Section 4.4.2 doesn't take into account the effect of pumping in the Buried Valley aquifer and VOC movement.

   Section 4.4 discusses the potential for contaminant movement based upon the physical characteristics of the media, the physical characteristics of the chemical and the integration of the two into section 4.4.3 on the rate and direction of migration. The titles of the three subsections have been revised for clarity and a discussion of the objectives of the subsections have been placed in the introductory paragraph of section 4.4. The effect of pumping on the movement of the contaminants has been taken into account because the groundwater velocity and direction of movement are estimated using water levels that are a result of the long-term pumping in the Buried Valley aquifer.

3. The decay of radioactive isotopes into daughter products, resulting in subsequent contamination, has not been included addressed in the report or considered as a secondary release mechanism in developing a conceptual pathway model.

   Additional text has been added stating that the daughter products of radionuclides detected in Area B media can pose additional risks to potential future receptors. The risks from radionuclide daughter products were assessed using slope factors with the +D designation. Slope factors with a +D designation address the risks of both the parent radionuclide and its decay products in the various exposure pathways.

3. Units of Measure
   page xii
   Include the definition for "pg/g".

   The addition has been made.

SPECIFIC COMMENTS

1. Section 1.1.2, page 1-7, paragraph 2.

A typographical error exists in the reference to the RCRA regulated underground storage tank regulations. The correct citation should be "Subtitle I".

The correction has been made.

2. Figure 2.4, page 2-20.

The Area B boundary lines shown do not match other figures included in the report. Is Area B intended to extend as far south as Saxony Road or is the figure not to scale?

The figure has been redrafted to scale.

3. Section 2.2.6.3, page 2-24, paragraph 1.

The municipal or production well identified as Well 0912 is located east of the Great Miami River. The remaining four Miamisburg municipal wells are located west of the river.

The text has been modified to correctly identify <u>four</u> municipal wells in the well field on the west bank of the river. A paragraph has been added clarifying the nature of well 912 (old Miamisburg No. 2).

4. Table II.3, page 2-22.

This table refers to Production Well numbers, while the text usually refers to the same wells as 0071, 0271, 0076. For consistency and ease in reading, the table should also include the four digit number associated with Production Wells 1, 2, and 3.

Both designations for the Mound Plant production wells have been inserted in the table.

5. Table II.4, page 2-23.

The table should be titled ". . . On-site <u>Production</u> Wells . . .". Also, see above comment.

The corrections have been made.

6. Figure 4.2, page 4-4.

Four Miamisburg municipal wells have been included on the figure. However, page 2-18 states there are five municipal wells. Shouldn't the figure also include municipal well 0912? Please define "Ram Gauge".

See response to Specific Comment 3, above. Also, the misspelling of "<u>rain</u> gauge" has been corrected.

7. Section 4.2.2, page 4-16, paragraph 2.

The WESTON ditch has not been shown on Figure 4.11. What is the WESTON ditch and where is it located, to the west or south of the sanitary landfill?

The misspelling of the word "western" has been corrected.

8. Section 4.2.2, page 4-16, paragraph 3.

The french drain discussion is unclear. Page 4-48 provides a better description. Please clarify the paragraph.

The paragraph has been rewritten, using the language from page 4-48.

9. Table IV.2, pages 4-22 - 4-24.

A key has not been included as part of the table to define abbreviations used or superscripts.

The requested data has been added to the table.

10. Section 4.2.3, page 4-36, Table IV.4.

Why was well 0912 included for aquifer parameter analysis if well characteristics are unknown? Is this well the same well previously identified as a municipal well?

Well 0912 is the old Miamisburg Well 2. Although construction data are unknown, the well was used during the aquifer test analysis for three reasons: 1) it was monitored prior to the start of the aquifer test, 2) it was the most northern well to show the effect of pumping during the aquifer test, and 3) it was along a north-south transect through the Buried Valley aquifer. Of the wells in the area, it had the largest drawdown with time. Although the well construction information is not known, it is known to be about 50 feet deep. Thus, it is probably safe to assume that the well is completed in the Buried Valley aquifer and that it is not fully penetrating. Data from other nearby wells were not used because the data were either noisy or the well was not monitored prior to the onset of the aquifer test. Two examples are P007 and P014. The data in P007, a nearby well with similar response, was very noisy. P014 responded in a similar fashion as 0912, but P014 was not monitored prior to the start of the aquifer test.

11. Section 4.2.3, page 4-38, paragraph 5.

The narrative states that "screened lithologies and lengths, and formation of completion" are included in Table IV.5. This information is not present in the referenced table.

The sentence has been corrected.

12. Section 4.2.3, page 4-38, paragraph 7.

Figures G4a-G4n are located within Appendix G, not Appendix E, as listed.

The correction has been made.

13. Section 4.2.3, page 4-42, paragraph 1.

It is unclear why all 13 wells referenced in Table IV.4 were not included in the drawdown analyses, but several additional wells were included. What criteria were used to select the wells used in the drawdown analyses?

A distance-drawdown analysis uses wells located along a transect at different distances away from the pumped well. Not all of the 13 wells used for the Theis analyses were located along the transects. Because the thickness of the Buried Valley aquifer changes with direction (thicker toward the west and south and thinner toward the east and north), the distance drawdown analyses were oriented in specific directions using wells completed in like material.

For example, P042 is completed in bedrock. Using this well in the distance drawdown analysis would not provide a reasonable picture of the drawdown with distance in the Buried Valley aquifer. The text will be revised to explain the rationale applied in selecting the wells used in the distance-drawdown analyses.

14. Figure 4.25, page 4-59.

It is difficult to distinguish between individual symbols used on the graph. Please enlarge the symbols located on the plot or use more distinctive symbols.

The figure has been redrafted.

15. Figure 4.27, page 4-61.

See previous comment.

The figure has been redrafted.

16. Section 4.3.1, page 4-98, paragraph 4.

Dioxin and furan equivalent toxicities (2,3,7,8-TCDD equivalents) as calculated for the soil samples referenced here, should not be compared to MCL levels. Delete the last sentence in this paragraph.

The sentence has been deleted.

17. Section 4.3.2, page 4-103, last paragraph, Figure 4.40 - page 4-105.

Well 0378 has a listed concentration of 1,1,1-trichloroethane of 13 µg/L, while Figure 4.40 has a listed concentration of 18 µg/L for this location. Both are estimated values (J), which are qualified data, not non-qualified as stated. Data for well 0376 has not been included as qualified data in the narrative. Please correct the discrepancy.

Text has been modified, correcting the value for well 0378 and including qualified data for both wells 0376 and 0377 in section 4.3.2 Additional text was added in section 3.5.4.4, volatiles, further explaining the values reported. Corrections were also made to the database printout in Appendix A7.

18. Section 4.3.2, page 4-106, paragraph 1, Figure 4.41 - page 4-107.

Well 0374 has a listed level of 1,2-*cis*-dichloroethene of 48 µg/L in the narrative, but 30.0 µg/L is listed on Figure 4.41. Please review and correct.

Figure 4.41 has been corrected.

19. Section 4.4, page 4-137, paragraph 1.

Please include a summary table for the four VOC concentration levels noted during the March 1993 groundwater sampling. The text indicates that four VOCs were above regulatory limits. The summary table should also include the proposed or established regulatory levels.

A summary table comparing VOCs detected in the March 1993 sampling event with regulatory levels has been added in Section 4.4. During review of the data, it was noted that <u>five</u> VOCs actually exceeded regulatory levels.

20. Section 4.4.1, page 4-137, Heading.

A typographical error exists in the heading. It should read VOC rather than VDC.

The correction has been made.

21. Section 5.1, page 5-3, Figure 5.2.

A typographical error exists, creating a discrepancy between the Legend (Current Worker) and the chart (Future Worker). Please correct.

The correction has been made.

22. Section 5.1, page 5-4, paragraph 5.

Incidental ingestion of surface water is a potential exposure route which has not been included.

This pathway is now mentioned in this paragraph.

23. Section 5.2, page 5-4, paragraph 6.

The report does not include a list of "naturally occurring levels" to be used comparably with contaminant levels observed in OU 1. A summary table should be included which lists observed concentrations and regulatory limits or proposed limits, as well as regional background levels (since site-specific information is unavailable). This will allow the reader to see the criteria used to determine potential chemicals of concern. The report should be amended when regional and site-specific background levels are available for comparison.

A list of values utilized has been included. Further, we are now utilizing background data from Fernald. This should be an improvement over national values.

24. Section 5.2.2, page 5-6, paragraph 2.

MCLs are not appropriate for comparison purposes in determining whether a chemical constituent should be used in the baseline risk assessment. The cumulative effect of a number of chemical constituents may result in a risk number which differs from the MCL. MCLs are not necessarily risk-based numbers, but are regulatory requirements (ARARs). Please reevaluate the criteria used for determining potential chemicals of concern.

We agree. Newly available preliminary data from the OU 9 groundwater sweeps have been utilized.

25. Section 5.2.2.

The section contains only two paragraphs which pertain to radionuclides present in groundwater. A more thorough discussion of all radionuclides detected should be included.

A more expansive and thorough discussion has been included.

26. Table V.3, page 5-12.

Most of the radionuclides do not have MCLs or MCLGs. As indicated the previous comment, neither of these regulatory numbers should be used in eliminating chemical constituents from the baseline risk assessment. Please reevaluate the observed radionuclides for use in the

baseline risk assessment. 20 pCi/L is the proposed MCL for Ra-226. Please revise or list the current MCL.

Agreed. We have used the recently-available OU 9 groundwater sweeps data as substitutes.

27. Table V.4, page 5-13.

Are the daily intake and human toxic intake levels included in the table for adults only? The dietary intake range for chromium appears to have a typographical error (28-0.29?). Please correct.

For the revised risk assessment, daily intake of essential nutrients were compared to daily nutritional ranges. These daily nutritional ranges were taken from the following source: Recommended Dietary Allowances, Tenth Edition, 1989, National Research Council, National Academy Press. The daily nutritional ranges are for adults.

28. Section 5.2.2, page 5-14, paragraph 3.

A soil boring of 0 - 6 feet in depth appears unrealistic and may be causing a "dilution" value to result. The assumption that surficial plowing and erosion reach a depth of 6 feet also is unreasonable. Is information from a shallower depth available for use?

The exposure calculations do not explicitly utilize depth of the soil column to calculate exposure. Thus, there should be no dilution. The six-foot depth was selected in accordance with Ohio guidance during the time that the Site-Wide Risk Analysis for preliminary remediation goals was being developed. The operative result is that our list of contaminants of concern is longer.

The use of 6 feet of soil depth is considered conservative because chemical levels were generally found to be higher at depths below 18 inches. In addition, chemicals that were not detected in surface soils were detected at deeper depths. Thus, the number of chemicals detected within the top 6 feet of soil is larger than the total number detected in the surface soil which resulted in a larger COPC list. The 6-ft soil risk levels were also found to be higher than those for surface soils.

While it may appear to be a good idea to eliminate elements which occur at concentrations less than natural background averages, site-specific and regional background values remain unknown. Site-specific information could differ markedly from national values. The text states that soil concentrations were compared to national averages, although the table refers to the 95% UCL value as a comparison point. It is possible to calculate risks for elements which are below "background" levels and these values could be determined now and compared to more site-specific data at a later date. How does this approach deal with potential "hot spots", if only averages are used?

The revised risk assessment incorporates site and regional background data that have become available. The background comparison consists of two parts: 1) comparison of Area B maximum concentrations with Mound or regional background ranges; and 2) statistical comparisons of Area B concentrations with available background data using the T-Test and the Mann-Whitney Test. It should be noted that the background comparisons will not be performed for anthropogenic compounds.

29. Table V.5, page 19.

The maximum detection concentration for plutonium-238 was listed as 8.8 pCi/g. This conflicts with information in the Executive Summary (end of pages ES-10 and ES-11) which states that a subsurface sample had a concentration of 17.1 pCi/g. Please clarify.

The 17.1 pCi/g. measurement was from below the 6-ft depth of interest.

30. Table V.7, page 5-21.

Isn't Table V.7 a summary of elements which were eliminated based on the comparison to national values? The last sentence on page 5-14 (text for the table) should be revised to include Cesium-137 and radium-226. What is reported in the last column?

The table has been revised. A comparison of Area B radionuclide soil concentrations to soil background levels reported in Fernald, Ohio, is included. The geological characteristics of Fernald are similar to those of Mound Plant, and Fernald is located near the Mound Plant.

31. Section 5.2.3, page 5-22, paragraph 3.

Radium-226 should also be included as a contaminant of potential concern in groundwater. See comment #26.

Agreed. Radium-226 was found to be a levels that are above OU 9 background. As a result, radium-226 has been included as chemical of potential concern.

32. Section 5.3.2, page 5-26, paragraph 3.

A future industrial worker may also have dermal contact with soil. Outdoor maintenance workers should be considered.

Dermal exposure will be incorporated into the future worker scenario.

33. Tables V.10, V.11, V.12, + V.13, pages 5-30 - 5-34.

Garden produce parameter values have not been included. Were separate values used for the soil-root ratio and soil-plant ratio? Actual values used to represent these parameters should be included.

Garden produce parameters will be incorporated in the revised risk assessment.

34. Section 5.3.3.1, page 5-31, "Where" definitions and abbreviations.

IR_8 - Ingestion rate of leafy vegetables (kg/day) should be IR_1.

The table will be so modified.

35. Table V.15, page 5-36.

PCD or properties of contaminated dust in the radionuclide equation is not a variable which appears in RAGS, Part B. It is also not explained in the text. How was the value of 0.8 assigned? Please clarify.

PCD is defined as proportion of contaminated dust. The value of 0.8 is used for indoor particulate inhalation, while a value of 1.0 should have been incorporated into the table for

outdoor particulate inhalation. These parameter values were taken from the following reference: Hawley, J.K. (1985). "Assessment of Health Risk from Exposure to Contaminated Soil." Risk Analysis, 5, 289. This table has been modified to incorporate this information.

The intake rate for industrial worker's air is half the recommended value in RAGS, Part B, which recommends 20 m^3. Please clarify.

The breathing rate for industrial workers in the reasonable maximum exposure scenario was set at 1.25 m^3/hour, which translates to 30 m^3/day. The 20 m^3/day breathing rate listed in RAGS is based on a 24-hour day, not an 8-hour work day. Breathing 20 m^3 of air in an 8-hour period would translate to a breathing rate of 2.5 m^3/hour. This breathing rate is approximately 2 times higher than the suggested upper bound adult value of 1.25 m^3/hour (30 m^3/day) as defined in the Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Volume 1, Part A.

36. Section 5.3.3.1, pages 5-37 - 5-39.

Please include a table which lists adjusted air concentrations of volatile chemicals found in groundwater. A detailed set of equations is given.

These tables are too large to place in the risk assessment section of the RI report since many exposure pathways and COPC exposure concentrations were evaluated. Instead, tables of the exposure concentrations computed using the exposure calculation presented in Section 5 are presented with the Risk Assistant output in Appendix I of the RI report.

37. Table V.24, page 5-49.

The external radiation slope factors for plutonium-239 and plutonium-240, as noted in HEAST, are not the same. The slope factor for the former is 1.7×10^{-11}. The slope factors for uranium-236 are not listed, but uranium-236 is used in the risk tables, with the slope factors for uranium-235. Include uranium-236 in this table if it is to be used in risk calculations.

The slope factors for plutonium-239, plutonium-240, uranium-235, and uranium-236 will be incorporated into the table. It should be noted that the most conservative slope factors were used for computing the plutonium-239/240 and uranium-235/236 risks.

38. Section 5.5.2, pages 5-53 - 5-60, Risk Result Tables.

a) Cancer risks should be modified to one significant digit.

The table has been so modified.

b) An NA designation has been assigned to external radiation risks for most of the radionuclides in most of the scenarios, without explanation. Why have risks not been calculated?

Certain exposure pathways were not applicable for a COPC depending on the medium that it was contained in. For example, inhalation of plutonium-238 in groundwater cannot occur since plutonium-238 does not volatilize.

c) Spot checks, conducted by U.S. EPA's contractor, for external radionuclide exposure and ingestion of radionuclides in soil and water indicated accurate information.

Noted.

39. Section 5.6.2, page 5-74.

It is important to mention that error terms in the radiological data make it difficult to estimate concentrations of isotopes with much accuracy. The default procedure of relying on the maximum detected concentration in cases where the UCL was higher may have a bias toward lower or higher measured concentrations than is actually existing.

These aspects have been incorporated into the uncertainty assessment section.

40. Plate B.

It is difficult to correlate the fence diagram with the location map. Please clarify with letters or labels.

The well numbers have been posted on the location map.

41. Appendix D.

Please include well logs from wells installed during previous investigations, if available.

All well logs from previous investigations were published in "Operable Unit 9, Site Scoping Report Vol. 2 - Geologic Log and Well Information Report [FINAL]." (May 1992) All well logs from the recent site-wide investigation are published in "Remedial Investigation/Feasibility Study, Operable Unit 9, Hydrogeologic Investigation Well Information Report." (January 1994).

U.S. DOE MOUND PLANT
RI/FS
OPERABLE UNIT #1, AREA B
REMEDIAL INVESTIGATION REPORT
NOVEMBER 1993

OHIO ENVIRONMENTAL PROTECTION AGENCY COMMENTS

GENERAL COMMENTS

1. General Comment. DOE evaluated both resident farmer and industrial worker scenarios in the OU1 Remedial Investigation Report. Ohio EPA was informed by DOE after submittal of the OU1 RI report that DOE did not want to continue to evaluate the resident farmer scenario in the OU1 Feasibility Study. Ohio EPA's position on this issue it that both land use scenarios need to be carried throughout the entire Remedial Investigation and Feasibility Study for OU1. DOE needs to evaluate the residential farmer scenario for all media and evaluate the residential farmer scenario for all media and upon DOE's discretion may evaluate only on-site soils for the industrial worker scenario.

   Response to this comment is beyond our purview. The topic is under active discussion by the Remedial Project Managers. Revision of the RIR does not depend upon resolution of this issue.

2. General Comment. Significant amounts of data have been collected for OU1. The data presented in Section 4 needs to be presented in an easier to understand format in which the extent of contamination is easily discernible. After the data is presented in accordance with comments below, data needs (in addition to those noted below) may become apparent and additional work may be warranted. The scheduling of additional work, if needed to select, design or implement a remedial action is flexible and can be conducted accordingly.

   The data presentation in Section 4 has been modified in accordance with the specific comments below, as well as comments by others. It is not apparent that additional field work is required, either to complete the RIR or to initiate the feasibility study. If, in the course of completing the feasibility study, additional investigations are identified, the issue will be brought up with the Remedial Project Managers.

3. General Comment. The lack of analytical background data presents a serious problem for completing the OU1 RI report. It makes difficult assess the nature and extent of contamination. DOE should make an effort to finalize background sampling and analysis in the near future.

   Noted. Since site-specific background data are not available, additional efforts have been made to locate suitable background data from other sources. For soils, we are utilizing data from Wright-Patterson Air Force Base. For some groundwater parameters, we are using preliminary data from the OU 9 groundwater sweeps.

   We continue to assert that, when the data from OU 9 are available and accepted by all concerned, little impact will be observed on the conclusions of this study.

   In addition, contaminants such as dioxin/furans were not included in the background sampling program for OU9. Therefore no background dioxin data will be available. This issue needs to be resolved.

An expanded discussion of these contaminants is being prepared. The lack of background is unlikely to be of significance, since the observed concentrations are used, as is, in the risk assessment.

SPECIFIC COMMENTS

Regarding all of the following comments dealing with the Executive Summary: This portion of the document has been rewritten (shortened and simplified). Thus, some of the comments are not strictly applicable. The sense of the guidance provided has been incorporated into the body of the report.

1. Executive Summary, Page ES-10, 3rd Paragraph. Include a full list of contaminant (nature of contamination), not only those above present or proposed regulatory limits. This should be applied to the Executive Summary as well as the report.

   The intent of the Executive Summary is to convey the highlights or the most important aspects of the study. The occurrence of all contaminants of concern is described in Section 4.

2. Executive Summary, Page ES-11, 1st Paragraph. Please include DOE clean up standards for radionuclides (i.e. plutonium and thorium).

   All observations of plutonium are below the Mound D&D ALARA goal of 25 pCi/g. The text has been modified to so state.

3. Executive Summary, Page ES-13. Table ES.1 is not a summary of the carcinogenic and noncarcinogenic risks for the RME and CTE and should be clarified. It only addresses the contaminants of concern with greatest effects as is stated in the column heading.

   It addresses both. The table title and accompanying text has been clarified.

4. Executive Summary, Page ES-18, 1st Paragraph. The western portion of the old landfill area appears to a source area/hot spot according to volatile organic, inorganic ground water data.

   This is the site of the historical landfill and its associated waste disposal sites.

5. Executive Summary, Page ES-19, General. There is no discussion of dioxin contamination detected in Area B. Please include a paragraph discussing dioxin.

   The intent of the Executive Summary is to convey the highlights or the most important aspects of the study. As discussed in Sections 4 and 5, there appears to be no significant issue related to dioxin.

6. Executive Summary, Page ES-19, 2nd Paragraph. Discuss the observed versus calculated contaminant migration rates from the area of expected disposal.

   As stated elsewhere, this appears to be a steady-state system. Accordingly, observation of contaminant transport rates is difficult or impossible. Further, since it is steady state, actual transport rates are not pertinent. Observations during the pump test showed <u>less</u> retardation.

7. Executive Summary, Page ES-19, 3rd Paragraph. The rate of contaminant migration needs to take into account pumping of the Mound production wells. This is consistent with past conditions and may continue depending on actions taken for OU1.

See previous response. Additional consideration of transport rates, capture zones, etc., will be addressed in the Feasibility Study report, if warranted.

8. Section 1.3.1, Page 1-16, 5th Paragraph. Mercury was not included in the soil parameter list even though it was disposed of in Area B. This will need to be addressed.

   Mercury, a TAL metal, was included in the laboratory program, as reported in section 3.5.2 and Appendix A3.

9. Section 1.3.1, Page 1-22, 3rd Paragraph. Provide the disposal location for the hazardous liquid wastes after 1969.

   This information was obtained from the Site Scoping Report, Volume 7, Waste Management. No additional data was provided. The offsite location of the waste disposal is not germane to the OU-1 study.

10. Section 1.3.2.1 & 1.3.2.2, Page 1-28 through 1-31, General. DOE should not screen contaminants based on exceeding Maximum Contaminant Level (MCL). DOE should compile a table listing all potential/detected contaminant found in OU1 investigations. This provides the nature of contaminants for OU1 and helps summarize the investigations. The MCL (if available) should be provided on the table as a reference point for the readers.

    The purpose of these sections was to give the history of previous investigations and to identify past concerns. The complete analytical program is described in Section 3 and the results are presented in section 4.

11. Section 2.2.5, Page 2-17, Page 2-17, 4th Paragraph. Included the pumping rate/water usage for the various production wells.

    The typical production data for the Mound Plant production wells are provided, along with total 1992 production from the other fields; no other data are available.

12. Section 2.2.6.2, Page 2-19, 3rd Paragraph. A residential well survey (November 11, 1992) was conducted by Terran Corp. According to the map, approximately nine domestic wells are located on River Road and Saxony Road. Since the information is available, DOE should include this information in the OU1 RI Report, including Figure 2.5.

    This has been done.

13. Section 2.2.6.3, Page 2-23, Table II.4. The table is confusing. Use actual USEPA, Ohio EPA Maximum Contaminant Levels or DOE standards, whichever is the most conservative for comparison with contaminant levels found in the Mound water supply wells.

    This table was taken, verbatim, from the Mound Plant Environmental Monitoring Report; the relevant EPA limit is footnoted. No other data are available.

14. Section 2.2.6.3, page 2-23, table II.4, How were negative numbers calculated for minimum contaminant concentrations?

    This table was taken, verbatim, from the Mound Plant Environmental Monitoring Report; the negative numbers were calculated by subtracting the average environmental level from the data, as explained in the footnote. These "average environmental levels" were determined by sampling and analysis at sites removed from the plant. A negative number means that the observed levels are lower than the calculated environmental level. No other data are available.

15. Section 2.3.1, page 2-27, table II.5, See previous comment.

See previous response.

16. Section 4.1, Page 4-1, 2nd Paragraph. As discussed, Cross Section B-B6 (plate A) provides a good illustration of the sediments that underlie Area B. The till unit below Area B may act as an important factor in the contaminant migration and releases to the ground water. Several figures should be constructed to show the aerial extent, depth and thickness of the till before and after the construction of the current landfill and overflow pond.

Given the amount of excavation and reworking that has taken place, the till unit is of minimal importance in the distribution or movement of contaminants within Area B. The current cross sections and fence diagram should be sufficient to support an adequate understanding of the system. Further, the existing cross sections contain and present the available data.

17. Section 4.2.1, Page 4-5, and 4-7 through 4-10, Figure 4.3 through 4.7. Please include an outline of OU1 and the location of the production wells on the figure.

This has been done.

18. Section 4.2.1, Page 4-5, and 4-7 through 4-10, Figure 4.3 through 4.7. This shaded area that depicts the "Approximate boundary of Buried Valley Aquifer" needs to clarified. This line represents the area in which gradients flatten and ground water flow becomes consistent with the main body of the buried valley. The gradients east of the shaded area are much steeper due to the influence of the bedrock topography and possibly the nature of the sediments. The permeable tributary valley sediments that extends between the Main Hill and SM/PP Hill is part of the buried valley aquifer (BVA) system because the sediments are continuous and directly recharge the main portions of Great Miami Buried Valley. Please clarify the key and indicate that the shaded area represents the major portion of the BVA which has been designated a Class I Sole Source Aquifer.

The figure caption has been so modified.

19. Section 4.2.1, Page 4-6, General. In addition to the "Site Wide" ground water flow, included ground water flow maps for the OU1 area. All appropriate monitoring well and piezometer data for the immediate vicinity should be used if possible to develop the ground water flow maps. Ground water contour intervals may be very small (i.e. 0.1 or 0.2 feet) but it may be important to define specific flow patterns so that contaminants can be tracked back to potential source areas or hot spots. Also include the shaded source areas (i.e. thorium drums, liquid disposal area, Areas B-1 through B-1, etc.) on OU1 specific ground water flow maps.

In addition to the small-scale maps of the groundwater system, it is possible to examine the flow field within and immediately adjacent to Area B on a larger scale. A new figure is provided that shows the groundwater contours based on March 1993 data. With a 0.1-foot contour interval, the data are subject to measurement error of nearly the same magnitude as the contour interval. This is the primary cause of the apparent irregularities. The map reveals a generally southward flow of water, toward the plant production wells. By inspection, the large- and small-scale maps are in general agreement.

The new map, however, does not shed any additional light on very minute variations in flow path, so "hot"spot" analysis is not thereby supported.

Putting the often vaguely-known locations of potential source areas on the large-scale map does not assist in understanding the contaminant occurrence within Area B. Superimposing

another layer of information makes these busy maps even busier, and obscures, rather than highlights, information.

20. Section 4.2.1, Page 4-6, 2nd, 3rd and 4th Paragraphs. Please clarify the pumping scenario, if present, under which the gradients are 0.01 ft/ft along the northern edge of Area B and 0.0003 ft/ft western margin of Area B. Also indicate in the text changes in gradients and ground water flow direction that occur due to pumping at the various production wells.

    The gradients cited in the text were calculated from the average annual water level map. The water levels used to generate the map were affected by pumping for water supply at the Mound Plant. The water supply wells at Mound pump as needed to maintain sufficient water and head within the supply tank. The gradients are for the average, long-term condition at Mound which is the most usual. Changes in gradient will occur when the pumping well cycles off, but these changes are small compared to the long-term averages.

21. Section 4.2.1, Page 4-6, 3rd Paragraph. Well 0055 is located on Figure 4.3 as noted in the text. The text indicates that the figure will show the potentiometric high at well 0055 that indicates a recharge point. Please correct Figure 4.3 to reflect the text.

    The text reference to Figure 4.3 is incorrect. The figure should be Figure 4.5.

22. Section 4.2.1, Page 4-13, Figure 4.9. Bedrock topography contours are too light and difficult to read. Please darken bedrock contours.

    This has been done.

23. Section 4.2.2, Page 4-16, 2nd Paragraph. The surface water features are potential contamination pathways to the north and south that are not being addressed within the scope of OU1. Please indicate in the text where the pathways will be investigated.

    The surface water features (surface drainage ditches and french drains) within OU 1 are adequately addressed by this document. The overflow pond will be addressed as part of the OU 9 study. The text will be modified to reflect this.

24. Section 4.2.3, Page 4-22 through 4-24, Table IV.2. Include a key for the various symbols used in the table.

    This has been done.

25. Section 4.2.3, Page 4-25, 3rd Paragraph. Add to Table IV.3 or construct a new table showing the total drawdown (corrected) that occurred for each monitoring well or piezometer.

    The data collected for all 40 wells monitored during the aquifer test has not been corrected. One data point for each well was corrected at 14,400 minutes to create the drawdown map but this may not be the total drawdown that occurred at each well. The table will be modified to include the corrected drawdown at 14,400 minutes for those wells in which it was corrected.

26. Section 4.2.3, page 4-25, paragraph 3, DOE references Appendix H, Figures H1a-H1r. These are the incorrect references, the correct references are in Appendix G.

    The correction has been made.

27. Section 4.2.3, Page 4-31, 3rd Paragraph. Please clarify and explain the criteria used to select monitoring wells for the aquifer analysis. In addition, the information in Table IV.4 on page 4-36 does no correspond to the criteria listed in the text. Please clarify the purpose of the table.

The text and table has been clarified.

28. Section 4.2.3, Page 4-32, Figure 4.15. Include the total corrected drawdown due to the pumping at 0071 (#1) for each monitoring well or piezometer on Figure 4.15.

The corrected drawdown at each well due to pumping at 0071 has been added to the figure.

29. Section 4.2.3, Page 4-31, 2nd Paragraph. Construct a ground water flow map based on ground water elevations collected after drawdown stabilized (14,400 minutes). Include the estimated capture zone due to pumping of well 0071 (#1). The text should included a discussion and estimation of the vertical and horizontal (3-dimensional) capture zone.

The capture zone for 0071 and 0076 for time 14,400 minutes after pumping began can be delineated by the 1.0 ft drawdown contour. This will provide a conservative estimate of the area in which water will flow toward the two pumping wells. There are insufficient data to discuss the vertical extent of capture within that area, but there is every reason to believe that it extends through the full depth of the aquifer.

30. Section 4.2.3 page 4-36, Table IV.4 Why is well number 0912 used in the Aquifer parameter analysis if it has not been characterized?

Well 0912 is the old Miamisburg Well 2. It was used during the aquifer test analysis because the well was monitored prior to the start of the aquifer test, it was the most northern well to show the effect of pumping during the aquifer test, and it was along a north-south transect through the Buried Valley aquifer. Of the wells in the area, it had the largest drawdown with time. Although the well construction information is not known, it is known to be about 50 feet deep, so it is safe to assume that the well is completed in the Buried Valley aquifer and that it is not fully penetrating. The data in P007, a nearby well with similar response, was very noisy. P014 responded in a similar fashion as 0912, but P014 was not monitored prior to the start of the aquifer test.

31. Section 4.2.3, Page 4-38, 4th Paragraph. Time-drawdown curves are included in Appendix G, not Appendix E as indicated.

The correction has been made.

32. Section 4.2.3, Page 4-42, 3rd Paragraph. Calculate hydraulic conductivities (K) from the pump test at each well. Please include a table of the transmissivity, saturated thickness and corresponding K value. These K values should be compared to the slug test K values discussed in the 3rd paragraph on this page.

Only 13 of the 40 wells monitored during the aquifer test were analyzed for transmissivity because the effort involved in correcting the data and analyzing the data for each well does not gain sufficient information to make it cost effective. Table IV.4 includes the saturated thickness at the 13 wells analyzed.

Slug test were performed in 11 wells in 1988 and 1990. Of these 11 wells, five were monitored during the aquifer test in 1993. Data from 0309, one of the wells with both slug test data and aquifer test data had hydraulic conductivity values calculated for both tests, 0.6 and 3.8 ft/day for the slug tests and 500 ft/day for the aquifer test. You cannot compare the results from the two different tests for the following reasons:

1) *A slug test measures the ability of the formation in the immediate area of the well to transmit water away from the well. If the well has a sand pack that is partially unsaturated, the slug test will calculate the conductivity of the sand pack and not the formation.*

2) *An aquifer test is designed to stress a much larger volume of the aquifer so that an average transmissivity is calculated for the area within the cone of depression.*

The conductivity calculated at 0309 from the aquifer test data is heavily biased toward the conductivity of the Buried Valley aquifer, which is supplying the water to the well. The conductivity calculated in the slug test is for the immediate vicinity of the well. The two are not comparable.

33. Section 4.2.4, Page 4-48, 3rd Paragraph. The available information indicates that the landfill drain drained leachate for 6 months. The leachate draining from the landfill may have contaminated sediments in the pond area and caused a secondary source in the pond liner or sediments. This area appears to be consistent with the elevated volatile organic contamination in monitoring well 0370. Please provide evidence supporting or refuting this idea in the appropriate section.

There is very little likelihood that the minor amount of leachate observed would have deposited discernable amount of material in the liner. Further, recent soil gas measurements inside the site sanitary landfill reveal very small quantities of volatiles present.

If leachate had contained volatiles, subsequent conditions all act to reduce the likelihood of this creating a source. If the pond was dry at that point in time, then any volatiles would have tended to go into the air; if full, then the leachate would have been immediately diluted. Any material deposited at that time would have had nearly 20 years to diffuse back into the pond contents or be diluted by any infiltration through the liner.

34. Section 4.3.1, page 4-73, 3rd Paragraph. DOE has not presented any soil gas results in the text of the RI report. Rather extensive soil gas surveys have been conducted in OU1. Section 3.4.1, pages 3-12 through 3-22 provide detailed procedures and sampling locations. The results and limitations (soil type, ect.) need to be presented and discussed in the RI Report. Figures that show the sample location and contaminant concentrations should be included.

The complete soil gas report is presented in Appendix A. The soil gas work was done for scoping and to guide siting of wells and soil borings. At the time that the report was published, all agreed that no further action was warranted on the basis of the soil gas findings. Thus, the soil gas study results were not discussed in the text. The gas report, which does contain a discussion of results, remains in Appendix A.

35. Section 4.3.1, Page 4-73, 5th Paragraph. Dioxin were included in the analytical parameters. Include Dioxin in the list for soil parameters in subsurface soil samples.

This has been done.

36. Section 4.3.1, Page 4-73, 5th Paragraph. This section should identify and discuss the nature of contaminants. The text indicates "the parameters discussed in this section were selected in the risk assessment analyses based upon frequency of detection and background concentration levels." This statement needs to be clarified. First, one of the objectives of the RI is to identify the nature of contaminants. This would not be accomplished if the parameters discussed only included those with multiple detections or those that indicate a risk. Second, "background concentration levels" for the Site has not been determined. Therefore, there is

no data to compare the OU1 results with to make a contaminant determination. DOE should clarify the sentence and provide tables of the contaminants detected for each media investigated under the OU1 RI Work Plan.

The statement has been clarified. Background data are now available for comparison. The compounds discussed are those identified as chemicals of concern in section 5 or deemed to be of significant interest. All compounds detected are listed in section 4.3.1. All validated detections are presented in Appendix A6. Appendix A8 also lists all compounds detected.

37. Section 4.3.1, Page 4-75, 1st Paragraph. The analytical data in Appendix A needs to be referenced. Incorporate the reference into the text.

This has been done.

38. Section 4.3.1, General. DOE needs to clarify analytical sampling intervals/depths, specific parameters at specific depths, detects vs non-detects, etc. It is difficult to determine whether samples were analyzed for a specific parameter or that the parameter was not detected. The analytical results in Appendix A needs to be presented in a format that is easier to understand and in a form that depicts the lateral and vertical extent of contamination in relationship to the stratigraphy and water level water. DOE should construct multiple cross-sections for OU1 that show: 1) complete stratigraphy; 2) boring depth; 3) sampling depth for specific analytical result; 4) detections and concentration; 5) non-detects with detection limits; and 6) water level. Many cross-sections will be needed throughout the section to show the various contaminants (i.e. Total VOCs, Trichloroethene (TCE), tetrachloroethene, benzene, ethylbenzene, 1,2,-dichloroethene (DCE), toluene, total xylene, individual semivolatile compounds, pesticides/PCBs, etc. Of specific interest is the relationship between contamination depth and the material it found in, i.e. fill, undisturbed soils or the contact between the two.

The available data are presented in tables and on the existing cross sections. Attempts to plot analytical data on cross sections revealed no pattern and shed no additional light on contaminant occurrence. In particular, there is no relationship between contaminant occurrence and the interface between materials. As is stated elsewhere, further refinement of our understanding of contaminant occurrence within the zone of historical waste disposal is neither possible nor warranted.

39. Section 4.3.1, Page 4-75, 2nd Paragraph. Borings B001 through B003 are not shown on the Figure 4.34 or any of the figures showing the location of the validated VOC data.

The corrections have been made.

40. Section 4.3.1, Page 4-76, Figure 4.34. Eliminate or differentiate between all borings and well/piezometer locations that did not have soil samples collected for analytical purposes and those that did have analytical data. For example the following boring locations shown on the figure did not have any analytical data: 0126, P026, 0126, 0388, 0343, 0383, 0303, 0387, 0392, 0152, 0306, 0310, 0153, 0316, 0313, 0307, etc. These borings were completed during previous phases. This should be applied to all like figures.

*The locations with data are **bolded**; those with no data are shaded back. This explanation will be added to the legend. Removal of the items with no data would make orientation within the figure more difficult.*

41. Section 4.3.1, Page 4-76, Figure 4.34. Contaminant concentrations need to be plotted on the figures to show the lateral extent of contamination. Like figures should be constructed for all contaminants.

This figure shows the combined occurrence of any and all VOCS in soil. It the case of soil contamination, the most important observation is a combined occurrence, such as this. Individual plots of the occurrence of individual contaminants do not contribute to the understanding of the site. By contrast, individual contaminant occurrences in groundwater are significant and separate maps are provided.

42. Section 4.3.1, page 4-81, General.

a. The extent of VOC contamination has not been adequately defined. No data is available for the area west and north (below the overflow pond) of piezometer P001 and monitoring well 393. These locations are TCE and tetrachloroethene "hot spots:. Additional investigations will be needed to define the extent of VOC contamination below the overflow pond and near the north-south road. This becomes apparent when contaminant concentrations are plotted on figures and cross-section. The scheduling of this work will need to discussed.

Given the construction and operation history, the occurrence of VOCs below the overflow pond is unlikely, as is any significant occurrence adjacent to the pond. This is further supported by the groundwater flow geometry in the vicinity. We do not consider any additional work in this area to be warranted.

b. It was noted also that contamination (VOC, semivolatile organics, dioxin, radionuclides, tritium, etc.) probably associated with activities in Area B extends beyond the boundary of OU1 (i.e. P015, P008, P009, P014, etc.). The contaminant level needs to be compared to background levels and risk based levels to determine the next action and level of effort.

The soil data from P008 and P009 do not reveal contaminant levels that are of concern for this study. The low levels of VOCs and tritium detected are associated with groundwater transport and will be addressed as necessary when considering that pathway. The other locations cited are probably <u>not</u> associated with activities in Area B. The remedial investigations to be done for OU 2 and OU 5 will need to deal with the data from P014 and P015, respectively.

43. Section 4.3.1, Page 4-81, 5th Paragraph. The text indicates that VOC concentrations in wells in Area B appear to fluctuate seasonally due to changes in the source of recharge with time, and/or the VOCs source is periodically flushed by higher water levels. To show and support these conclusions, construct graphs of Time versus Concentrations for VOCs measured in ground water and compare the pattern or trends to water levels patterns and precipitation over the same time frame.

These data will be prepared and presented. The paragraph was out of place at the location cited. The complete discussion has been moved to the end of Section 4.3

Various constituents and wells were evaluated to identify correlations between concentrations of various constituents and groundwater elevation. The following graphs are included (at the end of the document) in the response to this comment:

1) *Figure 1. Correlation of TCE concentration and water level - well 0046*
2) *Figure 2. Correlation of PCE concentration and water level - well 0063*
3) *Figure 3. Correlation of iron concentration and water level - well 0063*
4) *Figure 4. Correlation of PCE concentration and water level - well 0153*
5) *Figure 5. Correlation of TCE concentration and water level - well 0153*
6) *Figure 6. Correlation of tritium concentration and water level - well 0305*
7) *Figure 7. Correlation of TCE concentration and water level - well 0305*
8) *Figure 8. Correlation of PCE concentration and water level - well 0305*

9) Figure 9. Correlation of manganese concentration and water level - well 0305
10) Figure 10. Correlation of chromium concentration and water level - well 0313
11) Figure 11. Correlation of tritium concentration and water level - well 0315
12) Figure 12. Correlation of TCE concentration and water level - well 0315

These graphs were chosen because sufficient data were available to make a graph and they are generally representative of the variety of groundwater conditions found at Area B.

Some of these graphs indicate a strong correlation (Figure 4. Correlation of PCE Concentration and Water Level - Well 0153, and Figure 5. Correlation of TCE Concentration and Water Level - Well 0153). Some of these graphs indicate a moderate correlation (Figure 6. Correlation of Tritium Concentration and Water Level - Well 0305, and Figure 7. Correlation of TCE Concentration and Water Level - Well 0305). Some of these graphs indicate a weak correlation (Figure 2. Correlation of PCE Concentration and Water Level - Well 0063, Figure 3. Correlation of Iron Concentration and Water Level - Well 0063, Figure 8. Correlation of PCE Concentration and Water Level - Well 0305, Figure 9. Correlation of Manganese Concentration and Water Level - Well 0305, and Figure 11. Correlation of Tritium Concentration and Water Level - Well 0315). Others graphs indicate no correlation (Figure 1. Correlation of TCE Concentration and Water Level - Well 0046, Figure 10. Correlation of Chromium Concentration and Water Level - Well 0313, and Figure 12. Correlation of TCE Concentration and Water Level - Well 0315).

Generally, the correlation appears to be strongest for the volatiles (TCE and PCE), in the shallow groundwater directly west of the landfill, as represented by data from well 0153. Some correlation appears to exist between groundwater levels and metals and tritium concentration but the correlation tends to be weak to moderate. Given the lack of definite, strong, consistent correlations, comparisons of precipitation to groundwater quality were not performed. The correlations of water level and concentration serve to establish the relationship.

44. Section 4.3.1, Page 4-93, 2nd Paragraph. DOE should not screen out contaminants based on the risk assessment until after the nature and extent of contamination has been shown and background has been determined.

Chemicals of potential concern will be screened based on background levels for both soils and groundwater.

45. Section 4.3.1, Page 4-93, 2nd Paragraph. The text references a regulatory limit for plutonium-238. Included the regulatory limit and source.

The reference to a <u>regulatory</u> limit was in error; we intended to cite the Mound D&D ALARA goal of 25 pCi/g.

46. Section 4.3.1, page 4-98, 3rd Paragraph. According to this paragraph "none of the surface soil samples showed detectable concentrations of either dioxin or furans." This is inconsistent with Table III.8 which includes the analytical parameter list for surface soils. Dioxin/furans were not included in the parameter list. Please remove the statement saying that no surface soil samples showed detectable concentrations of either dioxin or furans.

The sentence has been removed.

47. Section 4.3.1, Page 98 and 99, 1st Paragraph and Figure 4.39. The lateral and vertical extent of dioxin/furans has not been adequately determined. The burning of solid and hazardous waste in Area B may have produce significant amounts of dioxin. Results from subsurface samples indicate significant concentrations are present. For example, the highest concentration

of octachlorodibenzodioxin (OCDD) were detected in borings P003 (1780 pg/g), P004 (1660 pg/g), and P015 (2110 pg/g). Dioxin/furans were detected at various levels in every boring in which dioxin/furans samples were collected. The number of samples per boring sampled varied from 1 to 3 sample intervals. No dioxin/furan samples were collected north or northeast (down gradient wind direction) of the burn area(s) or burn cage. DOE should plot data as indicated in comment above regarding Section 4.3.1. General and compare to probable source areas. Also see the comment above regarding Section 4.3.1, Page 4-76, Figure 4.34.

The significance of the observed dioxin concentrations is considered in Sections 4 and 5. Had any dioxin been deposited within Area B during the operation of the burn cage, it would have been deposited on soils that have been incorporated into the site sanitary landfill. No additional sampling seems warranted.

48. Section 4.3.1, General. Inorganic contaminants (TAL metals) in soils were not discussed or presented. Incorporate a section presenting the data and discussing the results.

Results for metals has been included in section 4.3.1.

49. Section 4.3.1, Page 4-103, 3rd Paragraph.
    a. DOE needs to reference Appendix A7, March 1993 Ground Water Quality Data By Location.

This has been done.

    b. Appendix A7 (March 1993 Ground Water Quality Data By Location) contains March 1993 data only (monitoring wells 0370 through 397). Analytical data used to evaluate the the nature and extent of contamination in OU1 needs to be presented in the appendix. For example, Figure 4.56 includes data for monitoring wells 0129, 0305, 0306, production wells. The analytical data for these wells are not included in the appendices.

All groundwater monitoring data prior to March 1993 is published in the Cumulative Groundwater and Monitoring Well Data Report Through Fourth Quarter, FY92-Mound Plant, and does not need to be republished here. This reference will be cited in the text.

50. Section 4.3.2, Page 4-103, 3rd Paragraph. The nature of contaminants in the ground water needs to be identified. The parameters to show nature of contamination should not be selected in risk assessment. See comment from Section 4.3.1, page 4-73, 5th Paragraph above. A table should be constructed of all the ground water contaminants in OU1., frequency of detections, maximum concentrations, etc.

The referenced section has been modified to include all chemicals of concern and additional compounds relevant to the determination of contamination. All sample results are presented in Appendix A7. All groundwater detections are also presented in section 5, Table 5.1.

51. Section 4.3.2, General. The nature and extent of contamination in OU1 appears to be based on one round of sampling. Additional rounds of sampling are needed to confirm contaminant concentrations. In addition, validated data from previous sampling events should be used to evaluate data trends and confirm contaminants. See comment from Section 4.3.1, Page 4-81, 5th Paragraph.

All available validated data has been used in the interpretation of the nature and extent of groundwater contamination, not just the March 1993 data. Additional sampling is being carried out as part of the OU 9 groundwater sweeps sampling.

52. Section 4.3.2, General. Since dioxins were detected in soil samples at various depths in OU1, a selected group of monitoring wells should be sampled for the compounds.

The observed levels of dioxin contamination of soils suggest that dioxin occurrence in groundwater will be vanishingly small. No dioxin sampling was included in the previous quarterly events, nor is it incorporated into the OU 9 groundwater sweeps.

53. Section 4.3.2, Page 4-103, 5th Paragraph. As indicated, 1,1,1-trichloroethane has been detected off-property to the west (see Figure 4.40). This may indicate off-property migration is occurring. Additional considerations of potential sources and ground water flows are needed to identify a source.

The pattern of occurrence of 1,1,1-TCA suggests that it is <u>not</u> originating in Area B. Further, given its observed concentrations and its prevalence throughout the valley, it is not a contaminant of concern for Area B.

54. Section 4.3.2, Page 4-106, 1st and 2rd Paragraph. Discuss the possibility of the 1,2 trans and 1,2 cis dichloroethene as a degradations product.

Sentences have been added to both paragraphs noting that both isomers of DCE are possible degradation products or original impurities in the solvents. The degradation pathways for PCE and TCE are discussed in section 2.4.

No clear-cut case can be made for the origin of the DCE, since we do not have a data set that shows reductions in PCE or DCE over time or distance along a plume, accompanied by an proportional increase in daughter products.

55. Section 4.3.2, Page 4-112, 1st and 2nd Paragraph and Figure 4.45. The tetrachloroethene and TCE concentrations indicate wide spread contamination in and outside OU1 with a "hot spot" near monitoring well 0370. This "hot spot" is fairly consistent with elevated concentration from abandoned well 0055 located between the current landfill and overflow pond. Additional investigation and potential interim actions should be considered. DOE and the regulating agencies should discuss future actions. Also see comment regarding Section 4.2.4, Page 4-48, 3rd Paragraph.

In addition, the extent of contamination to the west and south east Area B should be investigated. Tetrachloroethene concentrations at the property boundary to the west are above USEPA Maximum Concentration Levels (MCL) of 5 ug/l. Tetrachloroethene and TCE concentration to the south of the current landfill near the Mound Productions Wells are elevated above MCLs. DOE should sample the piezometers (P027 and P015) east of the Production Well 0071 to evaluate risk to the Production Wells and assist in determining the extent of contamination.

Piezometers P015 and P027 will be sampled as part of the spring OU 9 sweeps. These issues will be examined further in the FS.

56. Section 4.3.2, Page 4-116, 3rd Paragraph and Figure 4.51. Chromium results indicate elevated levels in monitoring wells 0305 (2880 ug/l), 0306 (333 ug/l), 0313 (315 ug/l), and off-property well 0376(?) (57 ug/l). The USEPA MCL for chromium is 100 ug/l. A ground water contamination appears to be the worst along western boundary of Area B. DOE needs to evaluate the presences of chromium and resample to confirm the results. A potential source for the metals may be Areas B-1, B-2 or B-3 where geophysical techniques identified high metal content. If confirmed, interim action should be considered to prevent further migration and protect the Mound water supply wells.

As is discussed elsewhere in the text, the bulk of the chromium appears to be associated with the sediments produced with the samples from these wells. Recent sampling (including the groundwater sweeps) has not confirmed a chromium or other metals problem.

57. Section 4.3.2, Page 4-121, 5th Paragraph and Figure 4.56. As with chromium, nickel results are elevated in monitoring wells 0305 (663 ug/l), 0306 (221 ug/l), and 0313 (425 ug/l). The USEPA MCL for nickel is 100 ug/l. DOE needs to evaluate the presences of nickel and resample to confirm the results. If confirmed, interim action should be considered to prevent further migration and protect the Mound water supply wells.

See response to comment 56.

58. Section 4.4, Page 4-133, 4th Paragraph. In addition to the concern of contaminant migrations from Area B to off-property away from the Mound Plant, Mound should be concerned with protection the Mound Production Well down gradient from Area B. This should be incorporated into the text.

Mound Plant's ongoing concern for protection of the production wells will be made explicit in the text.

59. Section 4.4, page 4-133/General. The contaminant migration should be discussed and determined for all significant contaminants found in the soil and ground water. This is important for future migration and risk. The list of contaminants provided on page 4-133, 5th paragraph does not include many of the contaminants found in the soils (i.e. PCBs, dioxin, etc.) or ground water (chromium, nickel, etc.) Supporting data regarding the physical characteristics, distribution coefficients, etc. and site specific data/concentrations should be included in the text. Data sources should be referenced.

All chemicals of concern are discussed in section 4.4 regarding mobility and persistence. Supporting chemical and physical characteristics have been included, with data sources. Site specific results are provided in Appendix A6 and Appendix A7.

60. Section 4.4.3, Page 4-147, 3rd Paragraph.
    a. DOE needs to calculate the contaminant flow velocity for all significant contaminants (organic and inorganic).

The text and table have been modified extensively. The intent is to provide a representative sample of computations, addressing the range of contaminants of concern.

    b. The rate and direction of contaminant migration needs to account for various pumping scenarios for the Mound Plant Productions Wells. These production wells represent contaminant receptors. Contaminant migration to the wells will change if ground water gradients increase or decrease. To be conservative, the migration rate needs to be calculated for the fastest time of travel.

The rate and direction of migration were calculated using the average annual water level maps. Although the rate and direction of movement may vary with time, in general, the water supply wells will be pumped at similar rates during similar times of the year. Daily fluctuations in pumping rate will have little affect on long-term movement. Only a sustained change in pumping rate will materially affect the rate of movement.

    c. In addition, the projected rate of contaminant migration for the major contaminants should be plotted and shown on a figure and then compared to documented contaminant migration. A discussion of the assumptions and limitations and a

comparison of modeled retardation versus documented ground water concentrations should be included in the text.

There are insufficient data to document when a contaminant entered the groundwater flow system, what the concentration of the contaminant was at this point and how long it took the leading edge of and the peak concentration of the contamination to reach a receptor such as a well. Any comparisons at this point would be highly speculative.

61. Section 4.4.3, Page 4-148, Table IV.24.
    a. DOE needs to provide references for non-site specific parameters used to calculate contaminant flow velocity.

References have been included in the footnote at the bottom of the table.

    b. DOE needs to provide additional explanation regarding the determination/calculation of site specific parameters (organic content, bulk density, etc). For example, an explanation of which organic content samples were averaged and why.

Bulk density, organic content, and porosity were all averaged from the geotechnical data collected at Mound Plant. The averages were for the alluvial, glacial till, and glacio-fluvial outwash samples. The values were averaged because we are looking for an average flow velocity in the Buried Valley aquifer. This explanation has been added to Table IV.24.

62. Section 5.1, Page 5-3. Figure 5.2 does not illustrate the surface water and sediment exposure pathways discussed on page 5-4. These exposure pathways should be included.

The surface water pathway will be added to the conceptual model and discussed briefly. Quantitative analysis will need to wait upon availability of analytical data. These data will not be available until at least FY 95. At that time, the surface water pathway will be addressed as part of the OU 9 studies. The plant surface drainage system is not an OU 1 concern/issue.

63. Section 5.2.2, Page 5-6. An inorganic cannot be eliminated as a contaminant of potential concern based on the computed intake being lower than the average daily intakes. The receptors will still be consuming inorganics as part of their typical dietary intake in addition to their exposure to the inorganics in the environment.

These materials will also be discussed in relation to the nutritional range.

64. Section 5.2.2, Page 5-6 to 5-7. Thallium should be retained as a chemical of concern until further analysis has confirmed that the reanalysis results are not representative.

The revised groundwater risk assessment is based on data obtained between June 1992 and March 1993. Thallium was not detected in any of the validated samples taken during this time period and was screened out as a chemical of potential concern.

65. Section 5.2.2 General. DOE failed to incorporate dioxins concentrations into the baseline risk assessment. DOE needs to include dioxin data in the baseline risk assessment.

All available dioxin data for soil were included in the baseline risk assessment.

66. Section 5.2.2, Page 5-6. A chemical should not be eliminated as a contaminant of potential concern if the detection frequency for a chemical is found to be less than 5 percent. It may still be a contaminant of potential concern, especially if it is found in relatively high concentrations at several sampling sites.

The Risk Assessment Guidance for Superfund: Human Health Evaluation Manual states that "chemicals that are infrequently detected may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal practices." EPA guidance also stipulates that if the detected concentration of an infrequently detected chemical (less than 5 percent) exists at high concentrations, the chemical should be retained as a chemical of potential concern (COPC). EPA guidance does not specify the definition of a "high" concentration. The maximum detected concentrations of infrequently detected chemicals were judged on two criteria that are based on scientific judgement: 1) if the maximum detected concentration of a chemical with a detection frequency of under 5 percent exceeded an applicable regulatory standard such as a Ohio drinking water standard or Federal MCL, the chemical was retained as a chemical of potential concern; or 2) in the case that no appropriate drinking water standard exists, the chemical was retained as a COPC if its maximum detected concentration exceeded two times the contract required quantitation limit. This procedure has been incorporated in the risk assessment.

67. Section 5.2.2. A value other than 95% UCL, such as the highest measured or modeled value, could be used as the concentration term if additional data cannot practicably be obtained when there is extreme variability in measured or modeled data (U.S. EPA, Supplemental Guidance to RAGS: Calculating the Concentration Term, May 1992). There appears to be a high variability between the maximum detected concentration and 95% UCL of the arithmetic mean in some cases. For example, see aluminum, iron, lead, manganese, potassium, 1,2-cis-dichloroethene, trichloroethene, and trichloromethane in groundwater (Table V.1, pages 5-7 to 5-9). See also Table V.5 for soils (pages 5-15 to 5-19) for 1,2-dichloroethene, 2,3,7,8 - TCDD, Arochlor - 1248, Bis (2-ethylhexyl)phthalate, dichloromethane, trichloroethene, copper, lead and mercury. Particular ares/sources which have high levels of contamination should be assessed separately in the baseline risk assessment to ensure accurate risk evaluation and proper remediation. The overflow pond may be significant source of contaminants and should be separately addressed in the Baseline Risk Assessment (the surface water and sediment sampling will help confirm this). Well numbers 0370, 0307, 0313, and 0373 consistently have relatively high contaminant concentrations. See also comment number 70.

We have re-examined the type of distribution that best fits the data (log-normal, etc.) and re-visited this issue.

As discussed previously, the contents of the overflow pond are not a significant part of the OU 1 baseline risk assessment. All surface water and sediment pathways will be addressed as part of OU 9.

68. Section 5.2.2, Page 5-6 states that "if a chemical's maximum concentration exceeded an applicable regulatory limit, such as an Ohio drinking water standard or an EPA MCL, the chemical was retained as a COC," Aluminum, iron, manganese, and nickel, as well as chromium, (Table V.2) exceed standards and should be retained as potential COCs.

The screening of chemicals of potential concern based primarily on regulatory standards (except in the case of infrequently detected chemicals) has been removed from the risk assessment. Inorganic and natural radionuclide levels in groundwater and soils have been compared to available site and regional background data for the purposes of COPC screening.

69. Section 5.2.2, Page 5-22. Surface water data is currently being collected and will be used to evaluate risk once it becomes available. Have sediments been sampled as well? Data for the sediment pathway should be obtained for analysis of risk.

Surface water and sediment background sampling are not currently scheduled. Efforts to carry out this sampling, analysis, and evaluation will not likely bear fruit until next year, at the earliest.

70. It was stated (page 5-5) that "concentrations qualified with a "J" were retained without change for the risk assessment." The March 1993 data set was not incorporated into the statistical summary of chemicals detected in OU1 groundwater (Table V.1). Page 4-103 stated that "the March 1993 sample set is the most recent analytical data set in terms of Area B contamination." The March 1993 data should be incorporated into the risk assessment. Page 4-107 shows that well 0370 had a concentration of 1,2-cis-dichloroethene of 640 ug/l in March 1993. 4.6 ug/l tetrachloromethane and 130 ug/l trichloromethane were found at well 0370 (pages 4-109 and 4-110), 270 ug/l tetrachloroehthene was measured at well 0370 and 40 ug/l was measured at well 0373 (page 4-111). 270 ug/l trichloroehtene was measured at well 0370 (page 4-113). These concentrations are high. These areas should be evaluated separately in the baseline risk assessment. Similarly, any other specific areas/sources of relatively high levels of contamination should be evaluated separately in the baseline risk assessment. See also comment number 67.

A smaller groundwater area has been delineated for the revised risk assessment. The risk assessment has only used groundwater samples taken from wells within Area B or in downgradient areas directly adjacent to Area B. This provides better characterization of the groundwater levels within Area B (i.e., higher concentration levels).

The March 1993 dataset has been incorporated into the revised risk assessment.

Regarding the issue of separate evaluations of selected portions of Area B: We do not believe it to be appropriate to subdivide the site in the Baseline Risk Assessment. As we begin to contemplate various remedies (in the FS), and identify portions of the site that could be separately remediated, risks (or residual risks) of the separate portions can be evaluated.

71. Section 5.3.2, Page 5-25. A current worker scenario should be considered in the baseline risk assessment for groundwater exposure (page 5-25). True, the Mound Plant is taking water from OU1 that is meeting acceptable drinking water standards, however, other wells clearly do not meet standards and this must be assessed. Exposure pathways of the outdoor onsite worker (i.e. maintenance worker) should also be assessed (page 5-26).

The current Mound Plant worker is being supplied with water that meets all applicable regulatory requirements. Evaluation of this water supply is beyond the purview of the Environmental Restoration Program. Further, this would be imposing an "outside" standard on the Mound Plant water supply to which other water supply systems are not subject.

The maintenance (outside) worker exposure has been incorporated into the future worker scenario.

72. This comment is to stress that National soil background ranges vary considerably. The assumptions made using this information will have to be reassessed when site background data becomes available.

Noted.

73. Section 5.3.2, Page 5-23. Dichloromethane should also be considered a potential contaminant of concern for soils.

We agree. The maximum detected dichloromethane concentration exceeded two times its contract required quantitation limit. Thus, dichloromethane was retained as a COPC.

74. The dermal exposure of chemicals from soil should be assessed for the onsite farmer, and onsite outdoor worker. Dermal exposure of chemicals from soil should use the following

absorption factors (Ryan et al., 1987 Health Assessment): 25% for volatile organic compound, 10% for semivolatile organic compounds, and 1% for inorganic compounds. However, when chemical-specific data is available, these default values should be modified accordingly. These values are what OEPA currently uses.

We have incorporated dermal exposure into the risk assessment, using the noted absorption factors.

75. The U.S. EPA Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment (EPA/600/R-93/089, July 1993) has published the document entitled "Provisional Guidance for Quantitative Risk Assessment of Polycyclic aromatic Hydrocarbons." The estimated order of magnitude potencies for 6 PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(K)fluoranthene, chrysene, dibenz (a,h) anthracene, and indeno (1,2,3-cd) pyrene) are presented and should be used. This is what U.S. EPA Region V is currently using and is what should be used in this baseline risk assessment.

We have incorporated these considerations into the risk assessment.

76. Section 6.5.3, 3rd Paragraph. The cone of influence and capture zone of production well 0076 has not been defined. Data indicates the well is down gradient of Area B and is a receptor. Unless data indicates that well 0076 captures all contaminants, please rephrase the sentence to state that the well is downgradient of Area B and portions of the contamination may be captured by the supply well.

The phrase "at least a portion of" have been inserted into the sentence.

77. Section 7, Page 7-1, General. DOE needs to incorporate validated results from the background sampling program. Soil samples from the soil series sampling and ground water OU9 sweeps should be included as preliminary background data.

These data will not be available in a timely manner for this submission.

The following graphs are included as a portion of response to comment number 43:

1) Figure 1. Correlation of TCE concentration and water level - well 0046
2) Figure 2. Correlation of PCE concentration and water level - well 0063
3) Figure 3. Correlation of iron concentration and water level - well 0063
4) Figure 4. Correlation of PCE concentration and water level - well 0153
5) Figure 5. Correlation of TCE concentration and water level - well 0153
6) Figure 6. Correlation of tritium concentration and water level - well 0305
7) Figure 7. Correlation of TCE concentration and water level - well 0305
8) Figure 8. Correlation of PCE concentration and water level - well 0305
9) Figure 9. Correlation of manganese concentration and water level - well 0305
10) Figure 10. Correlation of chromium concentration and water level - well 0313
11) Figure 11. Correlation of tritium concentration and water level - well 0315
12) Figure 12. Correlation of TCE concentration and water level - well 0315

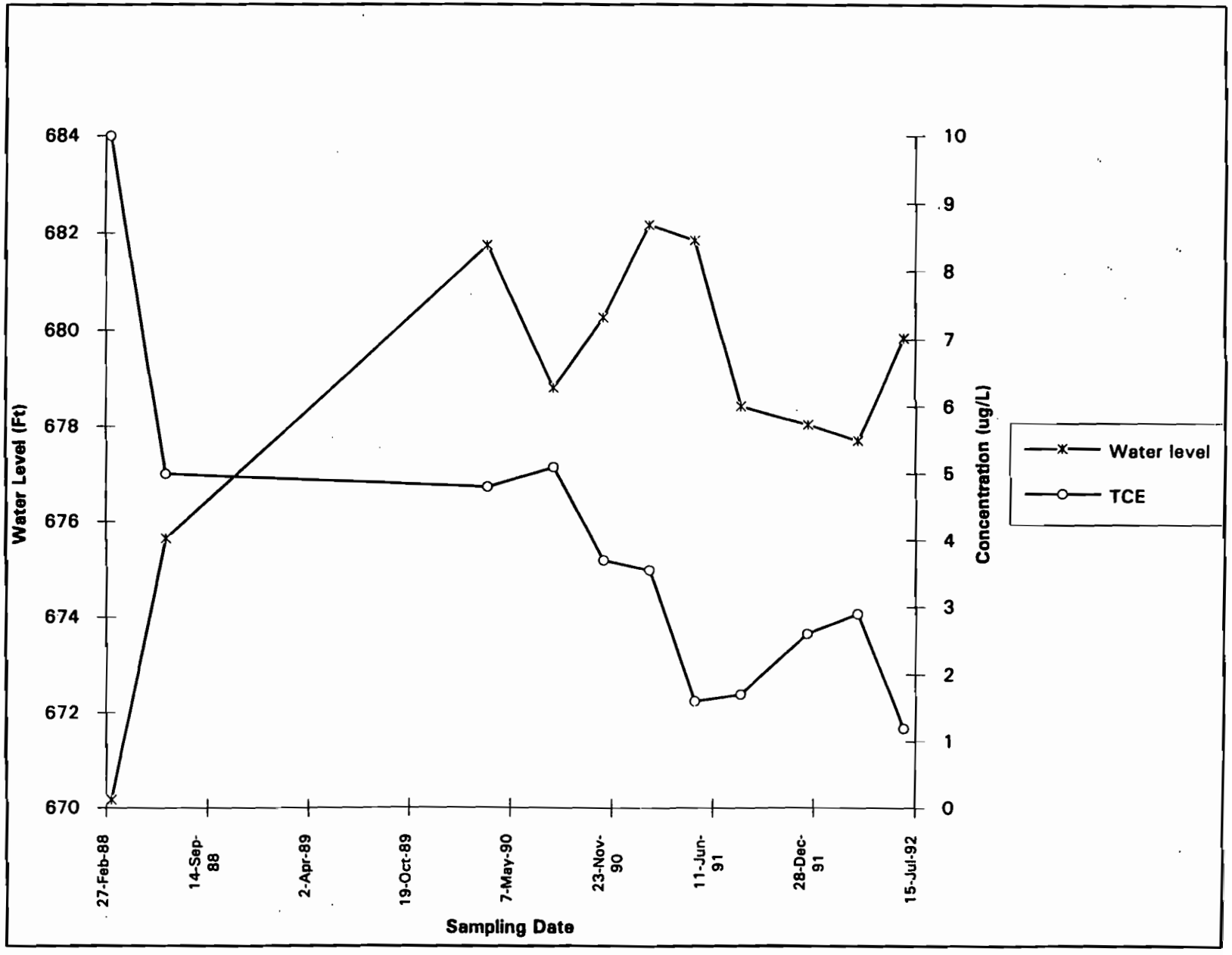

Figure 1. Correlation of TCE concentration and water level – well 0046.

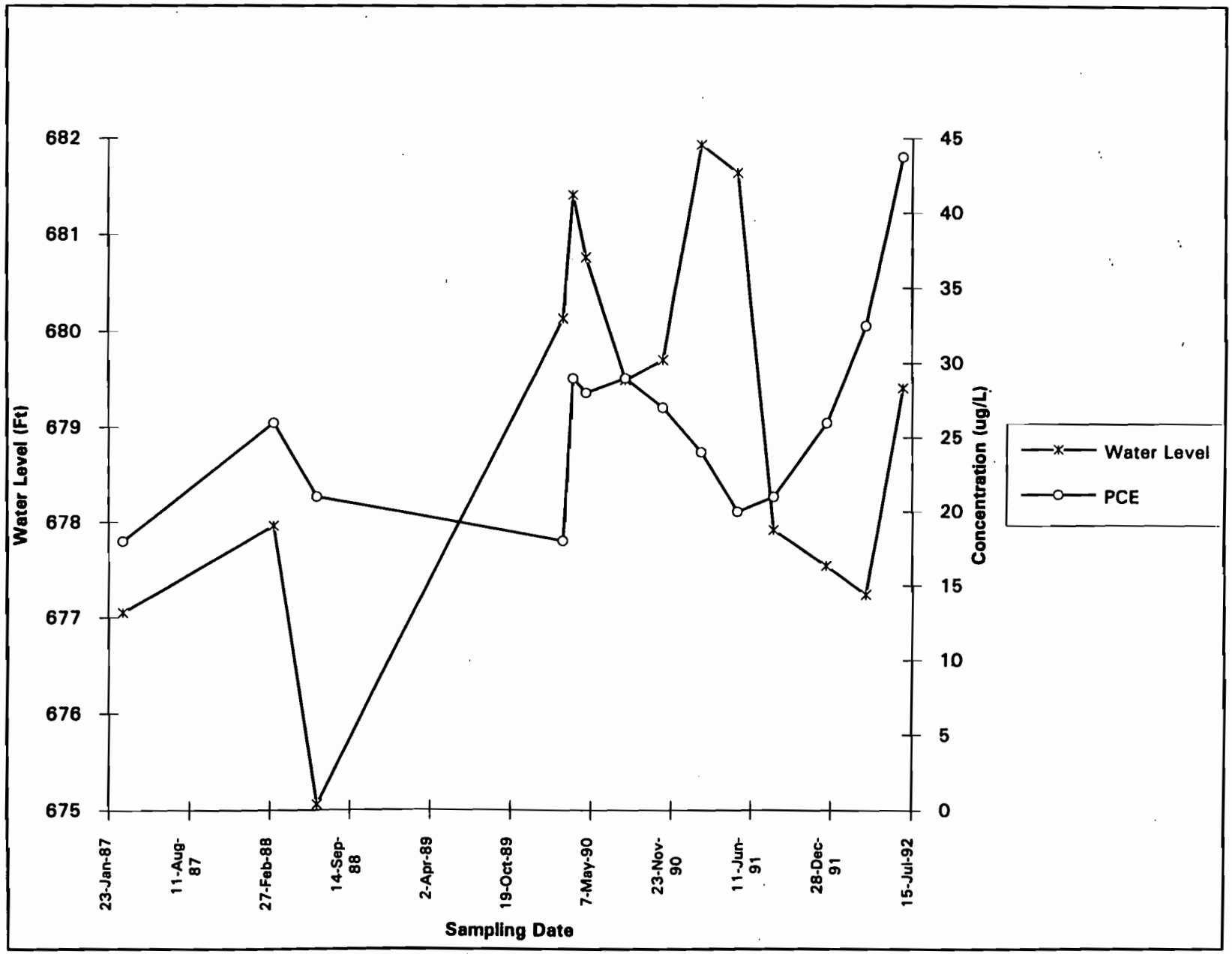

Figure 2. Correlation of PCE concentration and water level – well 0063.

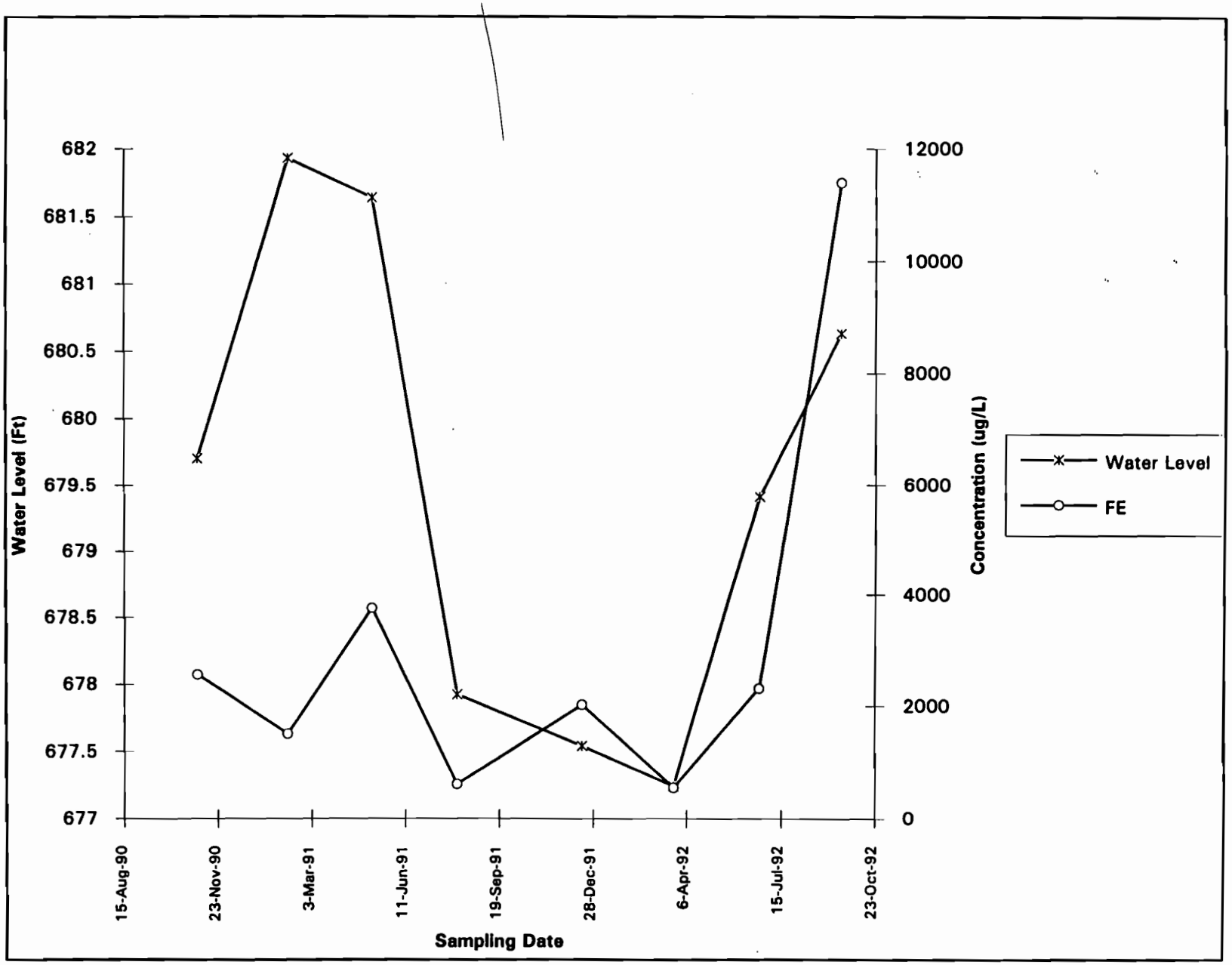

Figure 3. Correlation of iron concentration and water level – well 0063.

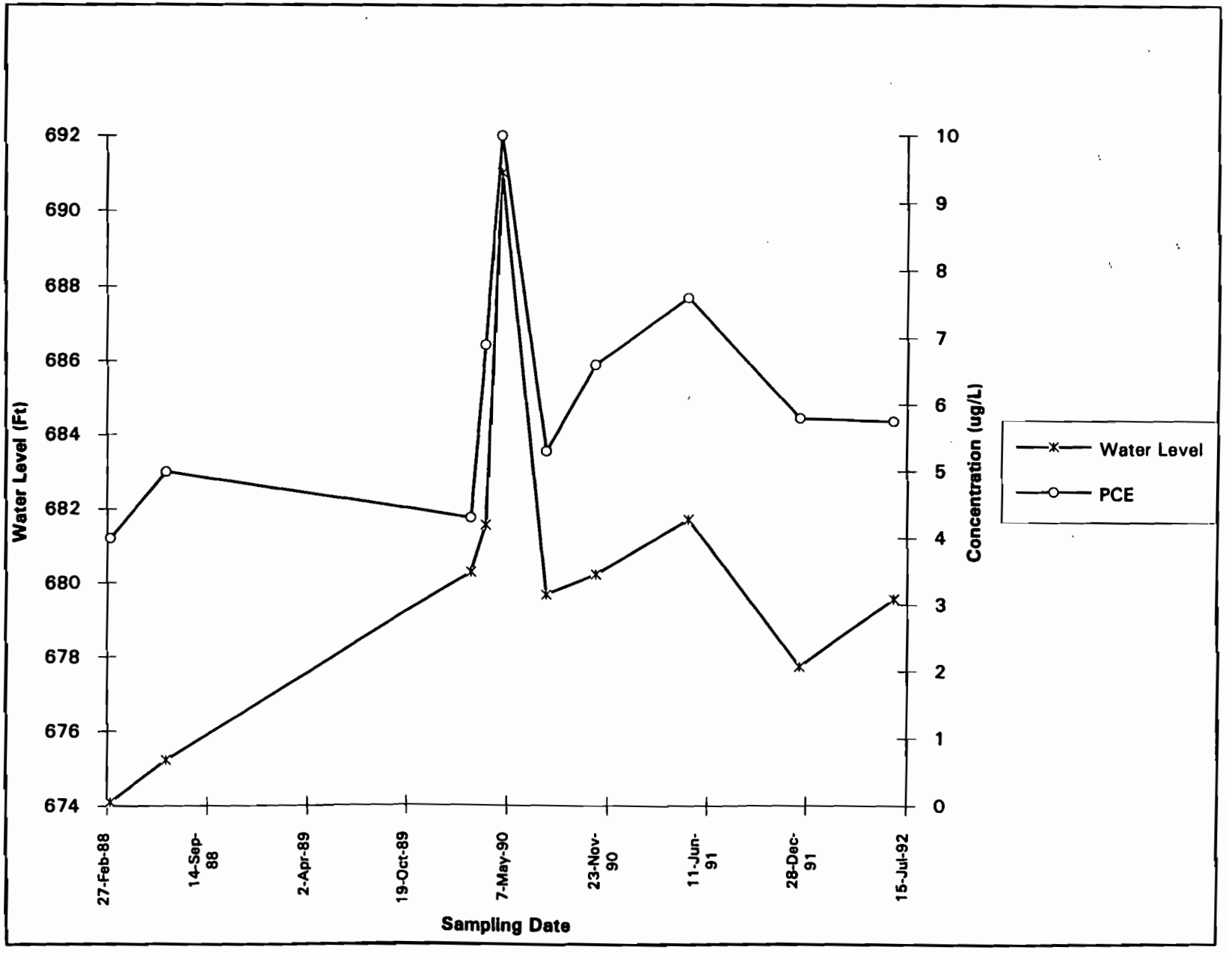

Figure 4. Correlation of PCE concentration and water level – well 0153.

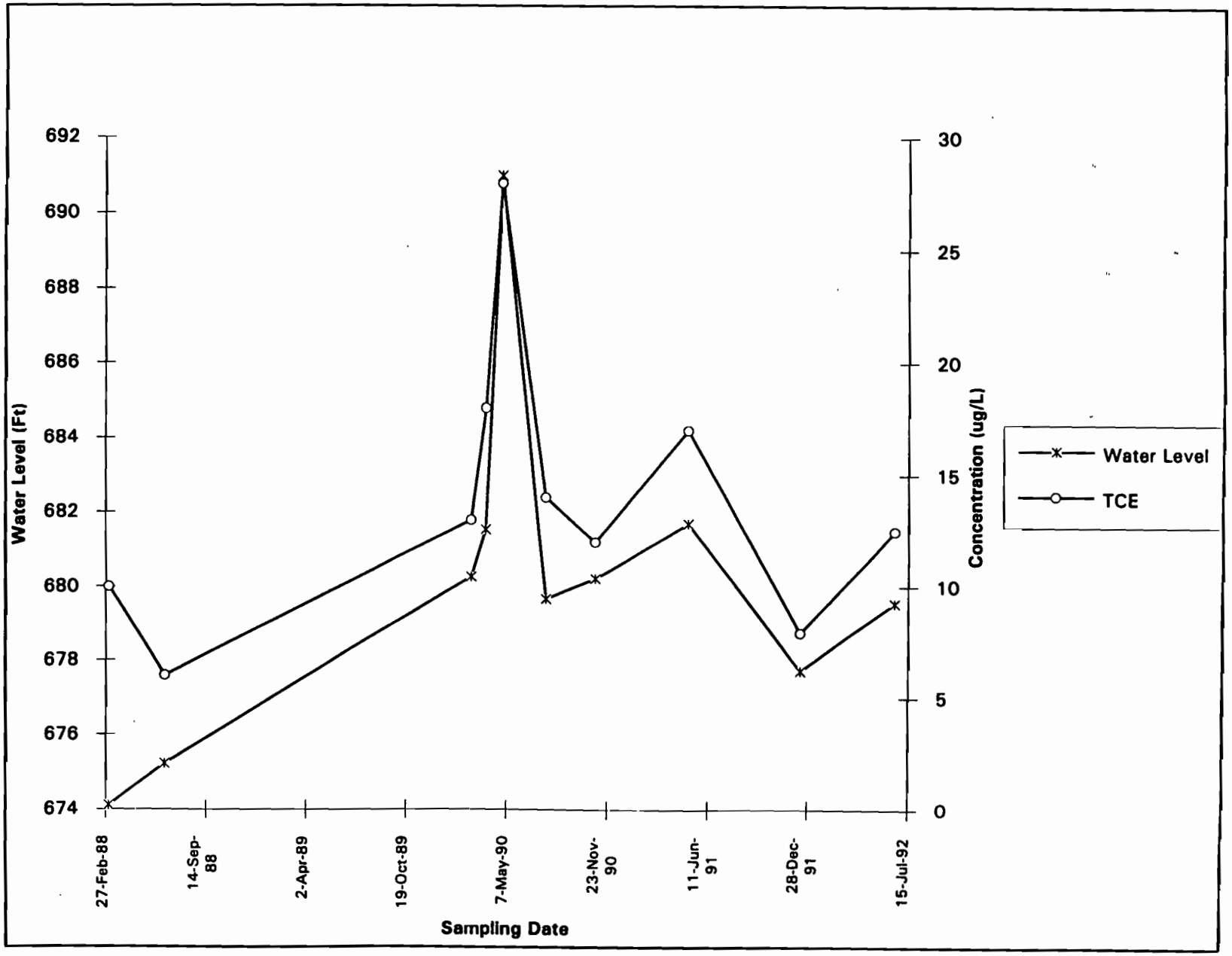

Figure 5. Correlation of TCE concentration and water level – well 0153.

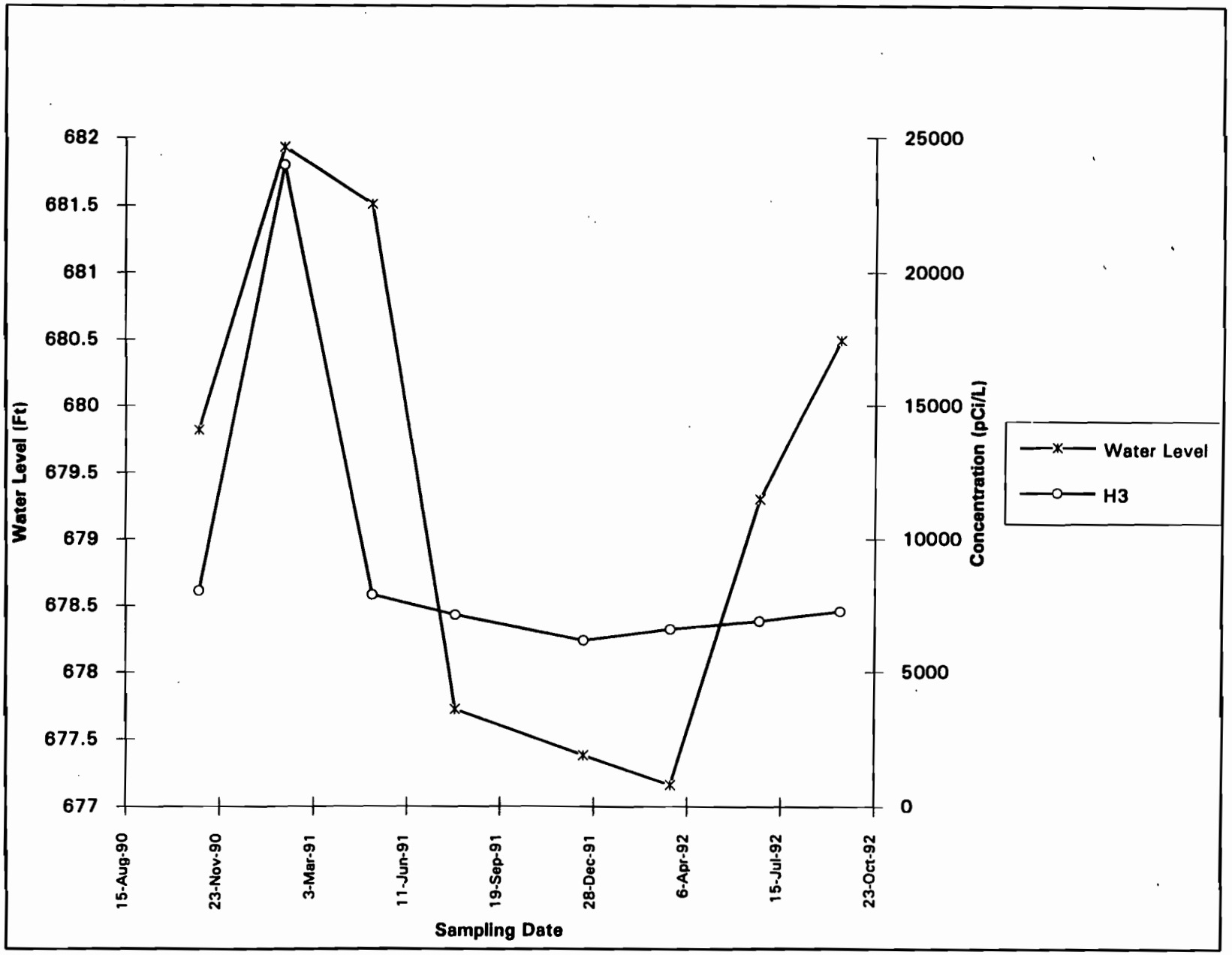

Figure 6. Correlation of tritium concentration and water level – well 0305.

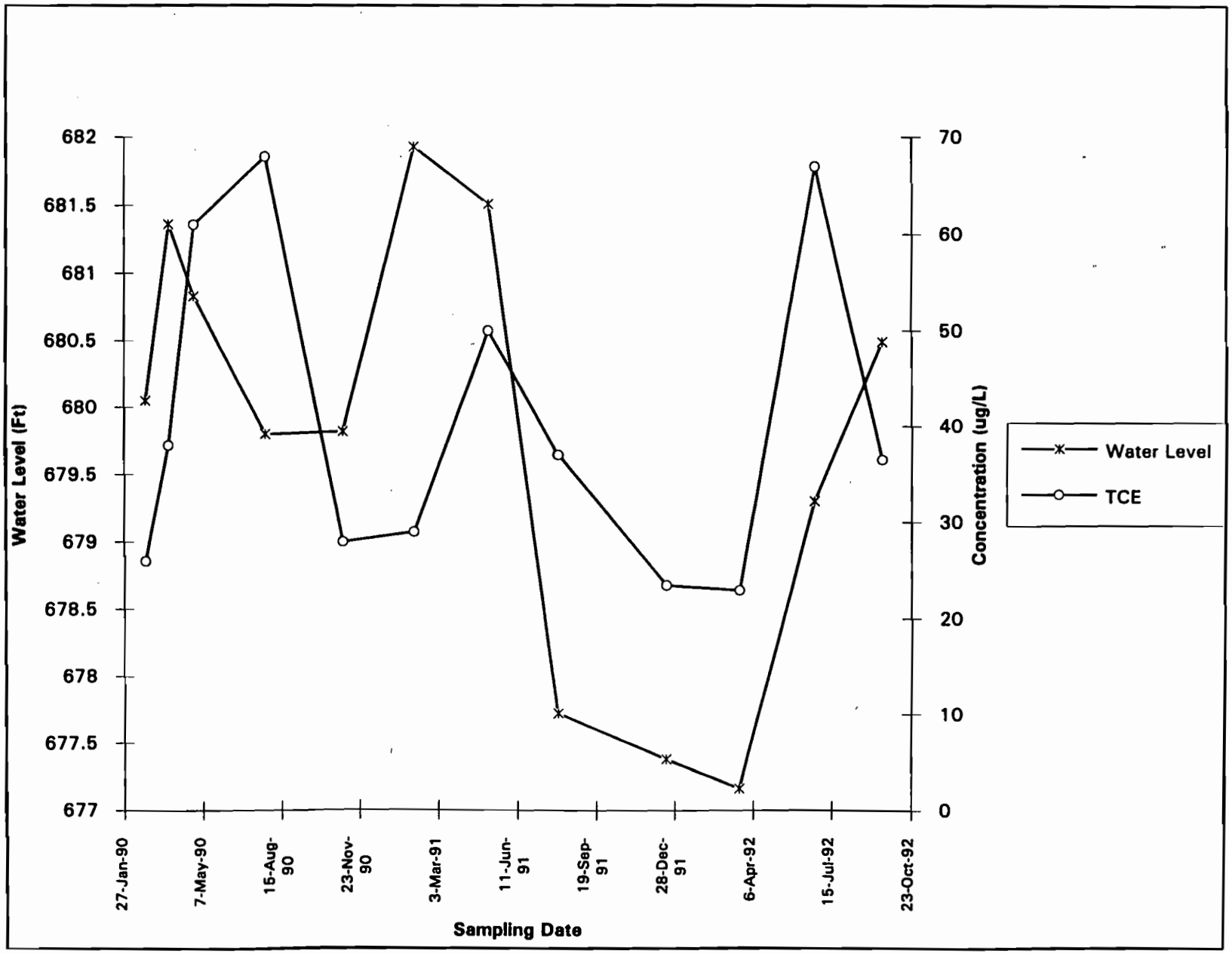

Figure 7. Correlation of TCE concentration and water level – well 0305.

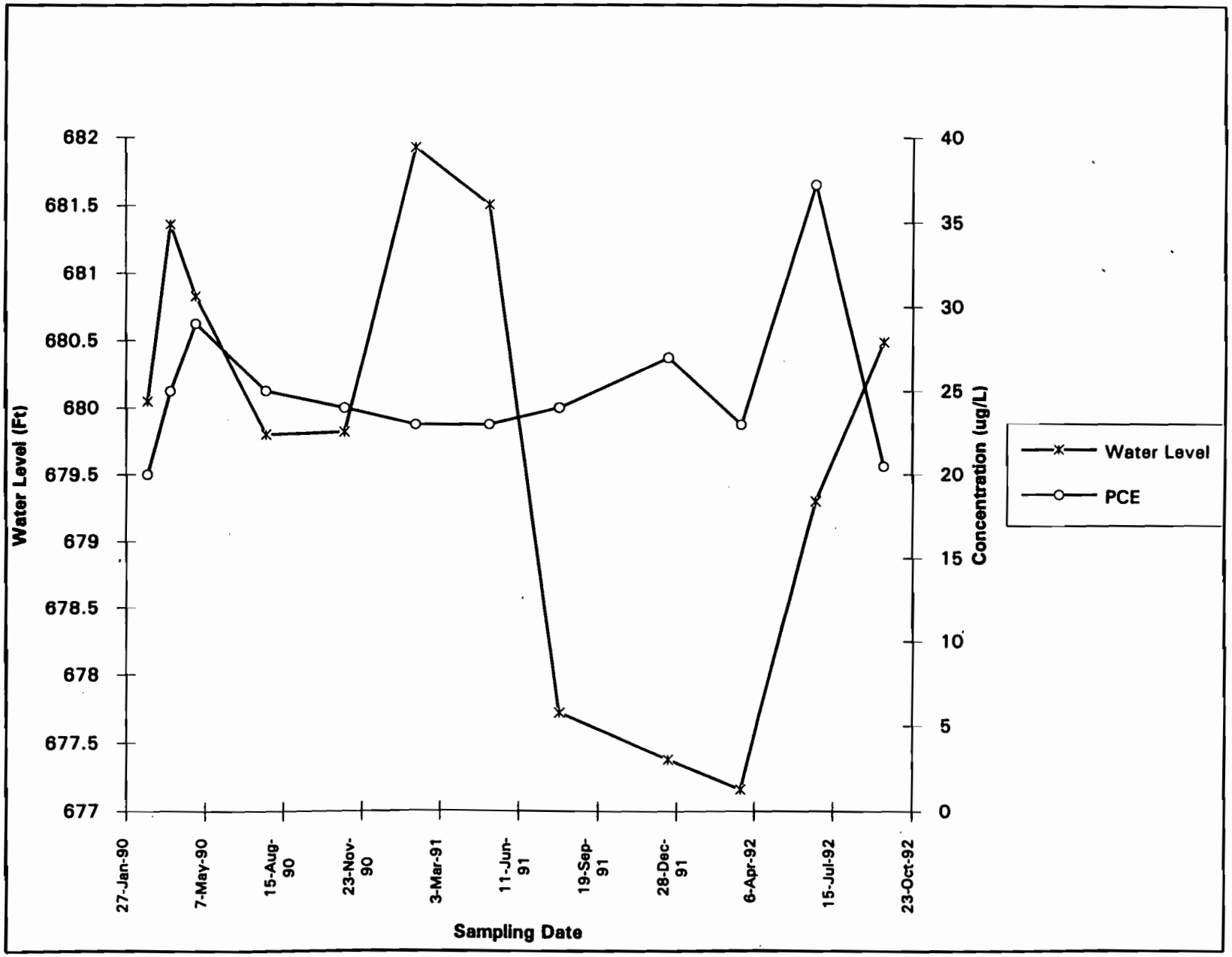

Figure 8. Correlation of PCE concentration and water level – well 0305.

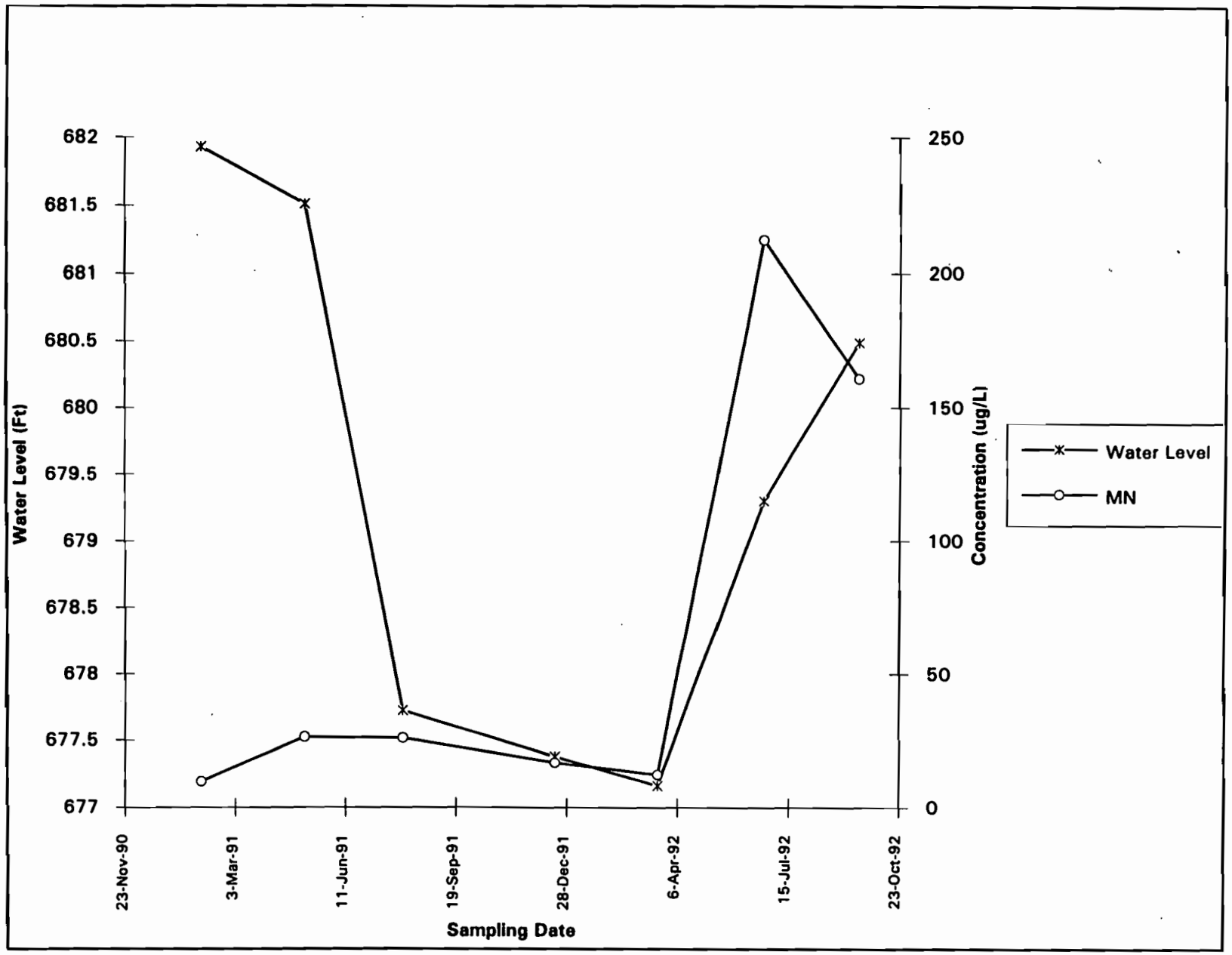

Figure 9. Correlation of manganese concentration and water level – well 0305.

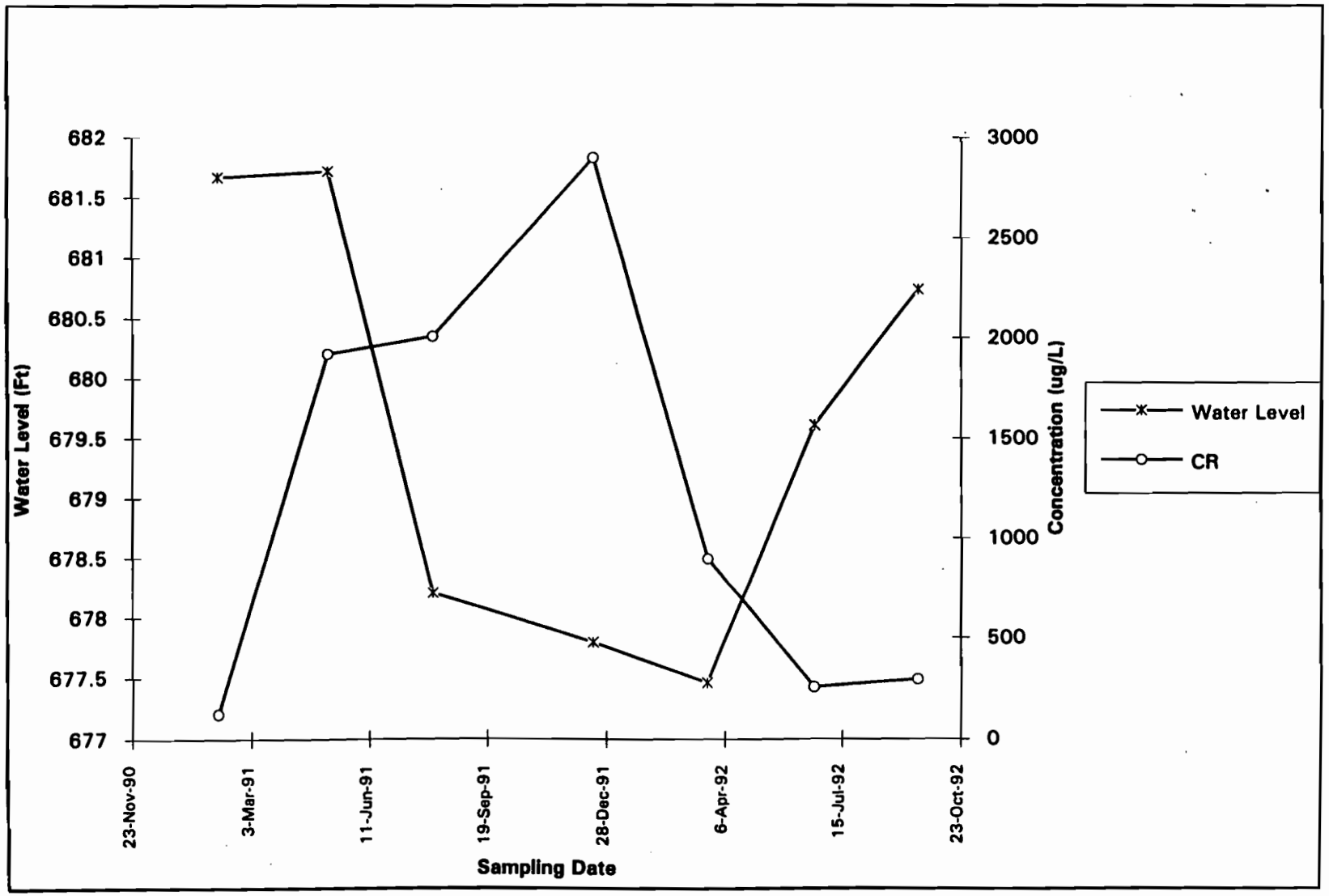

Figure 10. Correlation of chromium concentration and water level – well 0313.

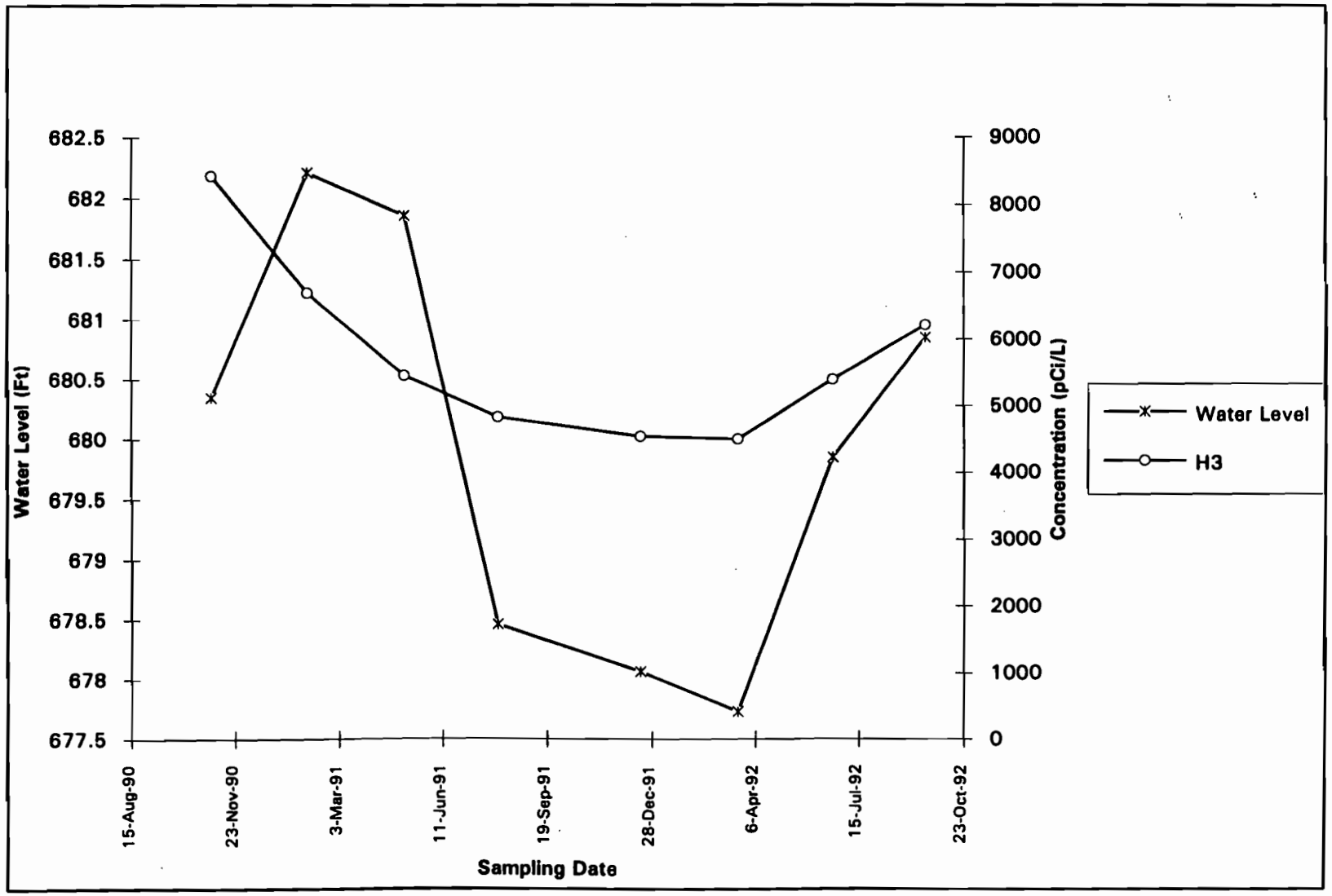

Figure 11. Correlation of tritium concentration and water level – well 0315.

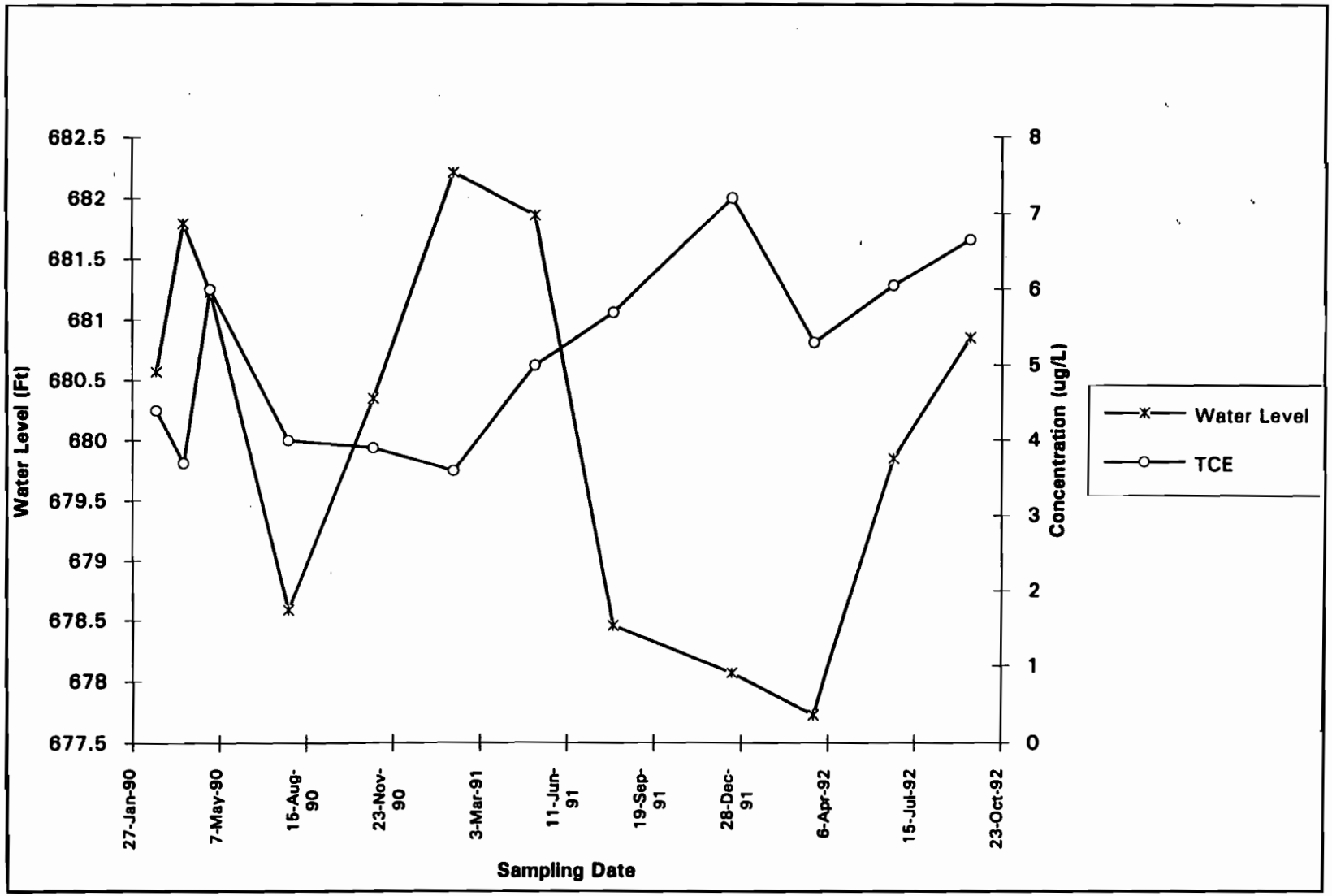

Figure 12. Correlation of TCE concentration and water level – well 0315.

ENVIRONMENTAL RESTORATION PROGRAM

OPERABLE UNIT 1
REMEDIAL INVESTIGATION REPORT

MOUND PLANT
MIAMISBURG, OHIO

May 1994

U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE

ENVIRONMENTAL RESTORATION PROGRAM
EG&G MOUND APPLIED TECHNOLOGIES

FINAL

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ACRONYMS

AA	atomic absorption
AL	(DOE) Albuquerque Operations Office
ASTM	American Society for Testing Materials
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	(EPA) Contract Laboratory Program
COC	contaminant of concern
CRA	CRDL Standards for AA
CRDL	contract-required detection limit
CRQL	contract-required quantitation limit
CTE	central tendency exposure
D&D	Decontamination and Decommissioning
DCE	dichloroethene
DNAPL	dense, non-aqueous phase liquid
DOE	U.S. Department of Energy
EA	Environmental Assessment
ECAO	Environmental Criteria and Assessment Office (EPA)
ECD	electron capture detector
EG&G-MAT	EG&G Mound Applied Technologies
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration (Program)
ERA	expedited response action
ESADDI	estimated safe and adequate daily dietary intakes
FFA	Federal Facility Agreement
FS	feasibility study
FSP	field sampling plan
GC/MS	gas chromatography/mass spectrometry
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments of 1984
ICP	inductively coupled plasma
IT	International Technologies
MCL	maximum contaminant level
MRC	Monsanto Research Corporation
MS/MSD	matrix spike/matrix spike duplicate
MSA	method of standard addition
MSL	mean sea level
NEPA	National Environmental Policy Act
NPDES	National Pollutants Discharge Elimination System
NPL	National Priority List (EPA)
OCDD	octachlorodibenzi-p-dioxin
OEPA	Ohio Environmental Protection Agency
OSWER	Office of Solid Waste and Emergency Response
PA	preliminary assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	dibenzo-p-dioxin
PCDF	polychlorinated dibenzodioxin
PCE	perchloroethylene or tetrachloroethene
PID	photoionization detector
PR	preliminary review
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Program Plan

QC	quality control
RA	remedial action
RAPCA	Regional Air Pollution Control Agency
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RDA	remedial design and action
RFA	RCRA Facility Assessment
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RRF	relative response factor
SI	site inspection
SOP	Standard Operating Procedure
SOW	Statement of Work
SWMU	solid waste management unit
TAL	Target Analyte List
TCA	trichlorethane
TCDD	tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TCL	Target Compound List
TEF	toxicity equivalency factor
TOC	total organic carbon
UCL	upper confidence limit
USDA	U.S. Department of Agriculture
VOC	volatile organic compound
VSI	visual site inspection
WD	Waste Disposal (Building)
WHIP	Well Hydraulics Interpretation Program

UNITS OF MEASURE

cm	centimeter
cm/sec	centimeters per second
gpm	gallons per minute
KeV	kiloelectron
ml/g	milliliter per gram
mm	millimeter
mph	miles per hour
nCi/g	nancocuries per gram
nCi/L	nancocuries per liter
pCi/g	picocuries per gram
pg/g	picograms per gram
pg/L	picograms per liter
ppb	parts per billion
ppm	parts per million
ppq	parts per quadrillion
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
pg/g	picograms per gram

EXECUTIVE SUMMARY

The Mound Plant was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (also known as Superfund) National Priority List on 21 November 1989 (54 Federal Register 48184). Pursuant to its National Priority List status, the U.S. Department of Energy (DOE) signed a CERCLA Section 120 Federal Facility Agreement (FFA) with the U.S. Environmental Protection Agency (EPA), which became effective 11 October 1990. A similar tripartite agreement was signed among the DOE, EPA, and Ohio Environmental Protection Agency (OEPA) in July 1993.

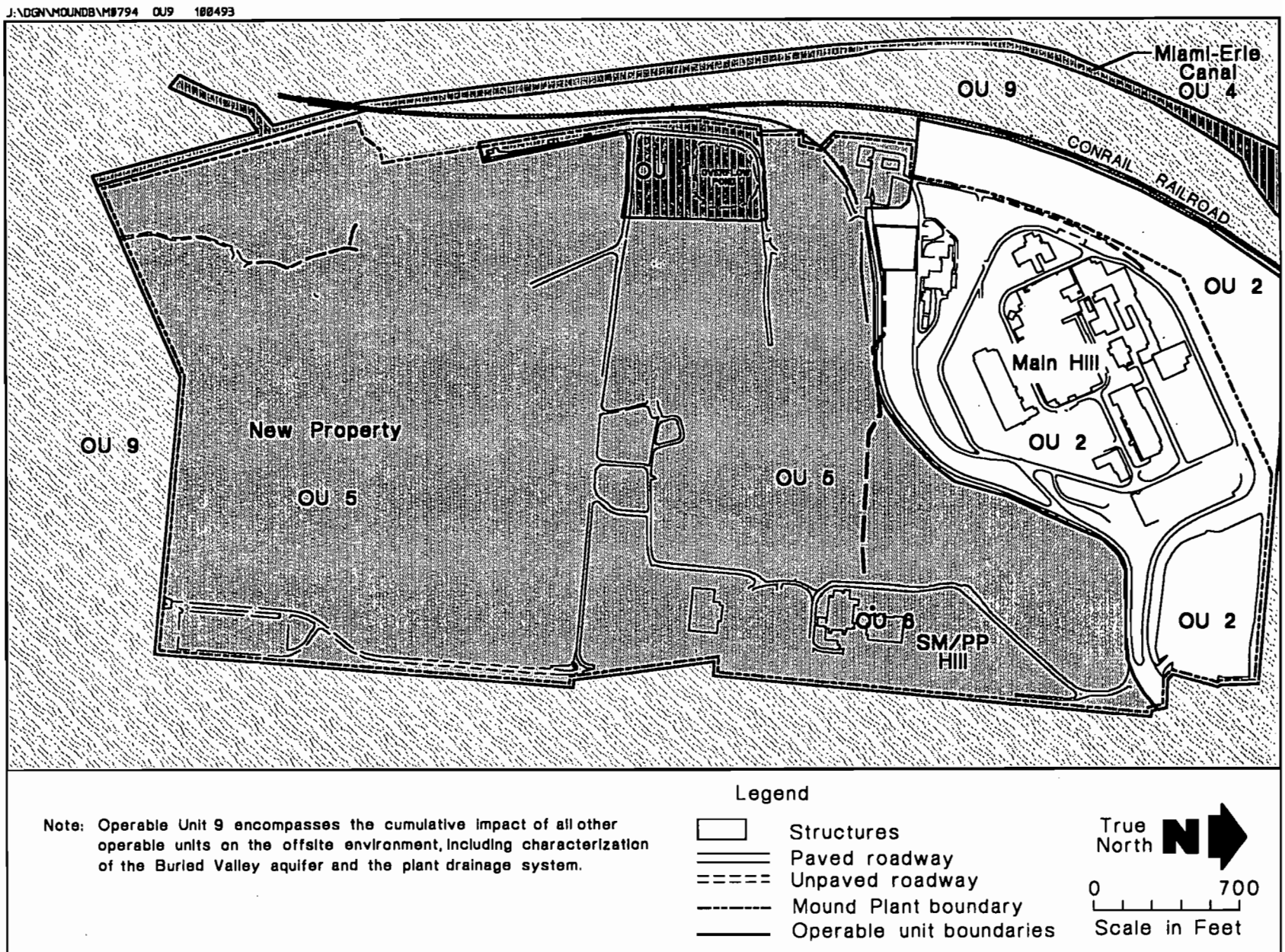
This remedial investigation (RI) report for Operable Unit 1, Area B, at the DOE Mound Plant, Miamisburg, Ohio, summarizes the results of the remedial investigation, including data analysis and baseline risk assessment. The physical and chemical characteristics at Operable Unit 1, Area B, and the nature and extent of chemical contamination and contaminant migration also are addressed. In addition, findings and data analysis for work performed, including a soil gas survey, surface soil sampling, piezometer and monitor well installation/development, aquifer testing, and groundwater sampling, are combined to form a conceptual model of the existing conditions at Area B. This conceptual model is sufficiently detailed to develop appropriate remedial actions through the feasibility study (FS) process. The baseline risk assessment, utilizing current contaminant occurrence data, quantifies the human health threats posed by the site, given assumed future use scenarios of either a resident farmer or an industrial site worker.

There are known releases of volatile organic compounds (VOCs) from Area B into the adjacent Buried Valley aquifer. In addition, tritium was detected in water samples from wells in Area B, although the concentrations were below the maximum contaminant level (MCL).

ES.1. BACKGROUND

Mound Plant is divided into six operable units based on geography and contaminant occurrence. Operable Units 1, 2, 4, 5, 6, and 9 divide the Mound Plant Site into general geographic areas (Figure ES.1). The elements of the Environmental Restoration (ER) Program and of the RI/FS process for each operable unit will address all media sources and contaminants within its assigned boundaries. The location of Operable Unit 1 within Mound Plant is shown on Figure ES.1.

Area B, Operable Unit 1, occupies approximately 4 acres in the southwestern portion of the Mound Plant. It encompasses four areas: the historic landfill, the site sanitary landfill, the overflow pond, and the three plant production wells. Mound Plant used the historic landfill site from 1948 to 1977. Waste materials that were disposed of, some by burning, in Area B included general trash, liquid



Note: Operable Unit 9 encompasses the cumulative impact of all other operable units on the offsite environment, including characterization of the Buried Valley aquifer and the plant drainage system.

Figure ES.1. Mound plant operable unit boundaries.

wastes, and low-level radioactive wastes. Much of this waste was relocated to and encapsulated in a site sanitary landfill constructed in 1977. An overflow pond was constructed simultaneously, partially covering the historic landfill site. After 1977, waste was no longer disposed of in Area B. Area B was extended recently to include the three plant production wells located along the southern plant boundary. An extended discussion of Area B history, including waste disposal and construction activities, is provided in Section 1.

The former waste disposal sites within Area B (the historic landfill and associated features) are concentrated within, beneath, and immediately adjacent to the current site sanitary landfill. These waste disposal sites are the result of a long history of dumping, burning, moving, reworking, burying, and partially removing and placing into the engineered structure (the site sanitary landfill). Currently, the area bounded by the overflow pond to the north, the paved roads to the west and south, and the bunker area to the east can be considered a single entity. It is internally heterogeneous and not all portions are contaminated; however, subdividing it does not increase understanding of the transport phenomena that are occurring, nor does it facilitate developing remedial alternatives for the area.

ES.2. CURRENT AND PREVIOUS INVESTIGATIONS SUMMARY

Mound Plant personnel began a periodic water sampling program for VOCs in 1984. Under the ER Program, the RI began in 1987, focusing on observations of groundwater contamination. Since 1986, VOCs have been detected and monitored in the groundwater (DOE 1992a).

To date, three formal stages of the RI have been completed, followed by a program of additional field work. The investigatory program, together with its supporting laboratory program, is described in Section 3.

In addition to the Operable Unit 1 installations, monitoring wells and piezometers were installed as part of the Operable Unit 9, Site-Wide RI. Specifications of these wells and piezometers are provided in the Operable Unit 9, Hydrogeologic Investigation Well Information Report (DOE 1993e). Installations in the vicinity of Area B are shown on Figure ES.2, which also depicts the areas of groundwater impacted by VOCs, as discussed below.

Groundwater Sampling

Groundwater quality data indicate the following:

- VOCs present with validated detections include 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,-dichloroethene, 1,2,-*cis*-dichloroethene, 1,2-*trans*-dichloroethene, 1,2-dichloroethene (total), brodichloromethane, vinyl chloride (chloroethene), dichloromethane, dibromochloromethane, tetrachloroethene, tetrachloromethane, total xylenes, trichloroethene, trichloromethane, freon-113, and trichlorofluoromethane.

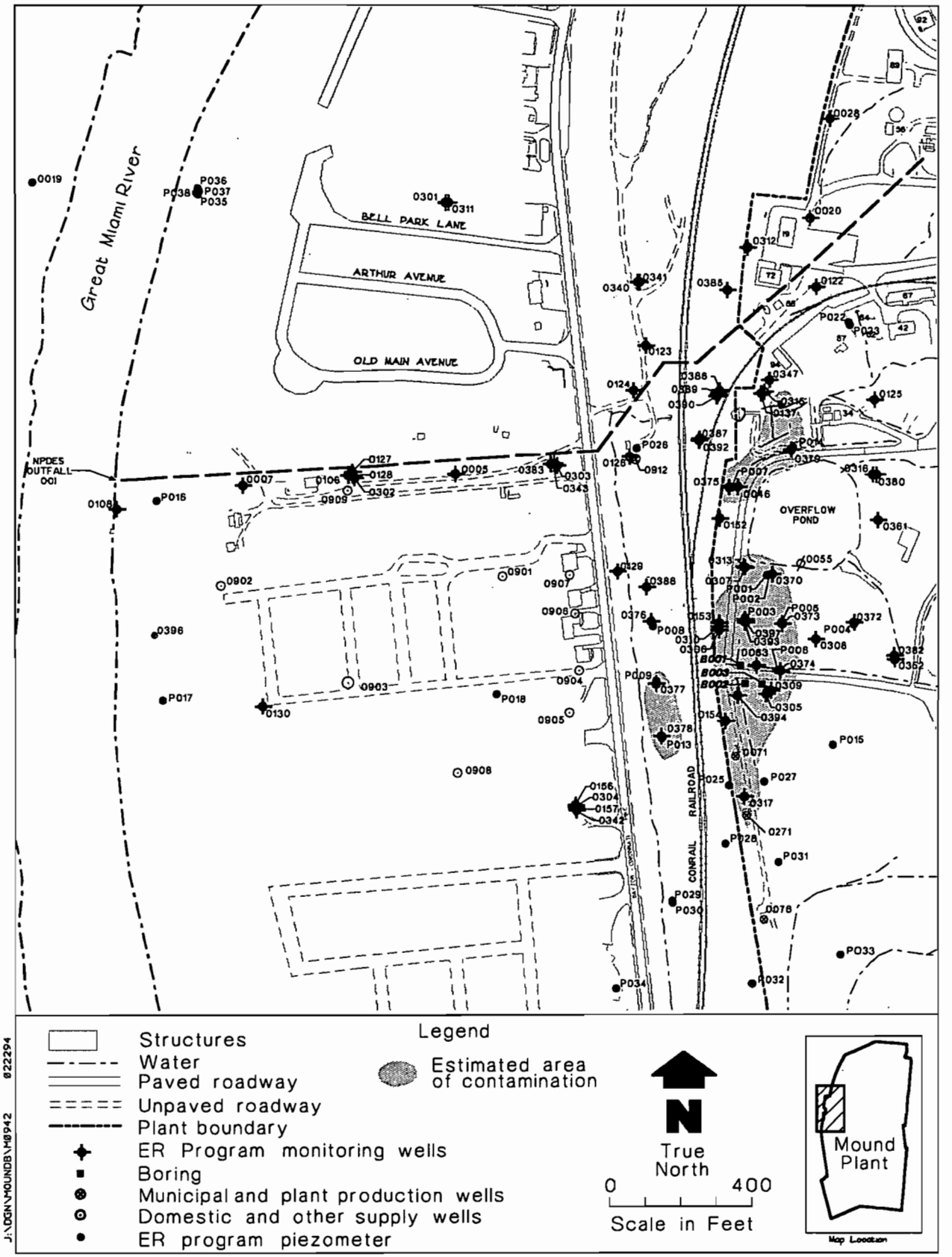


Figure ES.2. Location of ER Program exploration borings, piezometers, monitoring wells, and areas of groundwater impacted by volatile organic contamination.

- Metals present with validated detections include aluminum, antimony, arsenic, barium, cadmium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, vanadium, and zinc.

In January 1990, tritium was detected in Area B monitoring wells 306 and 310 at concentrations of 12.6 and 14.2 nanocuries per liter (nCi/L), respectively. These wells are west of the site sanitary landfill (Figure ES.2). Data from September 1992 and March 1993 confirm that tritium still exists in the groundwater in and adjacent to Area B; however, these concentrations (ranging from 1.4 to 10.6 nCi/L) are below the drinking water standard of 20 nCi/L (40 CFR 141).

Continued quarterly sampling has not revealed a significantly altered pattern of contamination. Because conditions at the site have not altered significantly since the mid-1970s, a relatively steady state regime has been established.

Radiological Sampling

From 1982 to 1985, Mound Plant collected radiologic data on the sanitary landfill cap (previously described as Area 18). Samples also were collected from the vicinity of an area used for disposing crushed empty thorium drums and polonium-210-contaminated sand. The results of the sampling are reported in the Site Scoping Report: Volume 3 - Radiological Site Survey (DOE 1993c). The data gathered indicated widespread, low-level plutonium-238 surface soil contamination. Except for one subsurface sample (17.1 pCi/g), all concentrations within Area B were within the range of <1 to approximately 4 pCi/g. Surface soil sampling, as part of this study, confirms these findings. With the exception of one sample (taken at the southeastern corner of Area B) with a plutonium level of 8.75 pCi/g, all samples were less than 4 pCi/g. All of these observations are well below the Mound D&D ALARA goal of 25 pCi/g.

ES.3. CONCEPTUAL MODEL

The conceptual model for Area B can be presented in terms of its geologic setting, hydrologic setting, contaminant occurrence, and immediate receptors.

Geologic Setting

Area B is partially located on a buried bedrock shelf that drops off to the west, north, and south (Plate B). The surface of the bedrock is a pre-glacial erosional surface that is weathered, but grades

rapidly into competent material. The bedrock section subjacent to Area B is dominated by shale with a significant limestone-bearing portion truncated by erosion immediately beneath the site sanitary landfill. The next nearest (vertically) significant limestone portion is approximately 30 ft lower in the section and does not intersect the bedrock interface until some distance to the west of Area B, at or beyond the plant boundary. This means that the opportunity for contaminant transport from Area B through limestone layers is nil.

The bedrock is overlain by glacial outwash materials, glacial till, and artificial fill. The outwash materials that contain the Buried Valley aquifer thin eastward against the buried valley margin, which is beneath the western edge of Area B adjacent to the waste disposal areas (site sanitary landfill, historic landfill). Only the western portion of the site sanitary landfill overlies the Buried Valley aquifer. The eastern portion overlies the bedrock shelf. To the north, these outwash materials extend up the plant tributary valley, as shown on cross section A-A[7] (Plate A). The portion of the Buried Valley aquifer immediately adjacent to Area B (to the west) varies from 0 to 40 ft thick and is relatively free of fine-grained till layers within the outwash. Typical transmissivities are between 30,000 and 50,000 ft^2/da. The aquifer is not composed of an upper and lower unit, as was supposed.

Hydrologic Setting

Groundwater occurs primarily in the outwash sediments of the Buried Valley aquifer or in its extension up the plant tributary valley. Within the tributary valley, gradients are steep and are governed by topography and the thickness of the unconsolidated zone; flow is west-southwest along the valley axis. In the main part of the Buried Valley aquifer, to the west of Area B, gradients are nearly flat; flow is west and south, governed by the interrelationships among recharge, river stage, and the pumping of the Mound Plant production wells. In the immediate vicinity of Area B, flow is governed by the plant production wells and is southward toward the then-pumping well.

The waste materials and contaminated soils within Area B are partially isolated from the hydrologic environment. Much of the surface is engineered to provide rapid runoff. The materials immediately below the waste disposal area are dominantly fine-grained. The water table is at or below the bedrock interface in this area, so the unconsolidated materials are also in the vadose zone. However, during periods of high seasonal groundwater (or enhanced recharge through the site), some waste materials or contaminated soil are exposed to circulating waters.

Contaminant Occurrence

Soils

VOCs were represented in subsurface soil analyses by 1,2-dichloroethene, ethylbenzene, tetrachloroethene, toluene, total xylenes, and trichloroethene. None of the surface soil samples had detectable quantities of VOCs. Examination of the areal extent of the VOC contamination in the soils shows that it is restricted to the area of past disposal activity in Area B, with no discernible source. The majority of the concentration detections occurs at a depth of less than 20 ft and is limited in areal extent. Aroclor-1248, a PCB, was detected in both the surficial and subsurface soil samples at 14 locations within Area B.

Tritium was detected at low levels throughout Area B. Radionuclides identified as contaminants of concern were plutonium-238 and strontium-90. Plutonium-239/240, thorium-230, uranium-234, and uranium-235/236 were also detected. The only discernible pattern in the radionuclide contamination was that all detections are in the site sanitary landfill area or along the drainage ditches.

The only discernible pattern for all the compounds detected during the surficial and subsurface soil sampling appear directly related to activities in and around the site sanitary landfill. There does not appear to be a major source of the contaminants detected, but rather a random pattern of dispersed contamination resulting from reworking and transporting of materials.

Groundwater

The recent groundwater sampling data (for June 1992 through March 1993) identified six VOCs in the groundwater beneath Area B at levels above proposed or established regulatory limits. These contaminants include vinyl chloride, trichloromethane, tetrachloromethane, 1,2-*cis*-dichloroethene, trichloroethene, and tetrachloroethene. Only trichloroethene and 1,1,1-trichloroethane show concentrations offsite; the pattern of occurrence of the latter suggests a source outside Area B. These are generally less than 1 μg/L and appear to vary seasonally. There is no consistent trend in concentrations with time in wells in the area. Also, there appears to be little trend in contamination with depth. Thus, the data do not show a discernible pattern or a particular area where a potential source might exist, although the detections appear to be concentrated in the site sanitary landfill area and the assumed location of the historic landfill.

Two metals (chromium and nickel) were detected above primary drinking water standards from December 1991 to March 1993. Aluminum, iron, and manganese were detected above secondary

drinking water standards from December 1991 to March 1993. There is no consistent trend in the concentrations in the area; however, the detections appear to be concentrated in the site sanitary landfill area.

A review of the VOC analytical data taken since 1991 shows no major change in the concentrations measured in wells in Area B. Concentrations appear to fluctuate seasonally, possibly caused by changes in the recharge source with time. Another source is from flushing unsaturated sediments by higher water levels. It is likely that pumping well 0076 for the plant water supply also affects the concentration of VOCs within the groundwater and the potential for movement offsite by acting as a discharge point for groundwater. The probable explanation for the distribution of contaminants measured within Area B is a combination of all four factors.

Migration Rate and Direction

Flow velocities (migration rates) for representative contaminants were calculated for the Buried Valley aquifer in the vicinity of Area B, assuming a uniform aquifer seepage velocity of 200 ft per year. Contaminants were chosen to illustrate a range of possible effects of retardation. Dichloroethene is retarded the least, with a possible velocity of 50 ft/yr. Dioxins are retarded the most (4.9×10^{-4} ft/yr); trichloromethane and trichloroethene fall between the two (41 and 20 ft/yr, respectively). However, all VOCs tend to remain in the groundwater and <u>not</u> partition appreciably back onto the soil. Thus, once in the groundwater system, they would tend to move with the groundwater and not at the retarded velocities shown here. Tritium is also expected to move at the same velocity as the groundwater; plutonium is not expected to move from contaminated soils.

Once a contaminant reaches the Buried Valley aquifer, it has the potential to move offsite quickly. However, these velocities assume there is no pumping within the Buried Valley aquifer. Analysis of groundwater flow patterns indicates that the pumping at well 0076 for the Mound Plant water supply creates a capture zone for at least a portion of the contamination within the Buried Valley aquifer adjacent to Area B.

<u>Immediate Points of Exposure</u>

The most immediate point of exposure for contaminants originating in Area B also lies within the confines of Operable Unit 1 — the system of plant production wells. Production well 1 (0071) was taken off-line due to increasing levels of VOCs in the discharge water. Production well 3 (0076) now is the primary source of process and potable water for the plant. Well 2 (0271) is pumped as required to provide a supplemental source of plant water.

ES.4. BASELINE RISK ASSESSMENT

The baseline risk assessment for Area B, Operable Unit 1 addresses future public health risks, assuming that no remedial actions will be performed. Therefore, the assessment serves as a baseline case to compare the relative effectiveness of alternative remedial strategies in reducing public health risks. This baseline risk assessment focuses on exposure of hypothetical future residents and site workers to soil and groundwater contamination. Any risk associated with a selected remedial action, such as landfill excavation, is not addressed as part of the baseline risk assessment, but will be addressed under adverse impacts in the FS.

This assessment involves 1) the determination of contaminant concentrations at exposure points for a future resident farmer scenario and future indoor and outdoor industrial park worker scenarios, and 2) the estimation of contaminant intake through potential exposure pathways. The future resident farmer scenario is considered the most conservative situation for the following reasons:

- the future onsite farmer would be exposed to concentrations much higher than those a current offsite resident would experience because the farmer is located at the contaminant source;
- the future onsite farmer would be exposed to Area B contaminant concentrations for much longer than a current or future onsite worker; and
- the future onsite farmer scenario evaluates the greatest number of exposure pathways.

The developed scenarios are conservative and hypothetical, and their relative risks can be interpreted more flexibly by examining the assumptions and conservatism inherent in the calculations. The FS will take advantage of this flexibility.

For the contaminants with the greatest risk contribution, the carcinogenic and noncarcinogenic risks for these two exposure scenarios (both reasonable maximum exposure (RME) and central tendency exposure (CTE)) are provided on Table ES.1, along with a summary of risk. Ingestion and/or inhalation contribute to almost all of the risk; groundwater is the most important exposure medium (90 to 100 percent of each category). Tetrachloroethene had the highest overall carcinogenic risk in each exposure scenario; tetrachloromethane had the highest noncarcinogenic hazard index (80 to 90 percent of the contribution in each category). Because groundwater would contribute most of the carcinogenic and noncarcinogenic risks to future onsite residents or workers, groundwater must be the focus of the remedial efforts to significantly reduce the overall risk.

Table ES.1. Summary of Risk and Contaminants with Greatest Risk Contribution

	Overall Risk		Percent of Exposure Due to Ingestion and Inhalation	Percent of Risk via Groundwater Pathways	Contaminants of Concern with Greatest Effect	COC Effect	
	RME	CTE				RME	CTE
Carcinogenic Risk							
Resident Farmer			83	93 (RME) 95 (CTE)	Tetrachloroethene	3×10^{-4} (Adult + Child)	6×10^{-5} (Adult + Child)
Adult	5×10^{-4}	1×10^{-4}			Trichloromethane	1×10^{-4} (Adult + Child)	4×10^{-5} (Adult + Child)
Child	2×10^{-4}	4×10^{-5}					
Industrial Worker (Indoor)	2×10^{-4}	5×10^{-5}	80	100	Tetrachloroethene	8×10^{-5}	2×10^{-5}
					Trichloromethane	7×10^{-5}	2×10^{-5}
Industrial Worker (Outdoor)	1×10^{-4}	2×10^{-5}	83 (Inhalation and Dermal)	95	Tetrachloroethene	7×10^{-5}	1×10^{-5}
Noncarcinogenic HI							
Resident Farmer			80	100	Tetrachloromethane	31 (Adult + Child)	20 (Adult + Child)
Adult	18	11					
Child	21	12					
Industrial Worker (Indoor)	17	11	96 (inhalation)	100	Tetrachloromethane	15	10
Industrial Worker (Outdoor)	15	9	95 (Inhalation)	100	Tetrachloromethane	14	9

COC - contaminant of concern
CTE - central tendency exposure
HI - hazard index
RME - reasonable maximum exposure

The baseline risk assessment is considered conservative and presents the RME and CTE scenarios in the absence of any remedial action. The general conclusion of the baseline risk assessment is that the contamination measured within Operable Unit 1, Area B, may represent a significant risk to future residents or workers on the site.

ES.5. RECOMMENDATIONS

RI data relative to Operable Unit 1 are sufficiently complete to proceed to FS development and remedy selection. Preparation of the FS is recommended.

When validated background soil and groundwater data are made available through the site-wide study, the conclusions based on background will be re-evaluated. It is anticipated that the re-evaluated conclusions will not change significantly.

When surface water and sediment data are available, the environmental and human health effects of the overflow pond and the adjacent portions of the storm water retention and discharge system (the plant drainage ditch and the retention basins) should be evaluated. This evaluation need not be a part of the Operable Unit 1 study since the surface water can be considered separately from all contaminant sources within Area B.

1. INTRODUCTION

The U.S. Department of Energy (DOE) Mound Plant, Miamisburg, Ohio, was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA [also known as Superfund]) National Priority List on 21 November 1989 (54 Federal Register 48184). Pursuant to its National Priority List status, the DOE signed a CERCLA Section 120 Federal Facility Agreement (FFA) with the U.S. Environmental Protection Agency (EPA), which became effective 11 October 1990. A similar agreement was signed between the DOE and the Ohio EPA (OEPA) in July 1993. The terms of the FFA require that the DOE develop and implement remedial investigations (RIs) and feasibility studies (FSs) and conduct interim remedial actions in order to ensure that environmental impacts associated with past and present activities at the Mound Plant (the Site) are thoroughly investigated and appropriate action is taken to protect the public health and welfare and the environment.

The statement of work of the FFA also requires the DOE to produce an RI/FS report, based on the RI field work. This document is the RI report for Operable Unit 1 (Area B) at the Mound Plant and summarizes the results of the remedial investigation, including data analysis and baseline risk assessment. The physical and chemical characteristics at Operable Unit 1 (Area B) and the nature and extent of chemical contamination and contaminant migration are also addressed. In addition, findings and data analysis for work performed, including a soil gas survey, surface soil sampling, piezometer and monitor well installation/development, aquifer testing, and groundwater sampling are combined to form a conceptual model of the existing conditions at Area B.

This RI report is part of the ongoing Environmental Restoration (ER) Program at the Mound Plant and is one of many documents that have been developed to implement the work necessary to accomplish the objectives of the FFA statement of work. Relevant background material for the development of the Operable Unit 1 RI Report includes, but is not limited to, the following documents:

- Area B, Operable Unit 1 Proposal for Additional Field Work, Volume I - Text and Quality Assurance Project Plan (QAPP), and Volume II - Health and Safety Plan, September 1992 (DOE 1992a);
- Remedial Investigation/Feasibility Study, Operable Unit 9, Site-Wide Work Plan, Final, May 1992 (DOE 1992b);
- Remedial Investigation/Feasibility Study, Operable Unit 9, Site-Wide QAPP, Draft Final, June 1992 (DOE 1992c);
- Cumulative Groundwater and Monitoring Well Data Report through Fourth Quarter, FY92-Mound Plant, May 1993 (DOE 1993a);
- Operable Unit 9, Site Scoping Report: Volume 7 - Waste Management, February 1993 (DOE 1993b);

- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01, Interim Final, Office of Emergency and Remedial Response, EPA, October 1988 (EPA 1988a);

- Federal Facility Agreement, Mound Plant, between DOE and EPA (Section XX), Administrative Docket Number VW-90-C-075 (EPA 1990a); and

- Federal Facility Agreement, Mound Plant, among DOE, EPA and OEPA, Administrative Docket Number OH6 890-008-984 (EPA 1993a).

This RI report is an integral part of the ER Program at Mound Plant, so the implementation and history of this program will be discussed in the following subsection.

1.1. ENVIRONMENTAL RESTORATION PROGRAM

The DOE Albuquerque Operations Office (AL) established the ER Program, formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP), in 1984. The DOE AL initiated the ER Program to fulfill its obligations under the following environmental laws:

- CERCLA, as amended by the Superfund Amendments and Reauthorization Act (40 CFR 300);

- the Resource Conservation and Recovery Act (RCRA) (40 CFR 260-270);

- the National Environmental Policy Act of 1969 (NEPA) (Volume 83, page 852 of the U.S. Statutes and Chapter 42, Section 4321 of the U.S. Code); and

- the Atomic Energy Act of 1954 (Volume 68, page 1919 of the U.S. Statutes and Chapter 42, Section 2011 of the U.S. Code).

The authority to implement the ER Program is derived primarily from the following DOE and DOE AL orders:

- CERCLA Requirements (DOE Order 5400.4);

- Hazardous, Toxic, and Radioactive Mixed Waste Management (DOE Order 5480.2);

- Prevention, Control, and Abatement of Environmental Pollution (DOE Order 5480.1, Chapter XII);

- Environmental Protection, Safety, and Health Protection Information Reporting Requirements (DOE Order 5484.1); and

- Proposed DOE NEPA Implementing Procedures (10 CFR 1021).

The ER Program, which consists of three phases, is patterned after the EPA CERCLA program. Phase I, preliminary assessment/site inspection (PA/SI), was completed at Mound Plant in 1986. Phase II, an RI/FS, is currently under way at Mound Plant. Phase III, remedial design/remedial action (RD/RA), will implement the remedial alternatives chosen in the feasibility studies of Phase II. Figure 1.1 shows the three phases and the components, or tasks, included in each phase. These tasks have been identified by the EPA to describe the activities performed during the PA/SI, RI/FS, and RD/RA phases of the CERCLA process.

DOE Order 5400.4 requires integration of CERCLA/RCRA with NEPA, and states that integration will be achieved through the RI/FS documents. This means that RI/FS reports are modified to meet both the RI/FS and NEPA requirements.

1.1.1. Mound Plant ER Program

Mound Plant was placed on the CERCLA National Priority List in November 1989. Pursuant to that status, a CERCLA Section 120 FFA was signed between DOE and EPA (EPA 1990a). This FFA became effective 12 October 1990. The DOE, EPA, and state of Ohio signed a three-party FFA on 15 July 1993 (EPA 1993a). Because of this, the RI/FS process at Mound Plant follows the methodology of the Superfund program that was established for characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and for evaluating potential remedial options (EPA 1988b). This approach is a flexible process that is tailored to specific circumstances of individual sites and can be adjusted as additional information becomes available.

The goal of the ER Program at Mound Plant is to reduce adverse impacts on public health and the environment by:

- reducing releases of hazardous or radioactive materials, and
- bringing all inactive waste sites requiring remediation into compliance with existing state and federal regulations and requirements.

These goals will be accomplished, in part, by activities stemming from the RI/FS process:

- investigating the nature and extent of contamination,
- performing risk assessments to identify and evaluate potential threats to human health and the environment,
- developing and evaluating RA alternatives to reduce these threats to acceptable levels, and
- implementing the selected RAs.

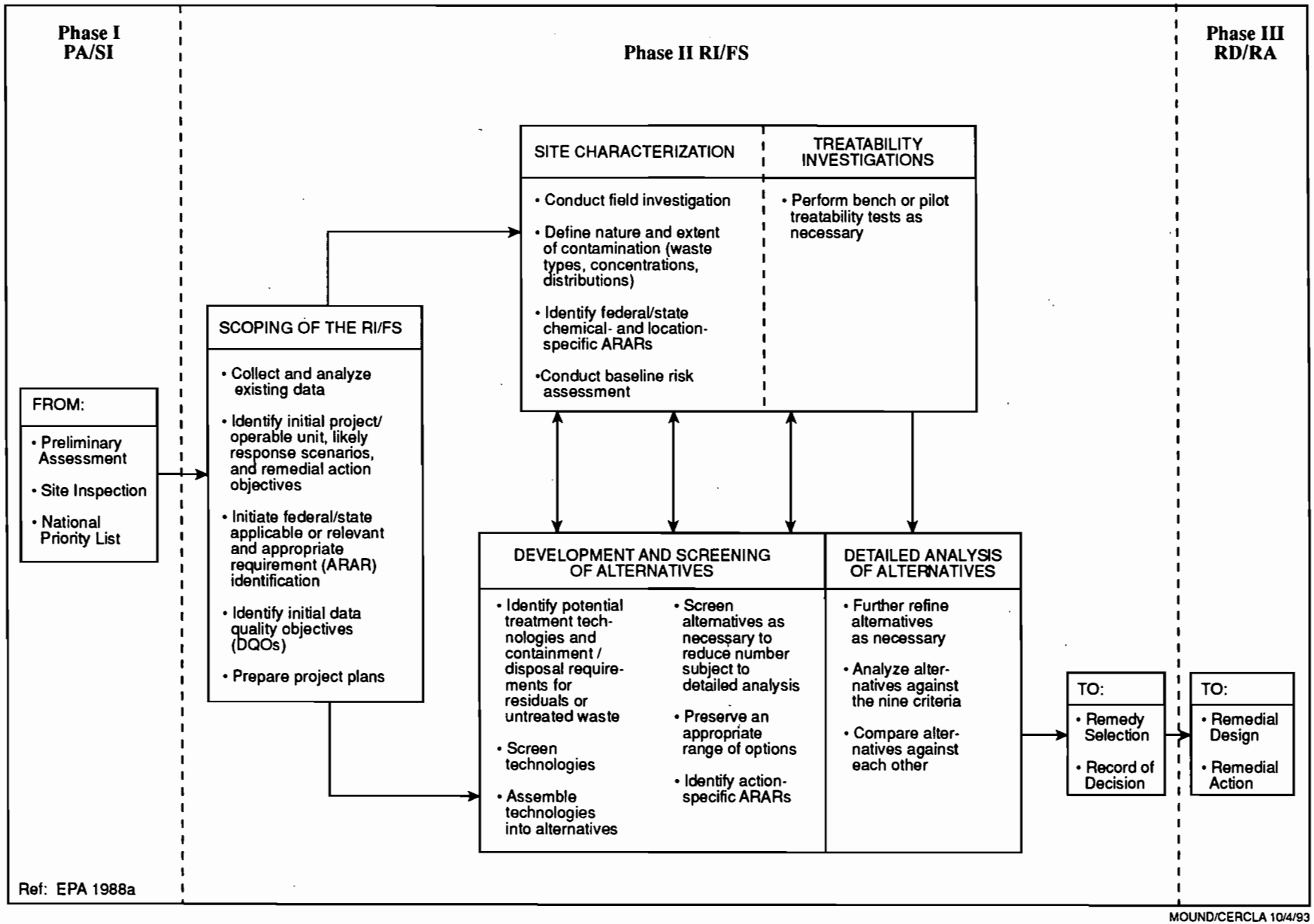


Figure 1.1. Phases of the CERCLA process.

The FFA between DOE and EPA contains both the procedural and substantive requirements for RI/FS work (EPA 1990a). The FFA defines the Mound Plant Site as follows:

> 'Site' shall mean any area where hazardous substances, pollutants or contaminants have come to be located, due to the activities at the Mound Plant (hereafter referred to as the Site). The U.S. EPA, after consulting with OEPA and U.S. DOE, may change the Site designation on the basis of additional investigations to more accurately reflect the areas contaminated by hazardous substances, pollutants or contaminants, related in whole or in part to the Mound Plant. The work to be performed in this Agreement will conform to the definition of the Site as established by U.S. EPA.

Consistent with this definition, DOE is proposing RI/FS activities for a broad geographic area, including the area within Mound Plant as well as areas beyond the Mound Plant boundaries.

Because of the magnitude and complexity of the Mound Plant RI/FS, the Site has been divided into operable units as a means of managing the investigation. Regardless of the current subdivision of the Site, the RI/FS must ultimately address all CERCLA- and RCRA-regulated environmental releases and not allow any problem to be overlooked. Also, the results of investigating individual operable units will be assembled in aggregate to provide a coherent, unified understanding of the Site.

The DOE has committed to full compliance not only with CERCLA, RCRA, and other environmental laws, but also with NEPA. DOE policy (SEN-15-90) will be implemented during the RI/FS with the recognition that NEPA implementation is dependent on CERCLA implementation, but that the CERCLA process will remain independent of NEPA compliance.

Assessment and possible remediation of Mound Plant will be completed in a comprehensive manner and will be enhanced by the division of the facility into operable units. At the completion of the RI/FS for each operable unit, the data and information will be compiled in the site-wide RI report to present a comprehensive, site-wide characterization of Mound Plant. The division of operable units for the RD/RA may not correspond exactly to that for the RI/FS, and the number of Records of Decision that will be necessary will be dependent, in part, on the outcome of each RI/FS for the individual operable units.

1.1.2. Description and Scope of Operable Units

The Mound Plant ER Program presently encompasses 109 identified or suspected release sites. The Site Scoping Report: Volume 12 (in preparation), will describe these release sites. Because of the number and complexity of potential release sites at Mound Plant, the RI/FS has been divided into nine operable units to facilitate program management. These nine operable units and current objectives are as follows:

- Area B, Operable Unit 1, includes a historical waste disposal area (landfill) from which there has been a known release of volatile organic compounds (VOCs) to the Buried Valley aquifer. Three stages of the remedial investigation, as well as additional work, have been performed for Area B.

- Main Hill, Operable Unit 2, includes potential release sites on the Mound Plant Main Hill, including some peripheral groundwater seeps. The scope of investigation includes characterization of the indurated bedrock and unconsolidated overburden on the Main Hill, associated soils, and groundwater.

- Miscellaneous Sites, Operable Unit 3, includes those potential release sites for which little or no data were available. Collection of site-specific data in a limited field investigation was undertaken for scoping. The report of that effort (DOE 1993c) separated all Operable Unit 3 sites into two categories: that for which no further action is required, and that for which additional information is needed. Areas that required additional information were reassigned to Operable Units 2 and 5, based on location. Operable Unit 3 has been closed out with no further documentation.

- Miami-Erie Canal, Operable Unit 4, addresses an abandoned segment of the Miami-Erie Canal west of Mound Plant that contains plutonium-contaminated sediments (from a 1969 waste-line break) and tritium-contaminated soils. It is 1 mile long, and is considered to be one potential release site.

- Radioactively Contaminated Soils, Operable Unit 5, includes soils with known or suspected radioactive contamination, and the geographical area of the SM/PP Hill and the New Property. The sites within Operable Unit 5 are not currently scheduled for Decontamination and Decommissioning (D&D) under the D&D Program at Mound Plant. It is anticipated that, as sites obtain funding under the D&D Program, they may be moved from Operable Unit 5 to Operable Unit 6, described below. Since many of the known radioactively contaminated sites are located on the SM/PP Hill, Operable Unit 5 has the geographic responsibility for the SM/PP Hill as well as the New Property. As with the Main Hill, investigations of the potential source terms on the SM/PP Hill may require characterization of the bedrock and unconsolidated overburden.

- D&D Program Sites, Operable Unit 6, includes potential release sites with radioactively contaminated soils that are undergoing cleanup or are scheduled for cleanup in the near future. Because it is already known that the contaminated soil will be cleaned up, and because the D&D Program is an ongoing activity under the Atomic Energy Act that reduces potential impacts to human health and the environment, the scope of the RI/FS for these sites is verification of cleanup after the soil is removed. The cleanup levels are to be determined through the CERCLA risk assessment process.

- Limited Action Sites, Operable Unit 7, includes potential release sites that are believed to have no contamination based on a review of site histories and an August 1990 joint visual site inspection by the DOE, the EPA, and the OEPA. No further action is required, and Operable Unit 7 has been closed out.

- Inactive Underground Storage Tanks, Operable Unit 8, included underground storage tanks primarily near the Waste Disposal (WD) Building. The scope of the RI/FS also included an early review to determine the regulatory status of all underground tanks at Mound Plant, and resulted in a distribution of responsibility for the tanks between the ER Program and a Mound Plant underground tank compliance program under RCRA Subtitle I (to be administered by the state of Ohio). Tanks remaining in the ER Program were reassigned to other operable units, based on location. An Underground Storage Tank Program Plan (DOE 1992d) was promulgated to address non-ER Program tanks. Operable Unit 8 has been closed out.

- Site-Wide RI/FS, Operable Unit 9, includes off-plant migration of contaminants in groundwater, soils, surface water and sediments, air, and flora and fauna. In addition, the Site-wide RI/FS will ensure that a comprehensive investigation is performed by compiling all data from individual operable unit investigations into a comprehensive report. Data reports from specific site-wide investigations conducted under this work plan will be initially reported in interim reports or technical memoranda to ensure that the off-plant and regional data are available early.

Operable Units 1, 2, 4, 5, 6, and 9 generally divide the Mound Plant Site into geographic areas (Figure 1.2). Each operable unit will address all media sources and contaminants within its assigned boundaries. Media will include soils and groundwater, surface water and sediment, and air, as appropriate. Contaminants will include radionuclides, VOCs, semivolatile organic compounds, metals, high explosives, and pesticides/polychlorinated biphenyls (PCBs), as appropriate.

Characterization of the groundwater pathway and of the nature and extent of contamination in the groundwater is an important element of the Mound Plant RI/FS. Four of the operable units have focused objectives with respect to groundwater:

- Area B, Operable Unit 1, addresses contamination of the Buried Valley aquifer from historic landfill operations at Area B;

- The Main Hill, Operable Unit 2, addresses contamination of groundwater on the Main Hill;

- Radioactively Contaminated Soils, Operable Unit 5, addresses potential contamination of groundwater on the SM/PP Hill; and

- The Site-Wide RI/FS, Operable Unit 9, integrates the groundwater investigations and includes specific investigations of regional water quality and off-plant migration of contamination from Mound Plant to the Buried Valley aquifer.

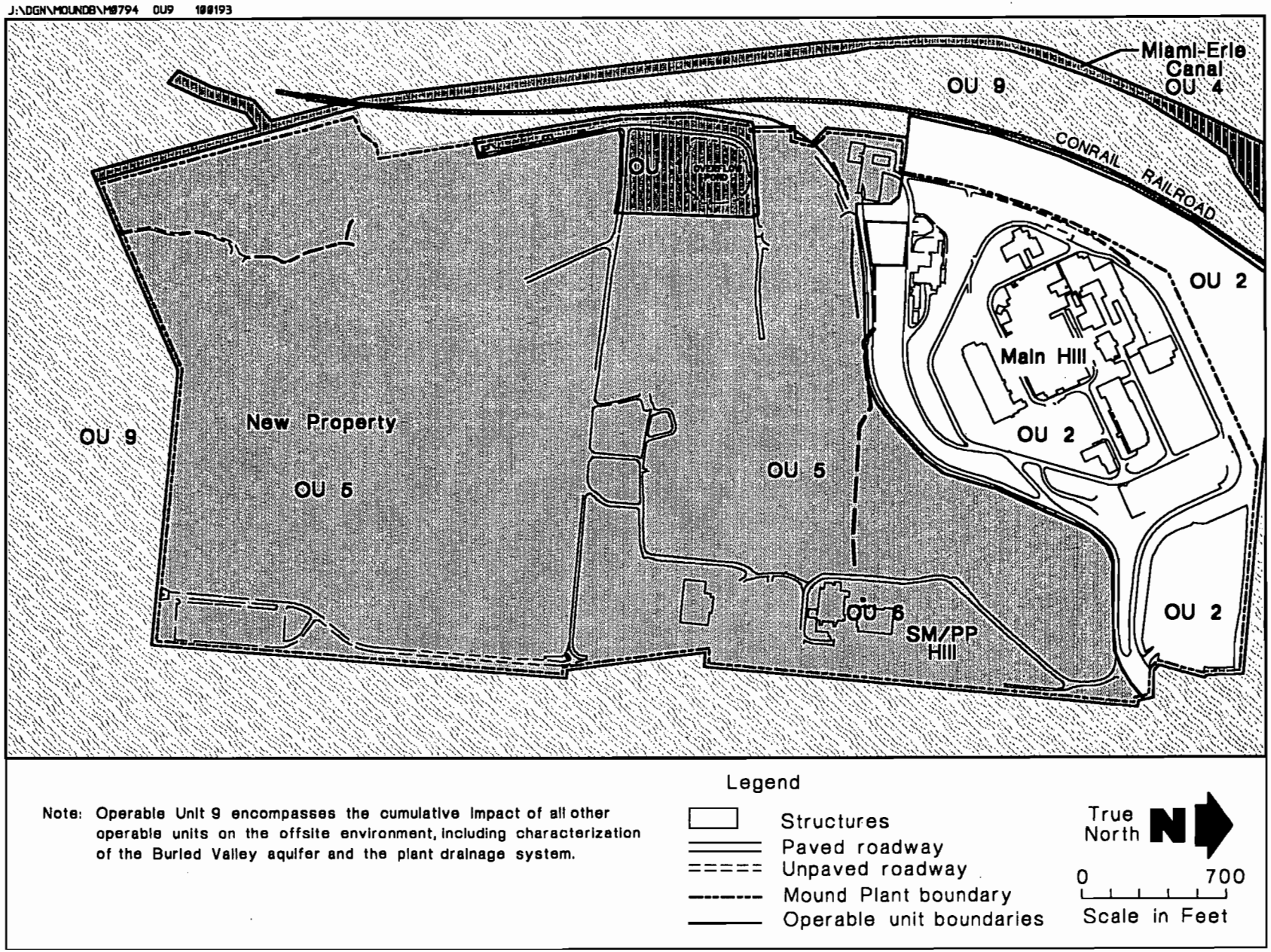


Figure 1.2. Mound plant operable unit boundaries.

1.2. INSTALLATION BACKGROUND

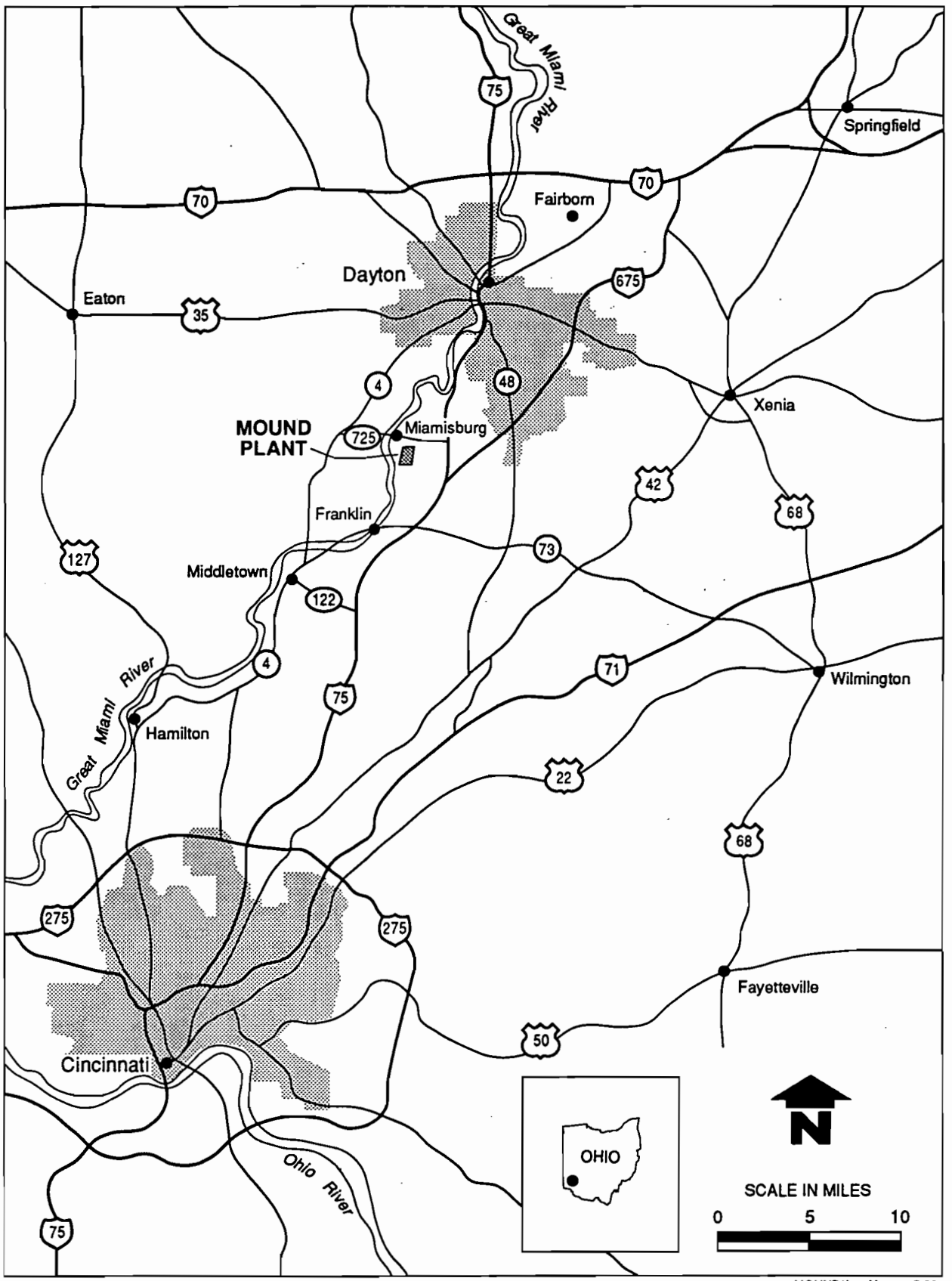
Mound Plant is a government-owned and contractor-operated facility occupying a 306-acre site on the outskirts of the town of Miamisburg in Montgomery County, Ohio (Figure 1.3). The site is approximately 10 miles south-southwest of Dayton and 45 miles north of Cincinnati (Figure 1.4). The Mound Laboratory was occupied by Monsanto Research Corporation (MRC) personnel in May 1948, and operations involving radionuclides began in January 1949 (Meyer 1991). The northern boundary of Mound Plant is approximately 0.13 mile south of Mound Avenue in Miamisburg. Brenner Road forms the southern boundary of Mound Plant, and the Conrail Railroad (formerly the Penn-Central) roughly parallels the western boundary at distances of about 50 to 200 ft (MRC 1985a). A railroad siding enters the plant from the west and services the lower plant valley. Details of the plant property boundaries, fencing, and utilities are included in the Site Scoping Report: Volume 4 - Engineering Map Series (DOE 1991a). The history of plant operations is presented in the RI/FS, Operable Unit 9, Site-Wide Work Plan (DOE 1992b).

In the early 1970s, as national concerns about the environment and the conservation of resources mounted, Mound Plant expanded its programs in environmental monitoring and waste management. The environmental monitoring program is discussed in the Site Scoping Report: Volume 8 - Environmental Monitoring Data (DOE 1992e), and the waste management program is detailed in Site Scoping Report: Volume 7 - Waste Management (DOE 1993b).

1.2.1. Description of Installation

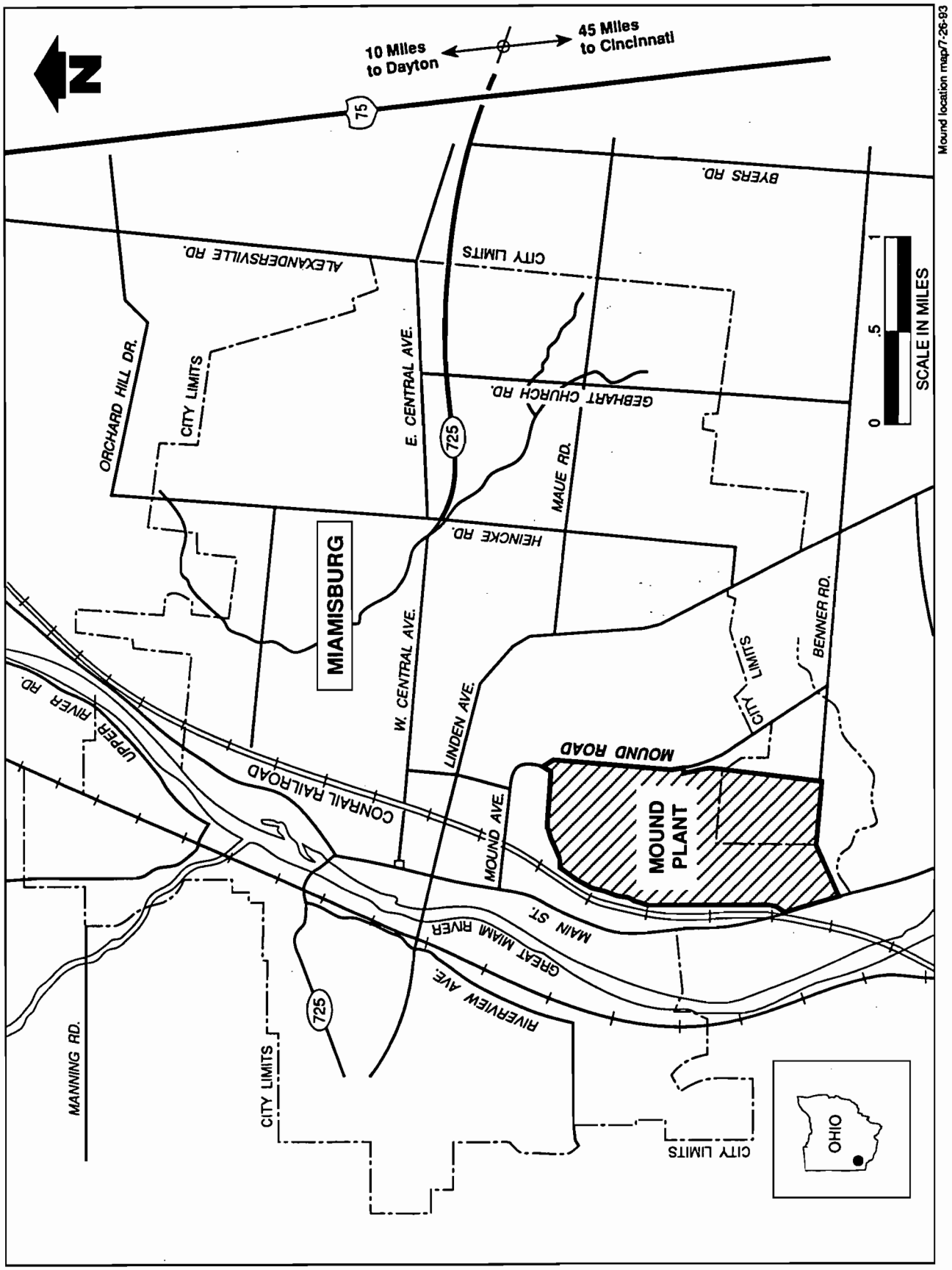
The predominant geographical feature in the region surrounding Mound Plant is the Great Miami River, which flows from northeast to southwest through Miamisburg, although near Mound Plant it flows essentially to the south. Mound Plant is situated on a high area overlooking Miamisburg, the Great Miami River, and the river floodplain to the west (Figure 1.5). The property is characterized by two high areas divided by a minor northeast-southwest trending valley that contains a tributary to the Great Miami River. Details of the plant topography and surface water features (springs, seeps, streams, and ponds) are included in the Site Scoping Report: Volume 5 - Topographic Map Series (DOE 1991c).

There are currently over 100 buildings on the site. Most of the buildings are located on the elevated northwest area known as the Main Hill. A smaller group of buildings is located on the elevated southeast area, known as the SM/PP Hill. Several buildings are located in the valley and on the valley slopes (Figure 1.6). Uses of the buildings are described in the Mound Site Development Plan (MRC 1985a). The southern part of the property is undeveloped except for an unpaved parking lot.



MOUND/AreaMap 4-15-92

Figure 1.3. Regional location of Mound Plant.



Mound location map/7-26-93

Figure 1.4. Location of Mound Plant, Miamisburg, Ohio.

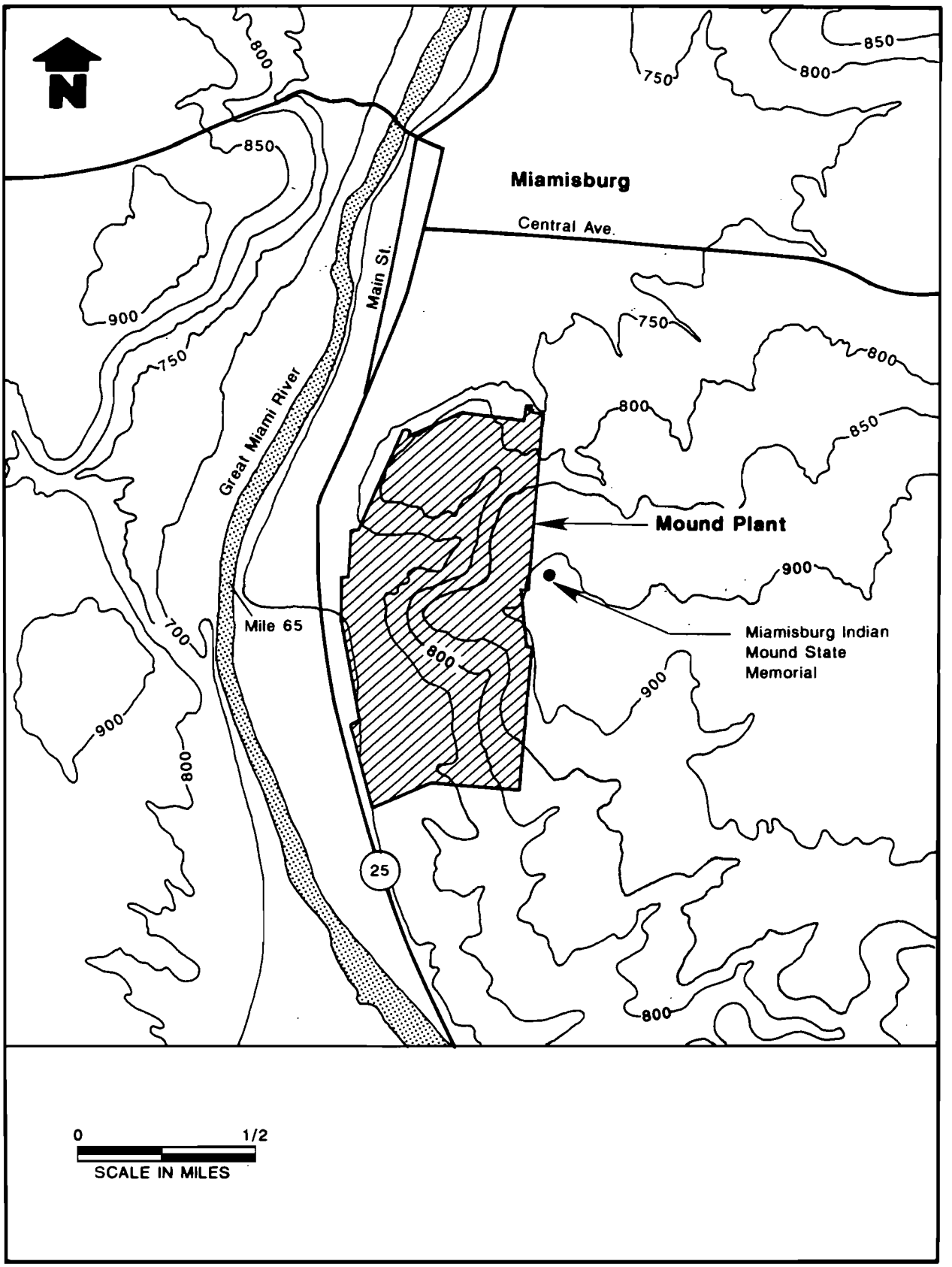


Figure 1.5. Topographic features of the Mound Plant area.

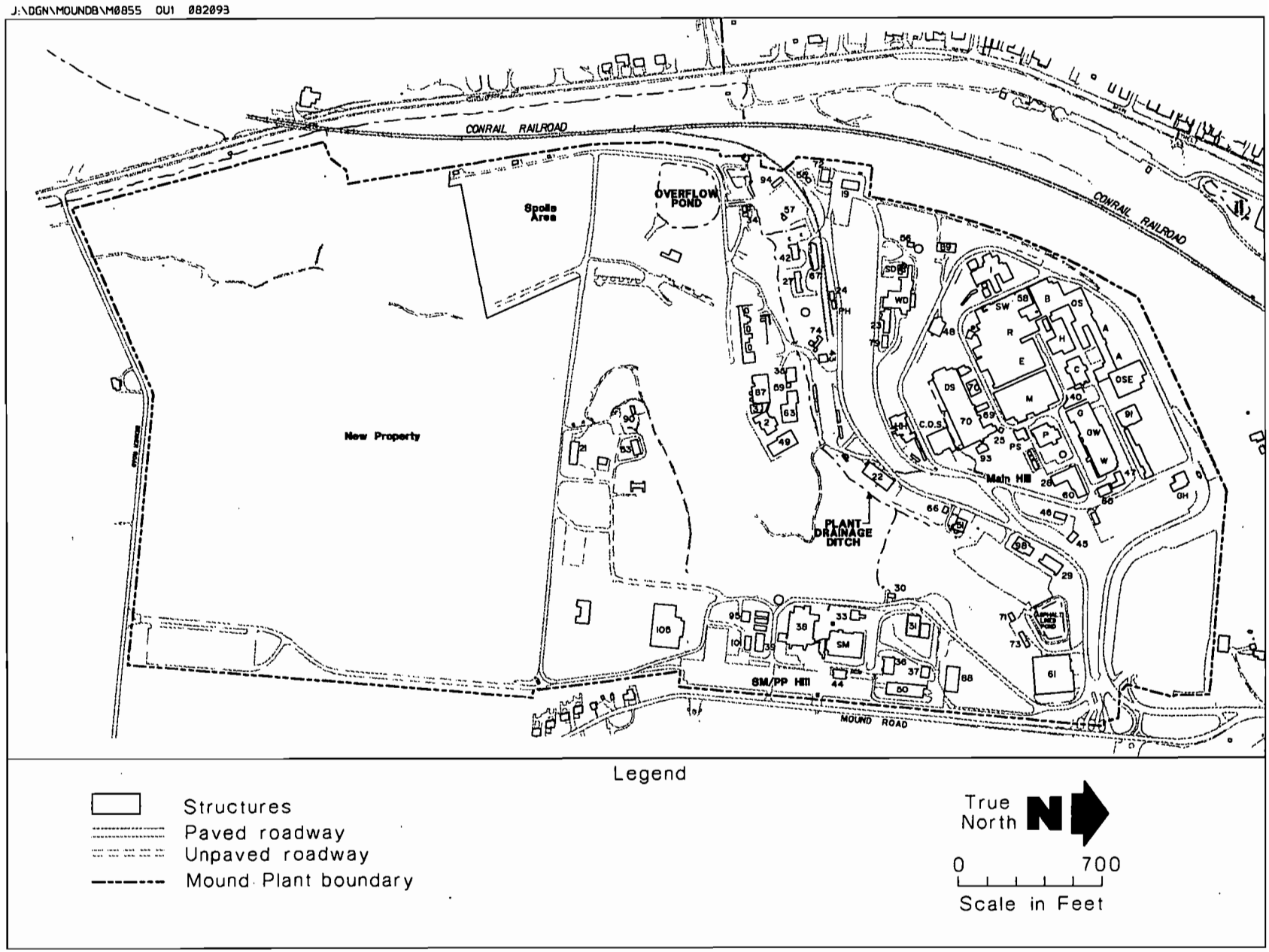


Figure 1.6. Mound Plant building locations.

The surface features of Mound Plant are well known from previous and ongoing studies. Surface features have been described in the Site Safety Assessment (Dames and Moore 1973), the final environmental impact statement (DOE 1979), and the site-wide RI work plan (DOE 1992b). Disposal areas have been documented in the Site Scoping Report: Volume 7, Waste Management (DOE 1993b).

Other physical features of the plant are also well known or are parts of ongoing studies. The plant drainage ditch and surface water system were engineered to control flow. A map of surface water features is included in the Site Scoping Report: Volume 5 - Topographic Map Series (DOE 1991c), but the full identification and characterization of all surface water features remains an ongoing task. Leachate springs and seeps have been identified on the Main Hill and SM/PP Hill and are the subject of ongoing planning as part of the Operable Unit 2 effort. The Main Hill seeps have been sampled as part of the ER Program quarterly sampling, but the SM/PP Hill seeps have not been routinely sampled since early analysis indicated no contamination.

The structure of the surrounding community (residences and commercial buildings) has been described in the Site description and safety assessment (Dames and Moore 1973) and the final environmental impact statement (DOE 1979). Current information is provided in Section 2 of this document. Vegetation on the plant has been largely disturbed by construction activities and is discussed in the RI/FS, Operable Unit 9, site-wide work plan (DOE 1992b).

1.2.2. Waste Management Program Status at Mound Plant

The scope and character of the waste management program at Mound Plant are described in the Site Scoping Report: Volume 7 - Waste Management (DOE 1993b). A full listing of the permits and registrations applied for or received by the plant is detailed in the Operable Unit 9, Site Scoping Report: Volume 10 - Permits and Enforcement Actions (DOE 1992f).

In November 1980, Mound Plant submitted to EPA a Notification of Hazardous Waste Activity (EPA Form 8700-12). The facility I.D. Number is OH6890008984. At the same time, Mound Plant submitted a General Information Form (Form 1 General, EPA Form 3510-1) and a RCRA Part A Hazardous Waste Permit Application (Form 3 RCRA, EPA Form 3510-3) to store hazardous waste in containers and to treat hazardous waste onsite.

In May 1988, the preliminary review (PR) and visual site inspection (VSI) were conducted as part of the RCRA Facility Assessment (RFA) for the plant. The PR and VSI resulted in the identification of 86 solid waste management units (SWMUs) and 38 other areas of concern. A draft PR/VSI report was

prepared by A.T. Kearney, Inc., under contract to EPA Region V, but was never finalized (EPA 1988d). All of the 124 sites identified by the PR/VSI are currently included in the ER Program (DOE 1992b).

In May 1989, Mound Plant submitted a revised Part A permit application identifying EG&G Mound Applied Technologies (EG&G-MAT) as the new plant operator. The revised Part A permit application was reviewed and approved by EPA Region V in early June 1989. On 30 June 1989, the state of Ohio was granted final authorization by the EPA to operate its program in lieu of the federal program. In anticipation of the approval of the permit application, EPA and OEPA have recently conducted inspections of the plant.

At the request of the state of Ohio, a revised RCRA Part A and Part B Permit Application was submitted to the state in May 1990 (DOE 1990). This application includes a trial burn plan for the glass melter thermal treatment unit (glass melter furnace). Copies of the application and the trial burn plan were submitted to the EPA and are, at this writing, under review. The RCRA Part B permit application was resubmitted to the state of Ohio in October 1991. Mound Plant operates in interim status to store and dispose of hazardous and mixed waste (DOE 1992f).

1.3. TASK DESCRIPTION

This RI report is the completion report for many tasks performed under the ER Program at Mound Plant. These tasks began with the PA/SI and continued through scoping of the RI/FS and execution of the RI field activities resulting in site characterization for Operable Unit 1 (Area B).

Area B occupies an area of approximately 4 acres in the southwest portion of Mound Plant; it includes historic landfill site that was used by Mound Plant from 1948 to 1977. Waste materials that were disposed of (some by burning) in Area B included general trash, liquid waste, and low-level radioactive waste. Much of this waste was later relocated and encapsuled in a site sanitary landfill constructed in 1977. An overflow pond was also constructed at the same time, partially covering the historic landfill site. After 1977, waste was no longer disposed of in Area B.

There are known releases of VOCs from Area B into the adjacent Buried Valley aquifer. In addition, tritium has been detected in water samples taken from wells in Area B, although the concentration was below the maximum contaminant level (MCL). The following sections provide additional details of this information, as well as the historical background of Area B.

1.3.1. History of Area B

This discussion of the source history and waste disposal practices at Area B from 1948 to the present is based on interviews with Mound Plant employees (Mound 1990) and information gathered from various ER Program documents, including the following:

- Site Scoping Report: Volume 7 - Waste Management (DOE 1993b);
- Remedial Investigation/Feasibility Study Site-Wide Work Plan [Final] (DOE 1992b); and
- Site Scoping Report: Volume 3 - Radiological Site Survey [Final] (DOE 1993d).

Area B is comprised of approximately 4 acres in the southwestern part of Mound Plant (Figure 1.7). Cut-and-fill activities and refuse and waste disposal have occurred throughout the plant's history. Area B was used for waste disposal by Mound Plant from 1948 to 1977. However, no written manifests of the waste types and quantities exist, and uniform disposal practices were not followed.

Before 1947, Area B was a residential area with two or three small houses and storage buildings. During plant construction, the area was exploited for its gravel deposits. The gravel excavations extended from about the middle of Area B southward to the road and into the hillside to the east. The excavations were deepest along the southern part of Area B (estimated at 4 to 6 ft deep) and became progressively shallower to the north. Removal of gravel was routine until 1977, when Area B was modified by the overflow pond and site sanitary landfill. Trenches excavated by a front-end loader were cut along a north-south line. These small gravel trenches would typically fill with water during heavy rains, as would the lower, deeper parts of the old excavation.

When Mound Plant began operations in 1948, Area B consisted of a depression remaining from old gravel operations, bounded on the west and south by a dirt road (Figure 1.8). The area would typically flood during heavy rains. The old gravel excavation and the disturbed area just north of the excavation were used for landfill, including open burning of trash and garbage from plant operations. From 1948 to 1954, reportedly only nonradioactive waste was disposed of in Area B. Solid and liquid waste disposed of in Area B at that time consisted of administrative and laboratory trash, including paper, glass, wood, plastics, kitchen garbage, and bottled urine samples. A burn cage, consisting of a wire mesh structure that caught ashes from burning wood, paper, and other materials, was used (Figure 1.9).

From 1954 to 1969, Area B may have received solid and liquid waste containing beryllium, mercury, trichloroethene (TCE), tetrachloromethane, nickel carbonyl gas cylinders (that had been evacuated to

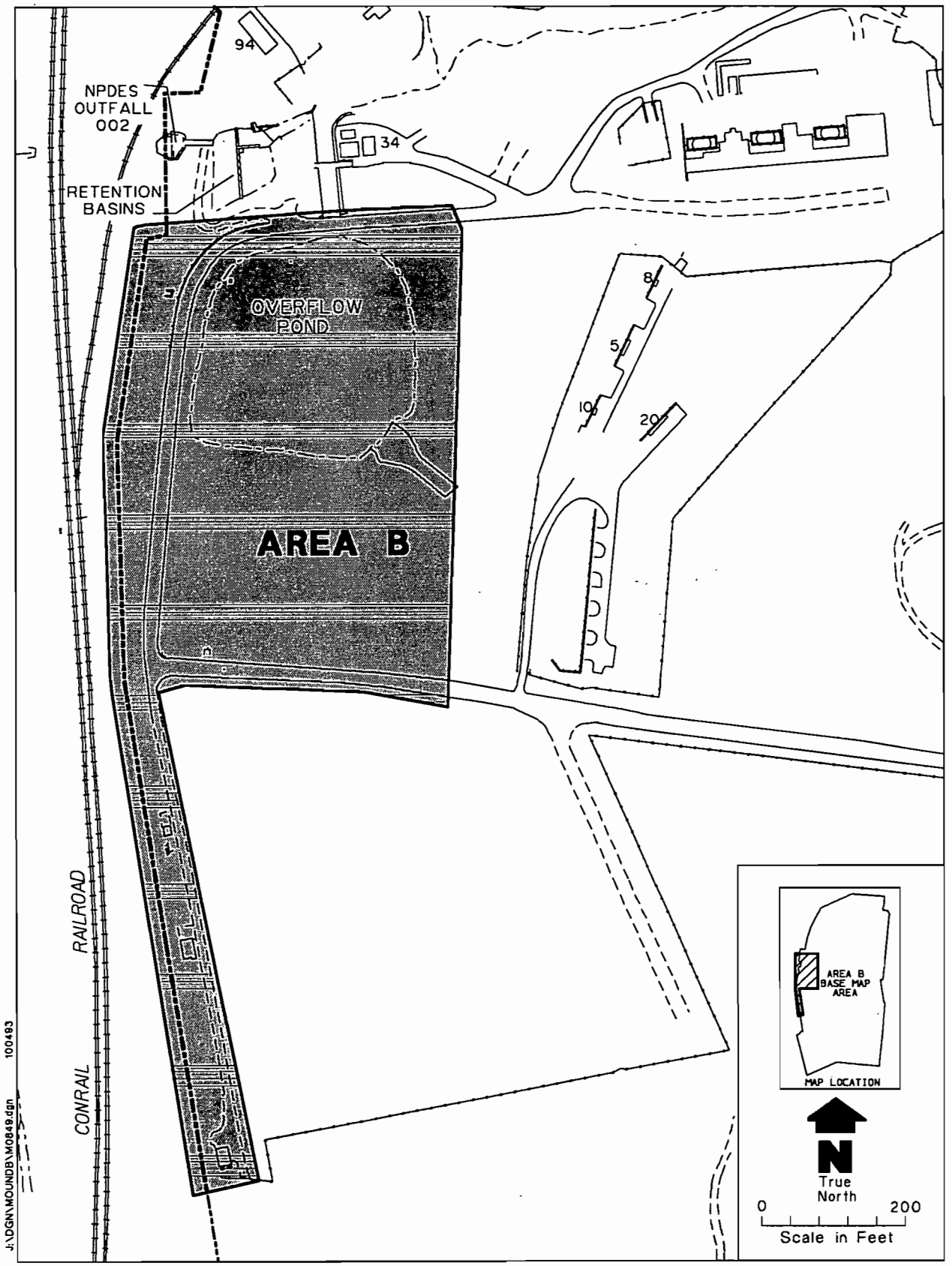


Figure 1.7. Area B base map with Area B outlined.

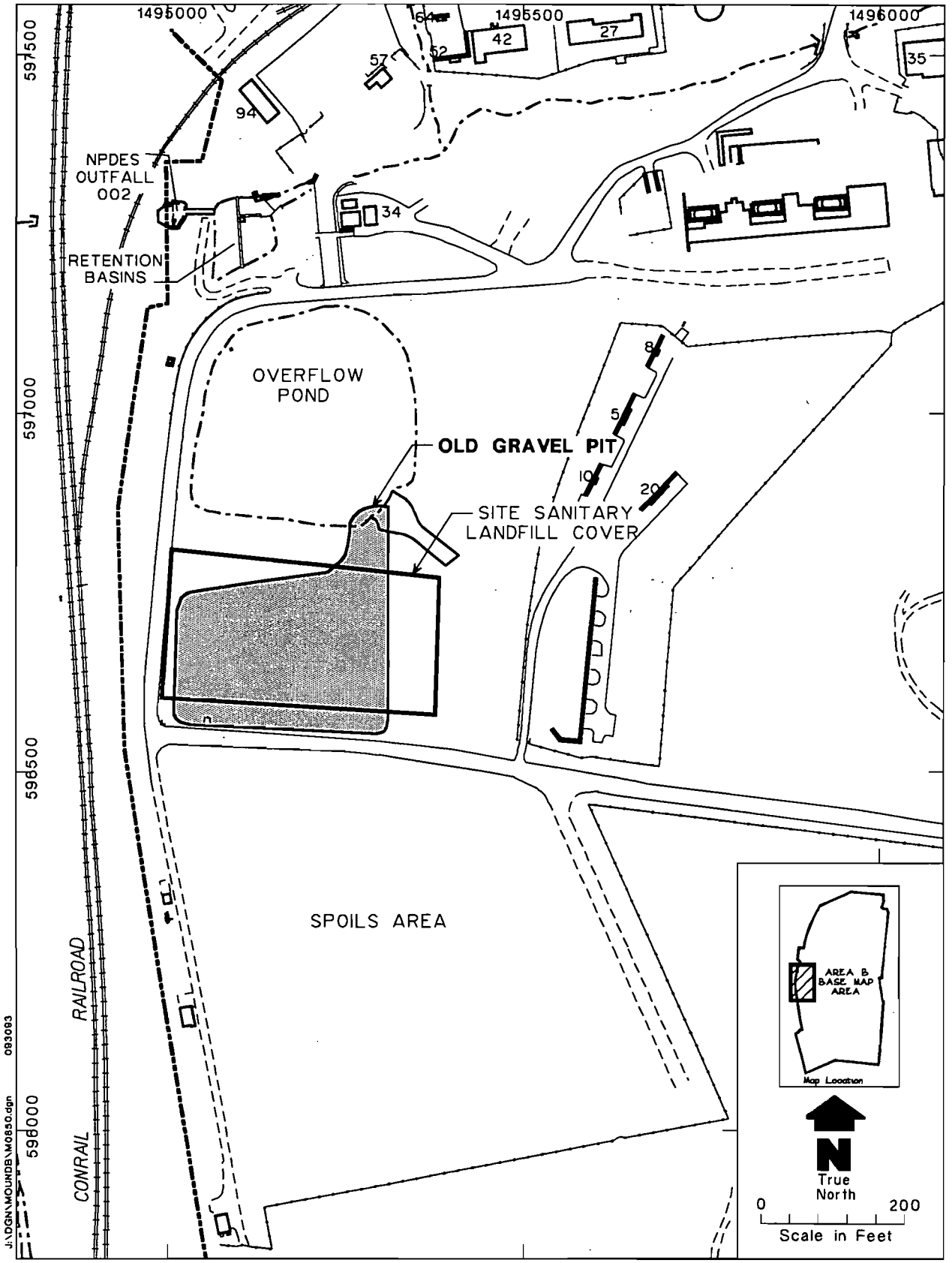


Figure 1.8. Old gravel pit in Area B, Mound Plant.

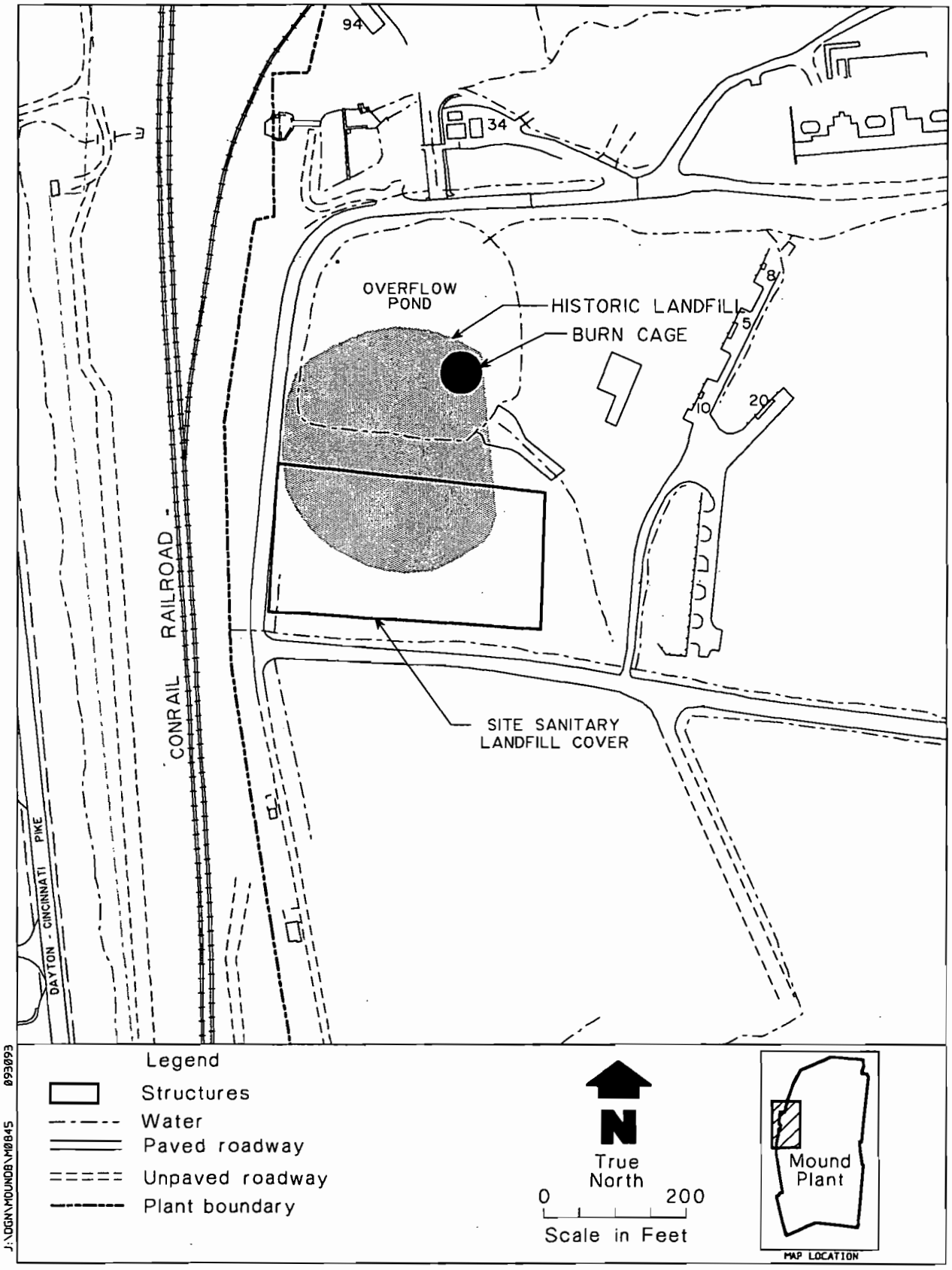


Figure 1.9. Historical landfill and burn cage in Area B, Mound Plant.

ensure no gas remained), benzene, alcohol, acetone (contained in paints), photoprocessing solutions, plating materials, small quantities of PCB oils, and other laboratory, office, and kitchen waste (DOE 1993b). Waste was generally collected weekly for disposal. Solid waste, mostly paper, office, and kitchen garbage, was placed in the burn cage and ignited to reduce its volume.

Nonradioactive liquid waste was picked up on Friday mornings, two to three times a month. The liquid waste was typically in closed jars, bottles, and cans and usually did not collectively exceed 50 gallons. These containers were dumped on the ground or stacked in groups and ignited. Other fuels were sometimes added to aid in burning; sometimes the liquids simply soaked into the ground (Brunner 1991; Burdg 1991; Thomas 1991).

In 1954, the first burial in Area B occurred along the southern boundary of the old gravel quarry, just north of and parallel to the east-west road that climbs the SM/PP Hill. An irregularly shaped trench was excavated to the maximum depth obtainable by the backhoe equipment of the day (Figure 1.10). The trench was deepest (estimated at 14 ft) on the east side, and it became shallower to the west toward the road intersection. Residual steel and metal debris (such as rebar and pipe), the result of a fire that consumed the Dayton Unit salvage materials on another part of the plant (now Area 13), were progressively buried in the trench. The burial started in the southeast corner of Area B and extended westward toward the road intersection, but it did not fully extend to the intersection. The debris and backfill were regraded to just below the road level. After regrading, a depression was left in the southwest corner of Area B that had remained unaffected by the burial project. The trench was open for about 5 days, since the excavation and burial project required one work week to complete (Thomas 1991).

During 1955 and possibly 1956, empty drums that had contained thorium were buried in the depression in the southwest corner of Area B in the second major burial project. A shallow excavation was made in the depression, and about 2,500 55-gallon drums were crushed with a crane and wrecking ball and then covered with a thin layer (about 1 to 2 ft) of soil cover (Figure 1.10). The buried drums and backfill were regraded to just below the level of the road.

In 1965, sand contaminated with polonium-210 was also placed in the southwest corner of Area B, and the site was regraded to blend with the landfill and burning operations to the north. The sand had come from the WD Building and was a residual product of the polonium research and production conducted in the early 1950s. Because of its short half-life (138 days), virtually all of the polonium-210 has decayed to inconsequential quantities of stable lead.

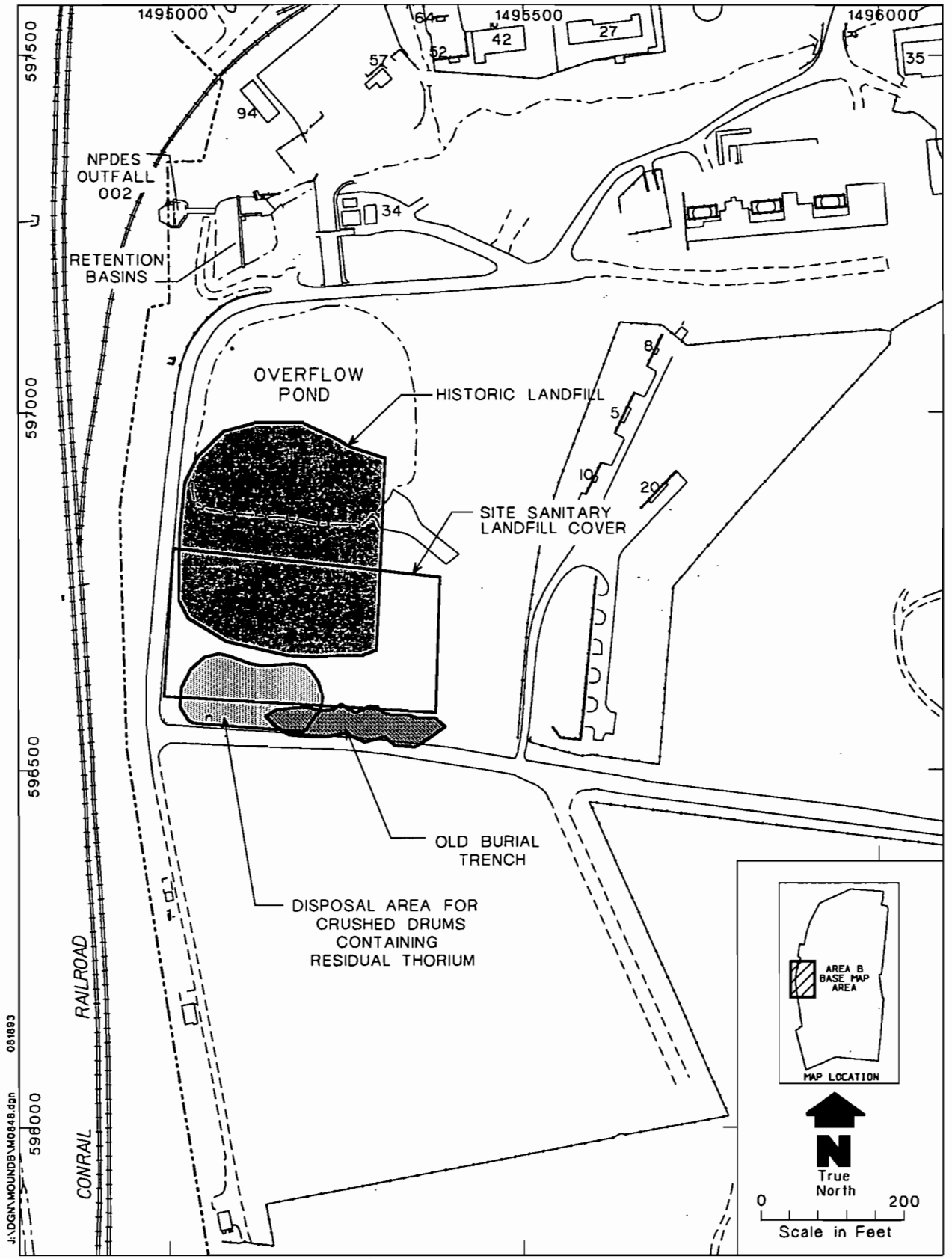


Figure 1.10. Location of buried thorium drums, old burial trench, and historic landfill in Area B, Mound Plant.

From some time after 1971 until 1976, low-level radioactive sediments dredged from the former flow monitoring station on the lower reach of the plant drainage ditch were routinely placed in Area B. Although these have been called the Area 18 ditch sediments in preceding documents, the dredging sediments do not appear to have been distinguished from other contamination and were probably incorporated into the site sanitary landfill when it was built in 1977.

Although the waste streams from the plant processing operations were separated into radioactive and nonradioactive streams, radioactive waste was, in one documented case, accidentally sent to Area B. In that incident during 1958 or 1959, some low-level radioactive waste contaminated with plutonium-239 was sent out of the building and burned in Area B. Normally, the low-level waste (for example, gloves and other disposable items) was shipped offsite. The error was discovered and the contaminated soils and burned materials in Area B were removed and disposed of as radioactive waste (Garner 1991).

In 1969, the state of Ohio banned open burning, and Mound Plant prohibited open burning of solid and liquid waste in Area B. Hazardous liquid waste was collected and disposed of offsite. Solid waste was placed in east-west-trending trenches cut by a bulldozer (Figure 1.11). Solid waste was dumped in the middle of Area B and moved by bulldozer to the trenches, where it was compressed and covered with a few inches of soil. Solid waste was rarely dumped directly into the trenches because of the muddy conditions in the area. The solid waste typically consisted of plastic bags containing paper, plastic, glass, cloth, other unknown office and laboratory trash, food scraps from the cafeteria, and plastic sample vials containing urine and liquid scintillation "cocktails." About 4 ft of soil cover was placed over the filled trenches to complete the landfill cells. The southernmost trench was not used before the area was remodeled for the overflow pond and sanitary landfill (Brunner 1991).

Sometime during 1972 or 1973, soil materials were excavated from the west-central portion of Area B and relocated to a ravine along the upper reach of the plant drainage ditch to serve as fill material and facilitate the construction of a parking lot behind the firehouse. This area along the drainage ditch will be addressed as part of Operable Unit 5. The relocated material probably consisted of natural fill and some burned and solid waste. The exact volumes of waste and fill involved are unknown.

In the mid-1970s, a drum storage area was located at the site of the historic landfill, near the southwestern corner of Area B. It was used in the mid-1970s to stage and temporarily store hazardous chemical waste before it was shipped off-plant for disposal. The area replaced the old firing range drum storage area for this activity. The waste chemicals were typically picked up weekly by waste management personnel and transferred from small laboratory vessels to 55-gallon drums. The drums were placed in open-topped, steel dumpsters that could be moved around to allow the solid waste

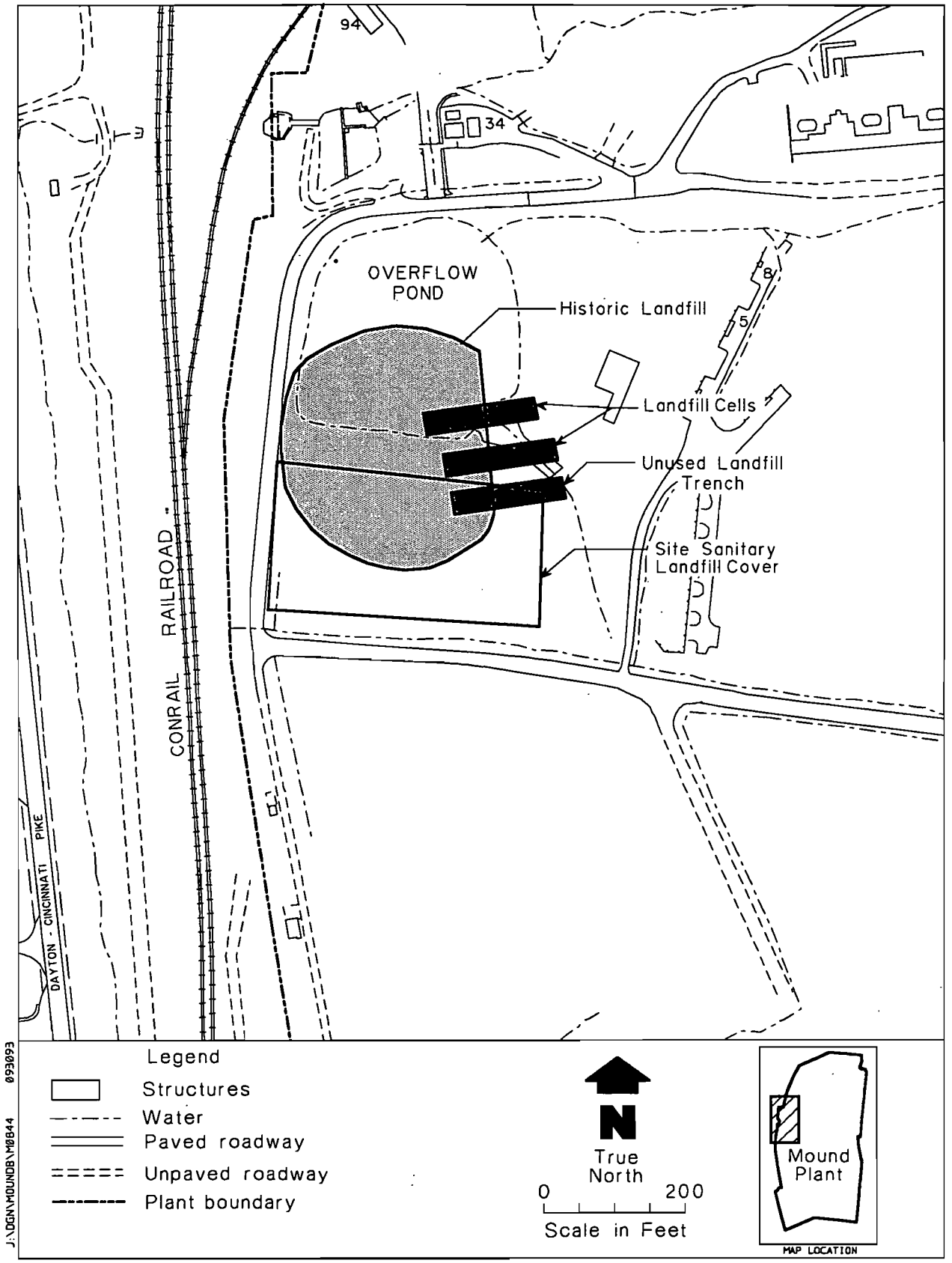


Figure 1.11. Landfill cells in Area B, Mound Plant.

landfill operations to continue concurrently. The chemical waste staging activities in Area B were moved to the chemical waste storage area in 1976 to allow the construction of the overflow pond and site sanitary landfill (DOE 1993b).

Prior to construction of the overflow pond and site sanitary landfill, Area B was surveyed for trash using soil boreholes and test pits installed by Dames and Moore (1976) and Bowser and Morner (1975). The trash to be excavated was defined in the bid invitation specifications document (DOE 1977) as "normally non-nuclear contaminated refuse from laboratory operations." The trash was described as consisting of two types: the first type was "unburned materials consisting of plastic bags containing paper, plastic, glass, cloth, other unknown office and laboratory trash, food scraps from the cafeteria, and plastic bottles of urine;" the second type of trash to be excavated was described as "burnt materials consisting of residues of metal scraps, tin cans, heavy plastic, wood, wire, short lengths of pipe, smashed drums, sheet metal, and laboratory trash" in well-defined layers.

The borehole samples were visually inspected, described, and monitored by Mound Plant health physicists, but samples were not analyzed chemically. Some of the original borehole logs indicate a "strong odor of solvent of some sort," and organic odors and layers were prominent. Distillates from the borehole samples were analyzed for tritium by plant personnel, and tritium concentrations were very low or not detected. During construction, no attempt was made to define trash by any means other than by visual inspection.

In 1977 and 1978, the overflow pond and site sanitary landfill were constructed on the site of Area B. The overflow pond was built to complement the low-flow retention basins, which were constructed in 1976 on the lower reach of the plant drainage ditch. Much of the solid waste in the historic landfill was excavated and moved to the site sanitary landfill. Generally, debris from the Dayton Unit fire in the first trench and empty, crushed drums that had contained thorium in the second trench were not excavated and remained under the landfill. The volume excavated was limited by the volume required for the pond construction. The overflow pond and site sanitary landfill are discussed in later subsections.

The entire overflow pond project was monitored by Mound Plant health physicists. Material with plutonium levels of greater than 100 picocuries per gram (pCi/g) was considered hazardous, and a small amount (<5 gallons) of soil with an elevated plutonium level above 100 pCi/g was detected and removed from the overflow pond construction area. Other than the dredged materials from the former flow channel that may have been mixed with other general soil materials, no known radioactive materials were included in construction of either the interior or the cover of the new site sanitary landfill.

Currently (1994), Area B remains much as it did in 1978 after the overflow pond and site sanitary landfill were constructed. The road along the north and west boundary has been paved and, in the 1980s, a bridge was built over the overflow channel from the plant drainage ditch to the overflow pond. Numerous monitoring wells have been installed around Area B as part of area environmental investigations. The Site Scoping Report: Volume 2 - Geologic Log and Well Information Report [Final] (DOE 1992g) contains a well location map and detailed construction logs for area wells installed through 1991 for the RI. Wells installed in 1993 as part of this and the site-wide RI are described in the Operable Unit 9, Hydrogeologic Investigation Well Information Report (DOE 1993e). Additional well information is included in this RI report.

1.3.1.1. Overflow Pond

The areas of the historic landfill site and gravel pit site were recontoured to permit construction of the overflow pond (Dames and Moore 1976). The purpose of the pond is to retain storm flows, settle sediment, and support compliance with National Pollutants Discharge Elimination System (NPDES) discharge standards for suspended solids. The bottom of the overflow pond is lined with a 3-ft-thick layer of natural clay distributed over an area of approximately 90,000 sq ft (DOE 1986; Mound 1977).

During the design phase of the overflow pond project, the Mound Plant environmental monitoring group installed several polyvinyl chloride (PVC)-cased groundwater monitoring wells as part of the Potable Water Standards Project (Dames and Moore 1976). All of the PVC well casings, except for well 0055, were filled with concrete prior to construction of the overflow pond. The PVC well casings were destroyed by heavy equipment operation during construction. During construction of the pond, well 0055 was not removed so that it could remain a permanent monitoring well. As excavation and construction progressed, the PVC well casing for well 0055 was protected, and the top of the casing was cut off by hand as the pond bottom was cut and lowered. Well 0055 was abandoned (the casing was removed and the boring was sealed with grout) as part of the additional field work in 1992.

In the construction of the overflow pond, glacial till was excavated and used for construction of the surrounding road embankments. On the east side, the pond embankment was benched into the hillside. Areas with steep slopes and areas of potentially concentrated runoff were lined with riprap, asphalt, or concrete for erosion protection. On the north and west sides, the road was elevated and constructed to specifications for water impoundment. The north side contains an overflow channel from the plant drainage ditch and the low-flow retention basins installed the year before. The pond liner is a natural clay-bearing glacial till deposit that was tested for conformance with geotechnical specifications before and during construction, and is at least 3 ft thick.

The pond is built with earthen dikes and has a 5,000,000-gallon capacity. This capacity allows the pond, if it is nearly empty, to retain all facility effluents for five days if a contaminant spill occurs. Effluent in the overflow pond is discharged through a standpipe in the northwest corner of the pond to the stilling basin below the low-flow retention basins. It then goes to the Miami-Erie Canal and to the Great Miami River through NPDES Outfall 002 at a rate of approximately 660,000 gallons per day (Mound 1990).

1.3.1.2. Site Sanitary Landfill

The site sanitary landfill was constructed during excavation of the overflow pond areas in 1978. A thin (<2-ft-thick) layer of burned trash on the west side was excavated directly beneath the landfill site. The site sanitary landfill was constructed to provide containment of solid waste removed from the historic landfill. The site sanitary landfill was constructed with a 4- to 5-ft-thick clay liner consisting of onsite materials (Mound 1977: Mound Drawings FSD 16978 and FSD 17044). The clay liner was compacted to ensure a proper seal and integrity over time. Clay berms were constructed on the landfill to prevent runoff from pooling on the top of the landfill and to direct it to the overflow pond. A leachate collection system was constructed, using collection drains at the top of the lower clay liner of the landfill (Mound 1977: Mound Drawings FSD 16978 and FSD 17044). The drains located in the landfill allow for drainage of any landfill liquids into the adjacent overflow pond. Five french drains were installed 2 to 25 ft below the landfill liner (Mound 1977: Mound Drawings FSD 16667 and FSD 16668). These drains were installed partially in a fine gravel/sand layer and partially in a silty clay layer. The purpose of these french drains is to drain moisture from under the site sanitary landfill to ensure soil slope stability.

The site sanitary landfill cap, 3 ft of clay with 2 to 5 ft of low-permeability topsoil, was designed to minimize infiltration of precipitation and snowmelt into the landfill and subsequent flow through contaminated soils and debris, and thereby to reduce leachate generation. In addition, the cover prevents direct contact with potentially contaminated surface soils and controls contaminant migration by way of air, surface water, and sediment pathways.

The base, berms, and liner of the landfill were constructed entirely of clean fill excavation from undisturbed slopes east and north of the waste disposal area. The geotechnical studies conducted as part of the preconstruction activities indicated enough clay-rich soil existed onsite that additional materials would not be needed. Clean fill and trash-filled excavations within the pond area had been identified from the soil boreholes. Clean fill was defined as soil that did not have visible trash or debris. However, the chemical content of the clean fill was not analyzed. Trash, excavated from the previously identified areas and compacted into the liner in 2-ft lifts, consisted of burned and unburned

debris mixed with soil. The base and berms of the landfill were compacted to 90 percent dry density. As the construction of the landfill progressed, the compacted density of the fill material was increased to 95 percent to form the landfill liner. The liner was designed to be 5 ft thick, but is probably closer to 10 ft thick (Burdg 1991). Before filling with trash, the liner was surveyed for interior dimensions and a perforated drain pipe was installed to drain any liquid into the new overflow pond to the north. As the construction neared the top of the designed landfill, the trash was overlain by clean fill that was compacted to 95 percent dry density so that the liner essentially surrounded and covered the trash. The compacted liner material extends to the surface and is covered with a thin layer of topsoil.

Approximately 100,000 cubic yards of trash were moved from the overflow pond site to the landfill. According to personal accounts, some of the trash was saturated during excavation and the drain pipe flowed liquid into the pond for six months afterward (DOE 1987a). No known samples of this leachate were collected. No known drainage has occurred since the initial six-month period.

Slightly more material was cut from the pond area than was needed. The extra material was used on the east side of the new sanitary landfill. The height of the landfill is within design specifications; however, the east slope is more gradual than the specifications because of the extra fill placed there. The height of the landfill was surveyed and checked for settling a year or two after construction; although no known written report exists, a verbal report suggests little or no settling occurred (Burdg 1991).

1.3.2. Summary of Previous Investigations

Mound Plant personnel began a periodic water sampling program for VOCs in 1984. Under the ER Program, RIs were begun in 1987 and focused on observations of groundwater contamination. VOCs have been detected and monitored in the groundwater since 1986 (DOE 1993c), and it is reasonably certain there is a relatively small plume (a few hundred feet in length and width and less than 40 ft thick) of contaminated groundwater.

To date, three formal stages of the RI have been completed, followed by a program of additional field work. Stage 1, which was completed in 1987, consisted of sampling existing wells at Mound Plant to assess the adequacy of the existing groundwater monitoring network and performing a soil gas survey to aid in optimally locating new wells. Stage 2 consisted of the installation and sampling of new monitoring wells to fill in data gaps and replace old wells. The well installation was completed in late 1987 and sampling began in December 1987. Stage 3 consisted of new well installations and further sampling to support a baseline risk assessment and an FS. Stage 3 well installation finished in late 1989 and sampling began in January 1990. After Stage 3 was complete, additional work was

proposed to more fully characterize the extent of possible contamination at Area B and to determine if an unacceptable threat to human health or the environment existed. As part of the additional work conducted from late 1992 to early 1993, an additional soil gas survey was performed, surface and subsurface soil samples were collected, and more monitoring wells were installed. Sampling of the newly installed monitoring wells began in March 1993. A long-term aquifer test was also completed as part of the additional field work.

Wells installed during the RI are sampled as part of the ongoing quarterly water sampling performed for Mound Plant. Both surface soil sampling for radiological parameters and surface geophysical investigations also have been conducted as part of the ER Program RI.

1.3.2.1. Groundwater and Soil Gas Sampling

Between 1984 and 1986, personnel at Mound Plant periodically sampled groundwater and analyzed for priority pollutants. The sampled wells consisted of onsite and offsite monitoring wells, the three Mound Plant production wells, and nearby domestic wells. Figure 1.12 shows the locations of the sampled wells in Area B.

Although they were later viewed as "reconnaissance only" due to problems with well construction methods and upkeep, the results of the sampling by Mound Plant did lead to the identification of groundwater contamination and the designation of Area B as a separate operable unit within the Mound Plant CERCLA program. Two VOCs, TCE and chloroethene, exceeded their respective MCLs. They were found at the highest concentrations near the encapsulated landfill and overflow pond area.

Stage 1 of the RI included reconnaissance sampling of the existing monitoring well locations already sampled by Mound Plant, and was performed partly to confirm the results of sampling previously completed by Mound Plant. Stage 1 sampling was completed according to the current ER Program standard operating procedures (SOPs).

The Stage 1 analytes included VOCs and semivolatile organic compounds; pesticides and PCBs; some metals; and the radionuclides tritium, plutonium, thorium, and uranium. VOCs detected in two of the onsite monitoring wells in Area B (0055 and 0063) during Stage 1 of the RI included tetrachloroethene (PCE), TCE, 1,2-*trans*-dichloroethene (DCE), trichloromethane, ethylbenzene, and trichlorofluoromethane. No other constituents, were detected at concentrations above MCLs or proposed MCLs.

A soil gas survey of VOC concentrations was used to optimize the locations of the monitoring wells installed in Stage 2 of the RI. Soil gas samples from 58 onsite locations were analyzed for TCE,

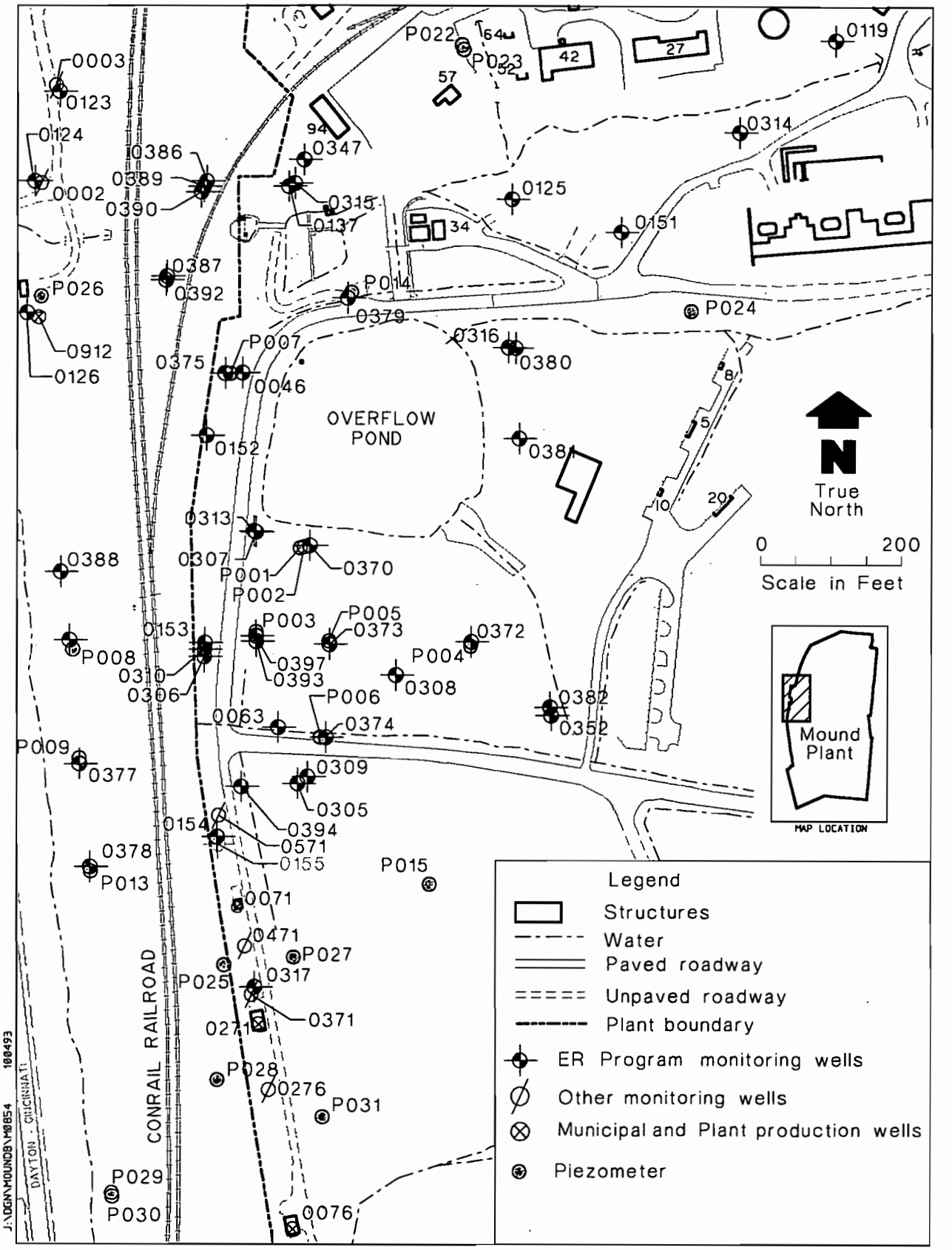


Figure 1.12. Area B well locations, including all wells existing as of June 1993.

1,2-*trans*-DCE, chloroethene, benzene, ethylbenzene, and toluene. These VOCs were detected at 19 locations adjacent to Area B.

After deficiencies were identified with the then existing monitoring network and monitoring wells and the results of the soil gas survey were incorporated into the conceptual model of contaminant migration, a revised RI plan was developed (DOE 1987b), and Stage 2 of the monitoring program was initiated. Twenty-eight new monitoring wells were installed during October and November of 1987; 21 wells were completed in alluvium, and seven wells were completed in bedrock. The new monitoring wells were sampled in December 1987 and March, June, and September 1988. The Stage 2 analytes included VOCs and semivolatile organic compounds; pesticides and PCBs; explosives (RDX, HMX, and PETN); some metals; and the radionuclides tritium, thorium, and uranium. The semivolatile compounds, PCBs, and explosives were not included in the analytical list for the samples collected in March 1988.

In Stage 2, the analytes identified with concentrations near or above present or proposed MCLs included TCE, 1,2-*trans*-DCE, tetrachloroethene, iron, manganese, and styrene. Only one sample (outside Area B) contained styrene, with a concentration 20 percent above the MCL of 5 micrograms per liter (μg/L) (40 CFR 141). Although groundwater samples contained manganese and iron at concentrations that exceeded the secondary drinking water standards, ambient groundwater in the area also contained concentrations that exceeded these standards (Spieker 1968).

Stage 3 of the groundwater sampling program was designed to further define the groundwater system to support evaluation, selection, and design of remedial alternatives. Groundwater quality analyses now available indicate the following:

- the same VOCs present in the old and Stage 2 monitoring wells are present in the samples from the Stage 3 monitoring wells, and
- TCE, 1,2-DCE (total), styrene, chloroethene, and PCE were detected above present or proposed regulatory limits.

In January 1990, tritium was detected in Area B monitoring wells 306 and 310 at concentrations of 12.6 and 14.2 nanocuries per liter (nCi/L), respectively. Wells 306 and 310 are west of the site sanitary landfill (Figure 1.12). These detections confirm that tritium still exists in the groundwater at and adjacent to Area B; however, these concentrations are below the drinking water standard of 20 nCi/L (40 CFR 141). Additional information on groundwater contamination is presented in subsection 4.1.6.

1.3.2.2. Radiological Sampling

From 1982 to 1985, Mound Plant collected radiologic data on the sanitary landfill cap (previously described as Area 18) and from the vicinity of an area used for the disposal of crushed empty thorium drums and polonium-210-contaminated sand filters (previously described as Area 2).

The results of the sampling are reported in the Site Scoping Report: Volume 3 - Radiological Site Survey Report (DOE 1993d). The data gathered indicated widespread, low-level plutonium-238 surface soil contamination. Except for one subsurface sample (17.1 pCi/g), all concentrations within Area B ranged from about 4 to less than 1 pCi/g.

1.3.2.3. Surface Geophysics

In September 1990, magnetic field strength data were collected in the southwest corner of Area B to locate the disposal area of 2,500 crushed steel drums that had contained thorium (Figure 1.13). These crushed empty drums are under the clay berm to the south of the landfill.

As a result of these data, several additional probable disposal areas have been delineated. Zone B-1 is interpreted to be the location of the 2,500 empty thorium drums (previously referred to as Area 2). Zones B-2 and B-3 are disposal areas for large amounts of ferrous materials.

1.4. REPORT ORGANIZATION

This RI report is divided into nine main sections; appendices with relevant field and analytical data are also included. This report is organized to give a comprehensive view of the Mound Plant setting, completed RI work, work results, and conclusions based on RI work performed. The nine main sections are headed as follows:

Executive Summary

1. Introduction
2. Environmental Setting
3. Field Investigation
4. Nature and Extent of Contamination
5. Baseline Risk Assessment
6. Findings and Conclusions
7. Recommendations
8. References

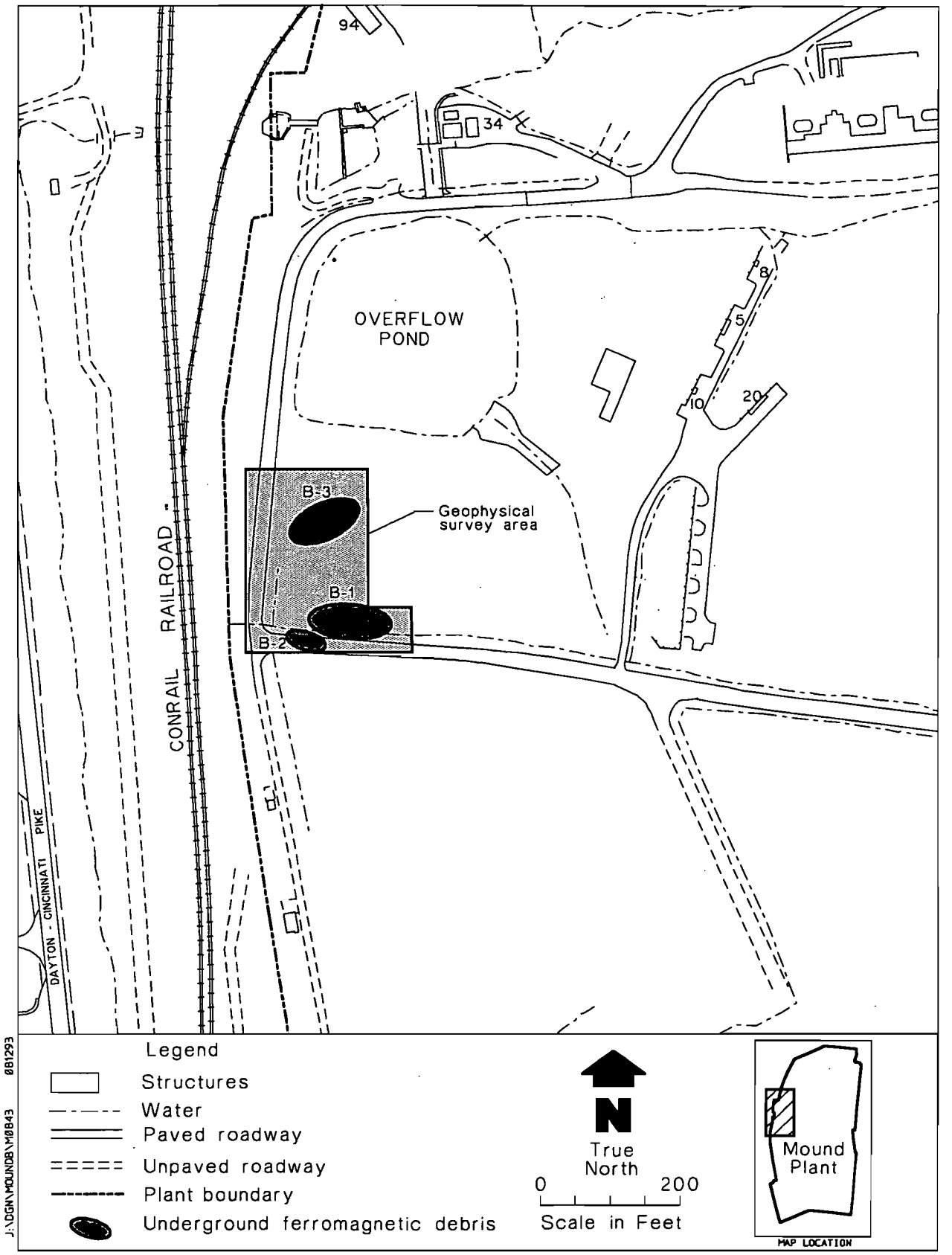


Figure 1.13. Area B geophysical survey area.

The executive summary is a brief summary of the entire RI report. Section 1 gives an ER Program and investigation review and provides relevant background information on Mound Plant and Area B. Section 2 presents land use, hydrogeologic setting, air quality, natural resources, climatology, and demography. Section 3 presents the entire field program (including methods used) and the drilling and sampling investigations (including the laboratory program). Section 4 provides relevant site contamination information as described by the RI/FS work done at the site. Site geology and hydrogeology are also addressed. Section 5 presents a baseline risk assessment. In Section 6, findings and conclusions are summarized. Finally, Section 7 addresses each problem area and provides recommendations and the rationale for the choices given. Section 8 contains a list of referenced material.

2. ENVIRONMENTAL SETTING

The following section of this RI Report discusses the natural and human environment surrounding the Mound Plant Site. Both demographics and geology are discussed in this section. The Mound Plant Site information presented in this section provides a basis for later sections of this report, and for conclusions regarding appropriate remedial actions.

A NEPA-responsive environmental assessment (EA) requires the collection of information similar to that required for the CERCLA RI/FS process. To the extent possible, these data needs have been combined in this section; no differing data requirements have been identified. The balance of the NEPA considerations will be addressed in the Feasibility Study Report.

2.1. LAND USE, RESOURCES, AND DEMOGRAPHICS

Mound Plant is in southern Montgomery County, Ohio, and is within the city limits of Miamisburg. Miamisburg is predominantly a residential community with some supportive commercial facilities and limited industrial development. Much of the residential, commercial, and industrial development within a 5-mile radius of the Site is concentrated on the Great Miami River floodplain. The adjacent upland areas are used primarily for residences and agriculture or are unused open spaces. Most of the residential development on the upland areas is relatively new in comparison to development on the floodplain. It is likely that most future development in the area will occur on the upland areas. The current land use for the two counties that are within a 5-mile radius surrounding Mound Plant (Montgomery County, and Warren County to the south) is summarized in Table II.1.

Miamisburg has 13 parks and four playgrounds. Mound Golf Course and Miamisburg Mound State Memorial Park, both directly east of the facility across Mound Road, are heavily used during favorable weather. The park is the site of a 68-ft-high ancient Indian mound, located 380 ft east of the Mound Plant boundary. Other recreational areas within 1 mile of the facility that are used extensively during the summer include the Miamisburg municipal park and swimming pool (located immediately west of Mound Plant), Harmon Athletic Field, and Library Park (MRC 1985a).

There are no large lakes within a 5-mile radius of the Site. Several fishing ponds are located 3.5 miles north-northeast in inactive gravel pits. Some vestiges of the old Miami-Erie Canal lie between the Conrail Railroad and the Dayton-Cincinnati Pike west of the Site. This remnant of the old Miami-Erie Canal is designated as Operable Unit 4. The city of Miamisburg has maintained two very small recreation ponds in the Miamisburg municipal park in this area (Figure 2.1). In 1978, Miamisburg converted the north pond into a lined, brine-filled solar pond to heat water for the municipal swimming pool. In late 1990, this solar pond was removed from service and infilled with soil.

Table II.1. Land Use within Counties Adjacent to Mound Plant

Land Use	Montgomery County	Warren County
Residential		
Acreage	47,200	23,268
Percentage of total land	16	9
Commercial		
Acreage	4,100	5,481
Percentage of total land	1	2
Industrial		
Acreage	4,100	5,481
Percentage of total land	1	2
Other Developed Land		
Acreage	21,904	10,735
Percentage of total land	2	1
Agricultural and Vacant		
Acreage	216,946	221,370
Percentage of total land	74	84
Total Acreage	296,050	261,488

Reference: MRC 1985a

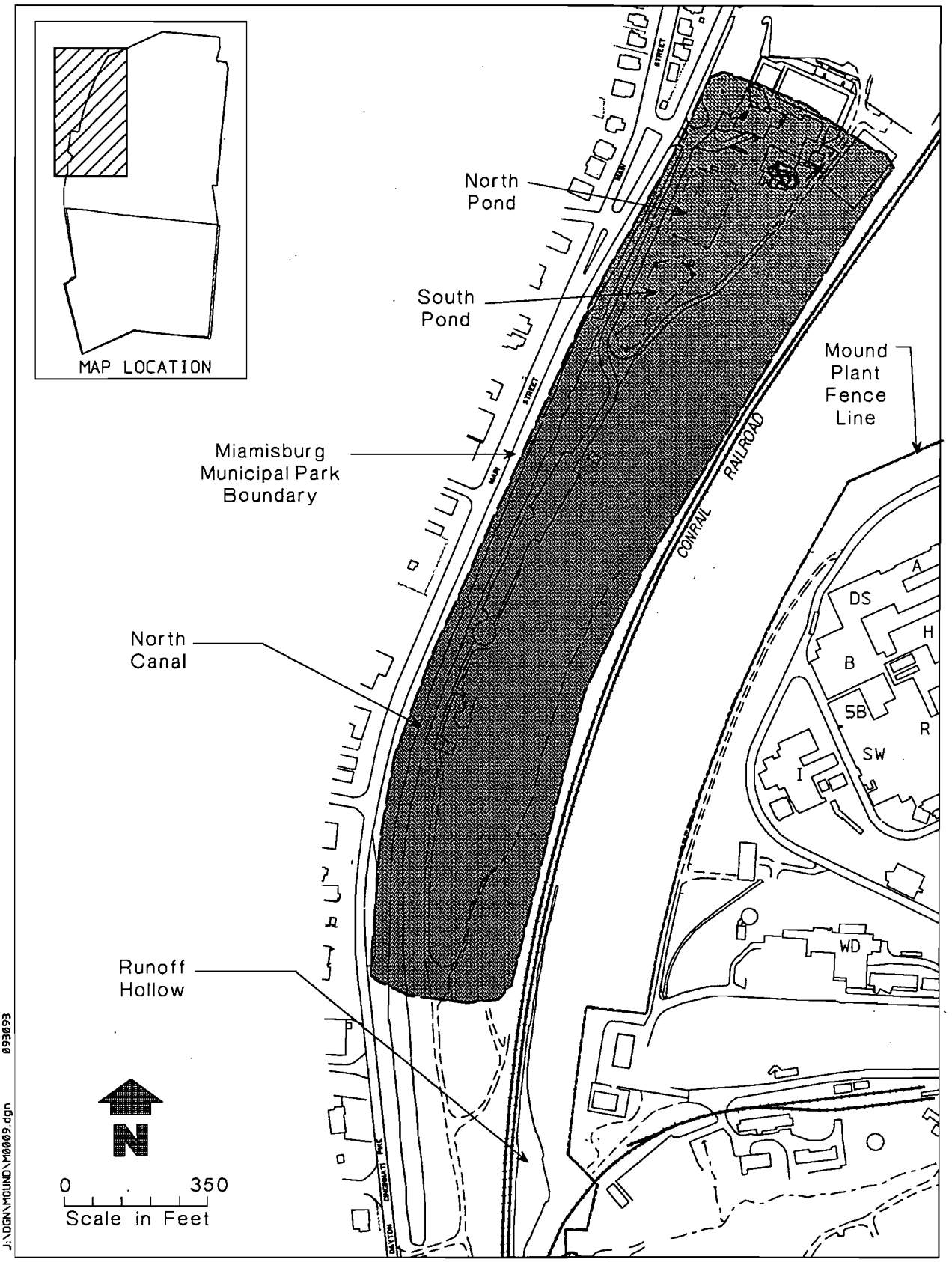


Figure 2.1. Approximate boundaries of the Miamisburg Municipal Park.

The major water body in the vicinity of the Mound Plant is the Great Miami River. It is approximately 150 to 200 ft wide in this area. There is no commercial barge traffic or commercial fishing on the Great Miami River, but some pleasure boating and sport fishing do occur, usually during the summer.

Agricultural land within a 5-mile radial area around the Site is primarily used for corn and soybean production and for livestock grazing. In 1970, 74 percent of Montgomery County was listed as agricultural or vacant land, and 84 percent of Warren County (the adjacent county to the south) was similarly classified. Some of these lands have been developed for residential housing since these estimates were made.

2.1.1. Population in the Mound Plant Area

According to 1990 census figures, the population of Miamisburg is 17,834, Dayton is 182,044, and Montgomery County is 573,809. Compared to 1980 census figures, Miamisburg has gained approximately 2,500 residents and Dayton lost approximately 11,500. Montgomery County gained only approximately 2,000 people from 1980 to 1990. There is no large seasonal variation in population for the local area surrounding Mound Plant. There are no major parks, major landmarks, or tourist attractions that draw a significant seasonal transient population to the area. There is, however, a significant variation of community members using facilities in close proximity to Mound Plant. During the spring and summer, the Mound Golf Course, the Miamisburg Municipal Park and Swimming Pool, the Mound State Memorial Park, and the Great Miami River attract recreational users.

Figure 2.2 depicts the local urban populations. Daily variations in the population do occur on the Mound Plant and in the immediate Miamisburg area. There are approximately 1,700 employees at the facility from 6:30 a.m. to 4:30 p.m. during the 4-day work week. Most of these employees are concentrated in the northwest area. Approximately 50 to 100 employees work on the 3 off-days and at night.

2.1.2. Cultural Resources in the Mound Plant Area

The only historic landmark in the vicinity of Mound Plant is the Miamisburg Mound, an ancient Indian mound located 380 ft east-southeast of Mound Plant in Miamisburg Mound State Memorial Park. The mound — a symmetrical, conical earthwork, 68 ft high and 800 ft in perimeter — is one of the largest of its type. It is believed to be the sepulcher of a chief of the Adena culture of Mound Builders who inhabited the Ohio region as early as 800 B.C. (DOE 1979).

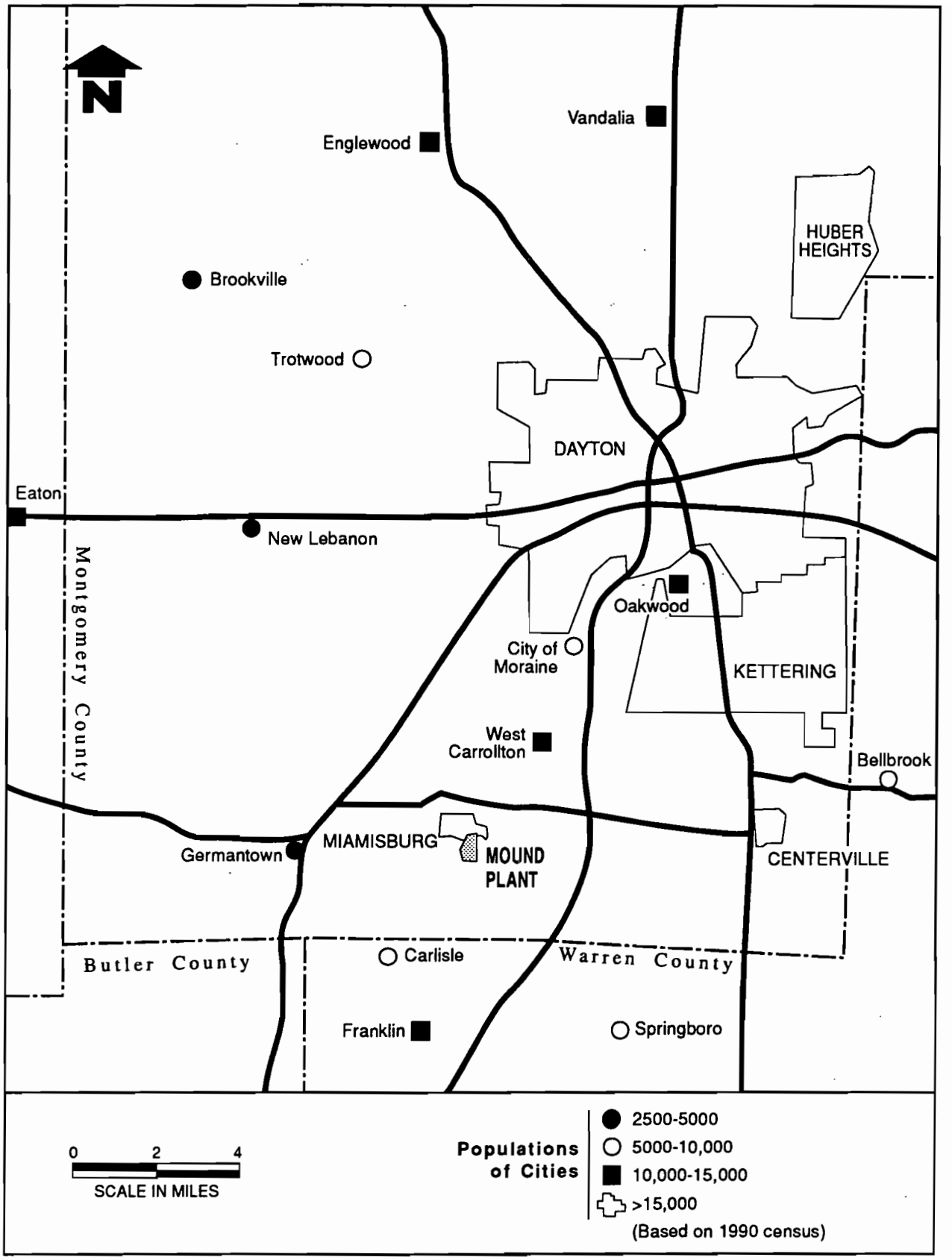


Figure 2.2. Populations of urban areas near Mound Plant.

MND/OU1/RIR-01/10-4-93

In 1990, Archaeological Services Consultants, Inc., was retained by EG&G-MAT to complete a literature review update and an archaeological survey of the Mound Plant and the adjacent run-off ditches, including a portion of the Miami-Erie Canal. The purpose of this investigation was to determine whether archaeological resources exist within the area, and if any identifiable cultural resources are eligible for inclusion in the National Register of Historic Places. The literature search of historical records indicated that four buildings appear to have existed within the main plant boundary. The four buildings consisted of two farmhouses that were shown on an 1875 county atlas, and two houses that were noted on the historical records of 1904-1905. Also, the historical records from 1914 indicated that two crescent-shaped earthworks existed within the main plant boundary (Beamer 1991). These buildings and earthworks were located in areas upon which modern structures now exist. Consequently, none of these structures, nor remnants of them, were located during the field survey (Beamer 1991). Four historic sites were inventoried within the project area during the archaeological survey completed in March 1991. These consisted of a portion of the Miami-Erie Canal and associated features, a bridge, a bridge remnant, and a 1935 city water well. None of the sites meet the minimum requirements for inclusion into the National Register of Historic Places, and no further work is recommended (Beamer 1991).

The FFA between the DOE and the EPA requires the collection of data, as necessary, to characterize human populations and land use. Most of the data have been collected previously for a variety of Mound Plant reports. The primary source of existing data is the 1973 safety analysis report (Dames and Moore 1973) and the 1979 environmental impact statement (DOE 1979). These will be superseded by a safety analysis report that is currently being prepared in compliance with DOE orders.

Because of the potential for contaminant migration in groundwater, land use, water supply, and population density in the areas downgradient of the plant will be examined. These issues will be addressed in the baseline risk assessment in Section 5.

2.1.3. Mineral Resources

In the southwest portion of the Mound Plant Site, in what is now Area B, sand and gravel deposits were excavated. The sand and gravel deposits were exploited from this area from the beginning of plant construction in 1948 until 1977, when the site landfill was built. These gravel deposits were used by Mound Plant; no commercial use of the deposits prior to the construction of Mound Plant is known. With the addition of 124 acres purchased in 1981, there are more extensive deposits of gravel within the Mound Plant Site. The additional acreage is adjacent to Area B and extends south to Brenner Road.

The geology of the Mound Plant Site consists of glacial outwash (sand and gravel deposits), glacial till, and interlayered shale and limestone bedrock (see subsections 2.2.3 and 2.2.4). The limestone in the bedrock sequence is minor and not commercially exploitable. There are no other known mineral resources associated with surficial deposits or bedrock at the Mound Plant Site.

2.2. HYDROGEOLOGIC SETTING

An understanding of the Mound Plant Site hydrogeology is important in discerning groundwater, surface water, and soil contaminant migration pathways at Mound Plant. Regional and site-specific geology must also be fully characterized to place site hydrogeology in the proper context. Therefore, this section will cover the geography, geologic setting, and groundwater characteristics near Mound Plant. In addition, the lithology and distribution of bedrock and unconsolidated deposits are presented.

2.2.1. Geography

Mound Plant occupies a total of 306 acres within and adjacent to the southern city limits of Miamisburg, Ohio. Mound Plant is located on the eastern side of the Great Miami River valley, within the Till Plains section of the Central Lowlands Province. Relief in the Miamisburg area is subdued, consisting of gentle to slightly steep rolling hills and broadly undulating flatland cut by small streams and valleys. The predominant geographical feature in the region near Mound Plant is the Great Miami River, which flows from northeast to southwest through Miamisburg, although near Mound Plant it flows essentially north to south. The Great Miami River flows in easy meanders through a flat valley with gentle to steep sides. Mound Plant is situated on a hill overlooking Miamisburg, the Great Miami River, and the river plain area to the west. The property is characterized by two topographic highs divided by a minor northeast-southwest trending valley that is a tributary to the Great Miami River (Figure 1.6).

To the west of the plant is an abandoned section of the Miami-Erie Canal that trends parallel to the river. The small stream that occupies the plant tributary valley drains through the southern portion of the canal to the river through an overflow ditch that once served to equalize water levels in the canal. Although the Great Miami River has been engineered with levees along its entire length, the 100-year floodplain may encroach the southwestern margin of the plant along the low-lying area that parallels this overflow ditch. The north portion of the Miami-Erie Canal stands dry, but retains its general morphology. Northwest of the plant, the canal was reclaimed and built over by the city of Miamisburg; other remnants of the canal lie to the north of Miamisburg. The mainline of the Conrail Railroad adjacent to Mound Plant is between the Miami-Erie Canal and the west boundary of the plant. A spur track from the mainline enters Mound Plant near the tributary valley.

To the north and east of Mound Plant property are residential areas of Miamisburg with many single-family homes. Some homes on the eastern boundary of Mound Plant are only tens of feet from the Mound Plant property fence. Directly east of Mound Plant, separated by Mound Plant Road, is a public golf course and state park. South of Brenner Road, the southern border of Mound Plant, are small farms and undeveloped land.

The bedrock in this area of Ohio is dissected to a maximum of 900 ft. The dominant drainage pattern is dendritic. The larger valleys are partially filled with glacial deposits. The modern Great Miami River occupies an ancient valley that was formed by meltwater from continental glaciers. This valley is filled with thick, extensive glacial outwash deposits of permeable sand and gravel referred to as the Buried Valley aquifer. Interlayered with the outwash deposits are glacial tills of variable thickness and extent.

2.2.2. Regional Geologic Setting

The present geologic setting of the Mound Plant area is a product of Paleozoic crustal warping and deposition of marine shales and limestones, and Quaternary continental glaciation.

The stratigraphic section in southwestern Ohio consists of mildly deformed sedimentary rocks overlying the broadly undulating topography of the Precambrian crystalline basement. The crystalline basement rock in this region is covered by approximately 3,100 ft of Cambrian- and Ordovician-age bedrock, principally marine shales and limestones (Lucius and Von Frese 1988). The bedrock in the vicinity of Mound Plant is essentially flat lying; the regional dip is approximately 5 ft per mile to the northeast (Stout 1941).

Portions of the following text were paraphrased or excerpted from The Water Resources of Montgomery County Report (Norris et al. 1948). The preglacial and glacial processes are discussed in a regional sense and are analogous with the morphologic conditions in the area of Mound Plant and vicinity.

During the Pleistocene epoch, at least two advances of continental ice sheets (or glaciers) spread southward across southwestern Ohio and deposited a thick mantle of glacial material consisting of clay, silt, sand, gravel, cobbles, and boulders. The latest ice sheet, that of the Wisconsin stage, advanced within a few miles of Cincinnati and covered Montgomery County for several thousand years. The Wisconsin glacier melted off this area about 30,000 years ago. The glacial stage that preceded the Wisconsin is called the Illinoian stage. The Illinoian ice advanced to a point slightly south of Cincinnati, farther south than any of the other glaciers. Illinoian drift is not exposed in Montgomery County, but has been penetrated by some wells and deep excavations. The Illinoian glacier is believed to have melted off this area some 200,000 years ago.

Preglacial topography in Montgomery County

Before glaciation, Montgomery County occupied an area of regional uplift in which rocks of Upper Ordovician age, with a border of lower Silurian limestones, were exposed at the surface. The bedrock topography exhibited a fairly smooth, gently rolling surface deeply dissected by short tributaries and broad, entrenched rivers. The covering of glacial drift over Montgomery County has subdued the former relief and masked all but the most prominent features of the ancient drainage.

Interglacial drainage

The interglacial drainage system was begun by the advance of the pre-Illinoian glacier and was terminated by the later advance of the Illinoian ice sheet. During this time, the streams cut deep, narrow valleys many feet below the levels previously established.

Wisconsin glacial deposits

The Wisconsin glacier may have caused some changes in the drainage of post-Illinoian time. It is believed, however, that the main effect of the Wisconsin ice sheet on the former drainage was in supplying the greater part of the glacial drift that now fills these valleys.

2.2.2.1. Seismology

The Mound Plant region, as is true with most of Ohio, has a comparatively low potential for damaging earthquakes. Since 1776, approximately 90 earthquakes have originated in Ohio, and several earthquakes with epicenters outside of Ohio have been felt within the state (Hansen 1988). Four earthquakes with a Modified Mercalli Intensity of I-II have been detected between 1873 and 1988 within a 30-mile radius of Mound Plant. Within a 30- to 60-mile radius of Mound Plant, there have been 44 recorded earthquakes from 1804 to 1988; approximately 32 of these had epicenters near Anna, a town 53 miles north of Mound Plant. Anna experienced the most damaging shock ever reported in Ohio, an Intensity VIII earthquake on March 9, 1937 (Bradley et al. 1965).

Seismic risk to the Mound Plant is insignificant. The subsurface in the immediate vicinity of the plant is very stable, and detailed geologic studies suggest there are no geophysical factors that would either cause or compound seismic disturbances (MRC 1985a).

2.2.3. Surficial Geology

The surficial geology near Mound Plant consists of exposed bedrock, unconsolidated deposits (alluvium, glacial till, and glacial outwash), and related soils. This section will discuss exposed bedrock and unconsolidated deposits. Relevant soils are covered in a separate subsection.

Exposed bedrock occurs on uplands and areas of steep relief in the Miamisburg region. At Mound Plant, this is evident on portions of the Main Hill and SM/PP Hill not covered by structures or pavement. Exposed bedrock is usually covered by a weathered clayey regolith at least a few feet thick with a well-developed soil.

Unconsolidated deposits near Mound Plant are of two major types: ice-laid deposits and water-laid deposits. In combination, these deposits vary from a few feet to more than 170 ft thick near the Mound Plant (Figure 2.3).

The ice-laid deposits (till) were formed as ground moraine when materials carried in the base of a glacier were laid beneath the advancing ice (lodgement till), or let down to the surface as ice melted during glacial retreat (ablation till). Ground moraines usually form relatively flat land except where the till thinly caps broad, rolling hills (commonly exposing bedrock) near a glacial margin (Goldthwait et al. 1979). The till in the area of the Mound Plant is composed of an unsorted, unstratified mixture of clay, silt, sand, and coarser material (Struble 1987), and ranges from less than 1 to more than 40 ft thick. Materials of this composition are known to have low permeability (Freeze and Cherry 1979). Radiocarbon age determinations of the youngest tills in the area of the Mound Plant have a range of 20,700 (± 600) years to 21,600 (± 400) years ago (Forsyth 1961).

The water-laid deposits consist of outwash composed of well- to moderately well-sorted sand and gravel. The sand and gravel deposit is horizontally layered, commonly cross-bedded, and ranges from a few to more than 80 ft thick. The outwash in the vicinity of the Mound Plant occurs as restricted valley-train deposits that were formed by the aggradation of glacial meltwater streams (Goldthwait et al. 1979). The channels that contain the valley-train deposits generally follow the present course of the Great Miami River. These channels were formed by interglacial streams that cut deeply (up to 200 ft) into bedrock. Some of these valley-train deposits may have been deposited during earlier Illinoian glaciation, but the majority of the outwash deposits are probably products of Wisconsin glaciation. The valley-train outwash is interstratified with till; therefore, glaciers must have covered the outwash deposits a number of times. The shape and continuity of till deposits have thus been affected by stream alluviation and dissection. The complex interstratification of glacial till and outwash has greatly affected the hydrologic condition existing at the present Mound Plant. The outwash

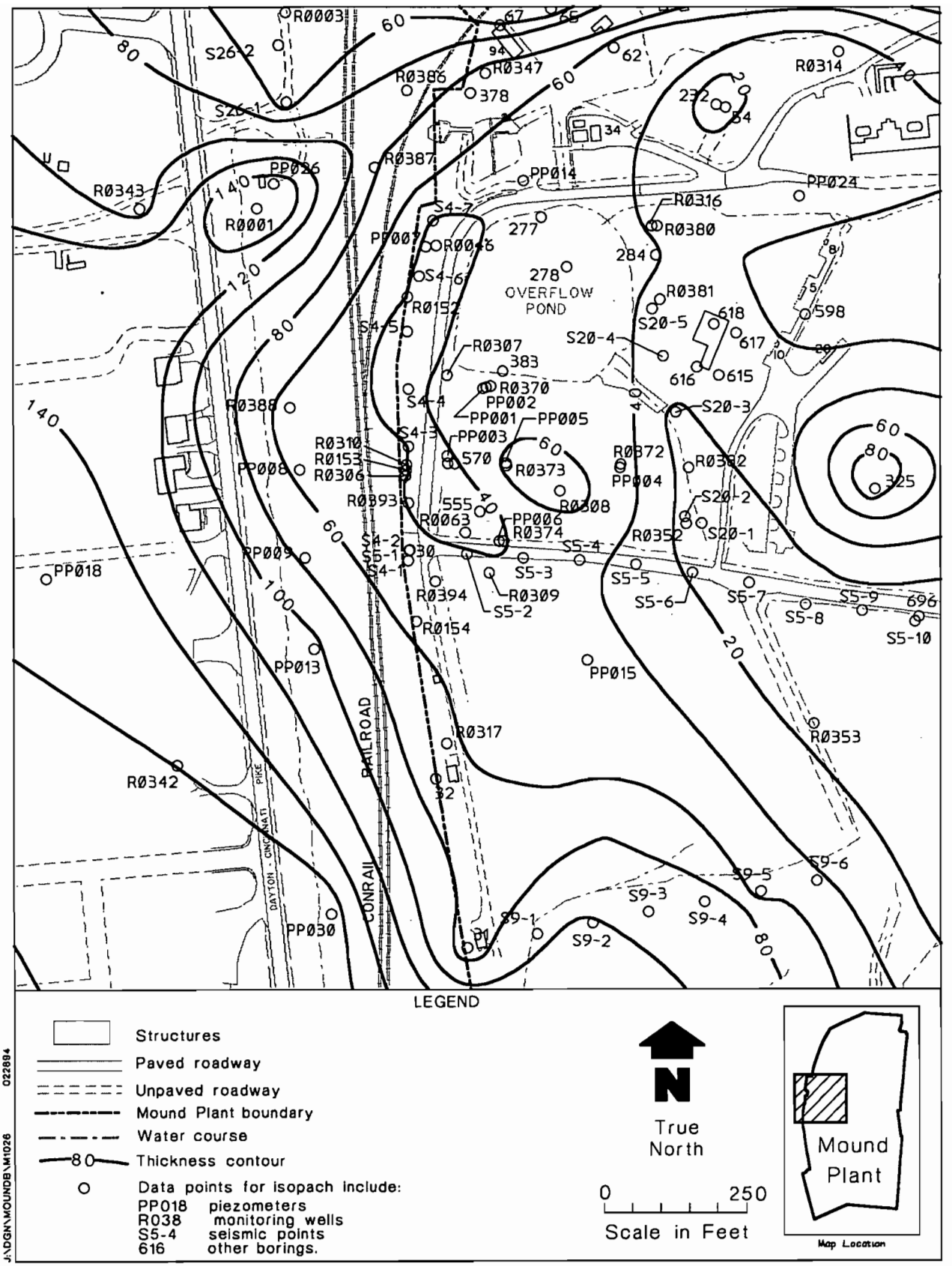


Figure 2.3. Isopach map of unconsolidated deposits in Area B.

deposited in the Miami River Valley and the associated tributary valley forms the Buried Valley aquifer and contiguous deposits. The Buried Valley aquifer and contiguous deposits are suspected to be one of the primary contaminant migration pathways from Mound Plant.

Stratigraphically overlying the glacial outwash and till are Holocene alluvial deposits associated with the floodplain of the Great Miami River and its tributaries. This alluvium is mostly overbank deposits consisting of stratified fine sands, silts, and clays and averages about 10 ft thick in Montgomery County (Struble 1987). These deposits include river-borne sediments deposited since the retreat of the last glaciers (younger than 12,000 years) (Goldthwait et al. 1979).

2.2.3.1. Soils

There are a variety of soils series, each with a distinctive profile, on and adjacent to the Mound Plant Site. A detailed soil survey of Montgomery County was published by the U.S. Department of Agriculture (USDA) Soil Conservation Service in June 1976. Most of the field work supporting this soil survey was performed from 1958 through 1967. Soil names and descriptions were approved in 1969, and are provided in the USDA Soil Survey Manual of Montgomery County (SCS 1976). This manual was used as a general guide in identifying soils found at Mound Plant. It identifies specific soil series, defined as mappable soil units of similar morphology, and the engineering properties of the soil units. Based on the information from this survey, nine soil series exist within the boundaries of Mound Plant. These include Corwin, Fairmont, Hennepin, Made Land, Miamian, Milton, Ritchey, Ross, and Urban Land series (SCS 1976). These nine series are broken down into 17 mapping units that separate the nine soil series by the general slope or location. Table II.2 provides the symbols of each mapping unit. Considerable portions of the soil cover at the Mound Plant Site have been disturbed over the years due to construction and building. It is estimated that approximately one-half of the property has been disturbed and is covered by structures or pavement.

Specific to Area B, the focus of this report, five soil series exist within or adjacent to its boundaries. The soil types include Made Land, Miamian Series, Ross Series, Corwin Series, and Fairmont Series. These soil series cover different portions of Area B (Figure 2.4) and are described below. It is important to note that Figure 2.4 represents conditions as they exist prior to 1978. Subsequent earthwork has modified the distribution of soils.

Corwin Series (CoB)

The Corwin Series consists of dark-colored, moderately well-drained soils that formed in calcareous loam glacial till. In places, these soils have a silt cap of loess as much as 18 inches thick. They are nearly level to gently sloping and occupy upland areas.

Table II.2. Soil Mapping Unit Symbols

Symbol	Mapping Unit
CoB	Corwin silt loam, 2 to 6% slopes
FaE2	Fairmont silty clay loam, 12 to 25% slopes, moderately eroded
FaF2	Fairmont silty clay loam, 25 to 50% slopes, moderately eroded
HeE2	Hennepin and Miamian silt loams, 18 to 25% slopes, moderately eroded
HeF2	Hennepin and Miamian silt loams, 25 to 50% slopes, moderately eroded
HmF3	Hennepin and Miamian soils, 18 to 50% slope, severely eroded
MIB2	Miamian silt loam, 2 to 6% slopes, moderately eroded
MnC3	Miamian clay loam, 6 to 12% slopes, severely eroded
MnD3	Miamian clay loam, 12 to 18% slopes, severely eroded
MoC	Miamian-Urban land complex, rolling
MtD3	Milton silty clay loam, 6 to 18% slopes, severely eroded
MsB	Milton silt loam, 2 to 6% slopes
MsC2	Milton silt loam, 6 to 12% slopes, moderately eroded
Mb	Made land
ReB2	Ritchey silt loam, 2 to 6% slopes, moderately eroded
RfD3	Ritchey silty clay loam, 6 to 18% slopes, severely eroded
Rs	Ross silt loam
UM	Urban land, loamy material

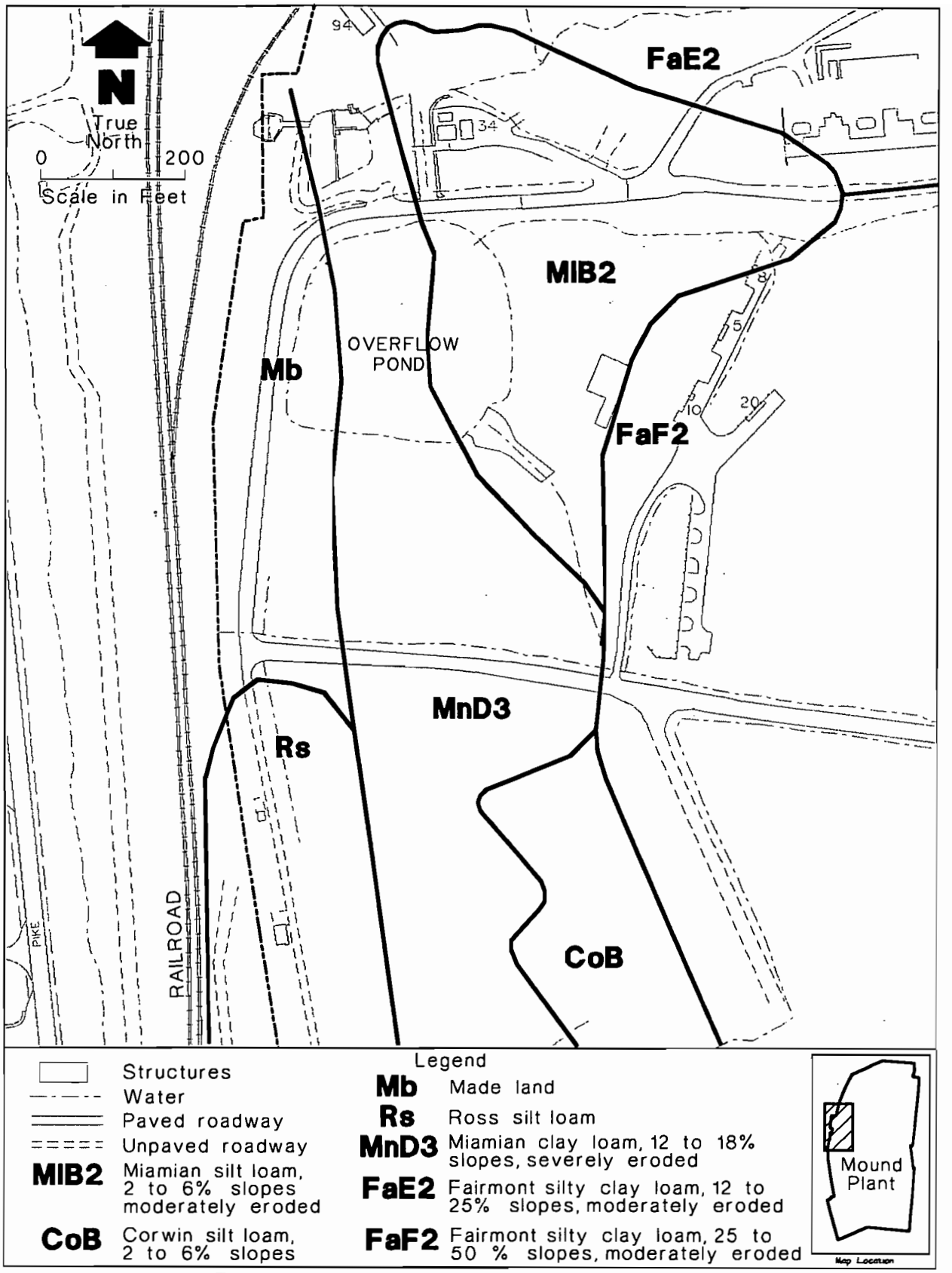


Figure 2.4. Pre-1978 distribution of soil units in the immediate vicinity of Area B, Mound Plant.

A representative profile has a very dark grayish-brown silt loam plow layer about 6 inches thick. The next layer is very dark brown silt loam 3 inches thick. Several layers make up the subsoil. The topmost layer of the subsoil is dark-brown silty clay loam. Deeper layers are dark yellowish-brown silty clay loam and clay loam and brown loam. The subsoil is underlain by calcareous loam glacial till at a depth of about 43 inches.

Corwin soils have a medium available moisture capacity and moderately slow permeability. They are seasonally saturated for short periods in winter and early spring. Organic-matter content is high in the uppermost 10 to 13 inches of these soils. The root zone is medium acid or strongly acid. Acidity decreases as depth increases.

Ross Series (Rs)

The Ross Series consists of dark-colored, well-drained soils that formed in recent alluvium on floodplains. These soils are nearly level and occupy bottom lands. They are the dominant soils along the larger streams and common along the smaller streams.

A representative profile has a very dark grayish-brown plow layer about 8 inches thick. At depths between 8 and 22 inches, there is very dark grayish-brown and very dark brown silt loam that differs only slightly from the plow layer. Between depths of 22 and 56 inches, there are brownish layers of fine sandy loam, silt loam, and loam. Gravelly loamy sand is below a depth of 56 inches.

Ross soils have high available moisture capacity. They are moderately permeable, but runoff is generally slow because these soils are nearly level. Ross soils have a deep root zone in summer. The root zone is mostly neutral to mildly alkaline.

Fairmont Series (FaE2, FaF2)

The Fairmont series consists of well-drained, dark-colored soils that formed in residuum weathered from thin-bedded limestone and clay shale bedrock. These soils form on slopes that are moderately steep and very steep. The primary use of these soils is for pastures and trees.

In a representative profile, the surface layer is very dark grayish-brown and olive silty clay. It overlies interbedded limestone and calcareous clay shale bedrock at a depth of 19 inches, which constitutes the C horizon.

Fairmont soils have a low available moisture capacity and moderately low permeability. They have a shallow rooting depth and are neutral to moderately alkaline.

Made Land (Mb)

Made Land consists of sanitary landfills and small, highly mixed spots outside of built-up areas. The original soil profile has been altered or buried. These areas contain a mixture of soil material and underlying material, and they commonly contain foreign material such as masonry or trash. The value of areas of Made Land for farming or construction differs, and on-plant investigations should be made before this land type is used for these purposes.

Miamian Series (MnC3, MnD3, MIB2, MoC)

The Miamian Series consists of well-drained soils that formed either wholly or partially in calcareous glacial till. The upper part of most Miamian soils is a capping of silt or loess that ranges from 0 to 18 inches in thickness. These soils form on slopes that are nearly level to very steep. They occupy upland areas of till plains and moraines in all parts of the county.

A representative profile has a brown silt loam plow layer about 7 inches thick. The upper part of the subsoil is 3 inches of dark yellowish-brown silty clay loam. In descending order, the subsoil from a depth of 10 to 30 inches is dark yellowish-brown clay, dark yellowish-brown clay loam, and yellowish-brown loam. Below the subsoil, at a depth of about 30 inches, is calcareous loam glacial till that is dense and compact.

Miamian soils have a medium available moisture capacity and moderately low permeability. The compact till tends to limit roots to a moderate depth. The root zone is strongly acid in some places in the uppermost 1.5 ft, but is less acid as depth increases.

Current Area B Soil Conditions

In 1977, Area B soils were reworked extensively by earth-moving equipment during the construction of the overflow pond, site landfill, and related structures. The reworking and redistribution of these soil series have altered their original textures. Once the natural condition of a soil series is modified, the unit is reclassified as Made Land. Made Land is considered the dominant soil series that presently exists in Area B. During the construction activities, it is likely that portions of the existing soils were intermixed with the underlying clay-bearing glacial till, which is extensive over the western portion of Area B. The degree of soil compaction, when mixed with underlying unconsolidated materials, is

variable and dependent on site conditions and the type of operation performed (SCS 1990). More detail concerning soils and soil sampling and analyses for Area B is presented in Section 4 of this RI report.

2.2.4. Bedrock Geology

The bedrock geology in the Mound Plant region consists of Precambrian basement rocks overlain by Cambrian through Upper Ordovician sedimentary rocks. The Precambrian basement in the vicinity of Mound Plant is buried by more than 3,000 ft of Paleozoic sediments and has no direct relevance to the immediate geology surrounding Mound Plant.

The bedrock sedimentary section immediately beneath Mound Plant consists of Cambrian and Ordovician formations. The Richmond Group of Upper Ordovician age is present at the surface at Mound Plant and throughout most of Montgomery County, and is generally 250 to 300 ft thick in the vicinity of Mound Plant. This group underlies the Main Hill and the SM/PP Hill and controls groundwater flow in those areas. The Richmond Group consists of thinly interbedded calcareous shale with limestone layers. The limestone beds range from 2 to 6 inches in thickness and generally comprise less than half of the Richmond Group (Fenneman 1916). The shale beds vary from 1 to 8 ft thick. In general, there are more and thicker beds of limestone near the surface; shale becomes more prevalent deeper in the bedrock section. The Richmond Group is highly fossiliferous, and is well known for its assemblage of rugose corals (Stout 1941). Well-preserved brachiopods and broken parts of crinods and bryozoans are also common fossils. The abundance of fossils, particularly corals, indicates that the Richmond Group was deposited in a shallow, warm marine environment.

2.2.5. Groundwater Occurrence and Movement

Groundwater parameters are discussed in full in the Site hydrogeology section later in this report. This section presents an overview and emphasizes key features of the groundwater system and the influences on that system. General components of the groundwater aquifer also will be discussed.

Geologic information indicates that a continuous unconsolidated aquifer extends from the Great Miami River to the Mound Plant hydrogeologic system. This aquifer is called the Buried Valley aquifer and is extensive west of Mound Plant and extends onto into the Mound Plant property in Area B and the tributary valley. The Buried Valley aquifer forms a primary path for contaminant migration and is a major source of potable water for Mound Plant and the neighboring communities. The Buried Valley aquifer consists of glacial outwash with complex interlayers of glacial till. These unconsolidated sediments rest on shale and limestone bedrock. The glacial till and outwash are most extensive in the

southwestern part of the Mound Plant Site, which includes all of Area B, and in the tributary valley. These deposits are part of a single aquifer and are continuous with the Buried Valley aquifer that fills the ancient valley of the Great Miami River.

The geologic stratigraphy has a strong influence on groundwater flow patterns at Mound Plant. The primary groundwater flow and contaminant transport beneath the water table at and near Mound Plant occur within glacial outwash, glacial till, and bedrock. Of the three lithologies, outwash and bedrock are the largest in volume, while till is present in lesser amounts. Hydraulic conductivities in the outwash are up to three orders of magnitude higher in the till and are up to three orders of magnitude higher than in bedrock; therefore, groundwater and contaminant flow away from Mound Plant occurs primarily through the outwash. Because highly permeable deposits of outwash sand and gravel overlying bedrock are present in and around Mound Plant, and much of the deposit lies beneath the water table, the outwash is capable of transporting significant volumes of groundwater. Groundwater levels in some of the well clusters indicate that groundwater from the outwash may also recharge the till and bedrock layers. However, groundwater in the bedrock moves, if it moves at all, at a much slower velocity than it would in outwash because of the significantly lower permeability of the bedrock.

Groundwater beneath the southwest portion of Mound Plant flows primarily in a west and southwest direction. Groundwater flows to the west and southwest within the sediments of the tributary valley on the Mound Plant site. Water flowing south from the Main Hill and water flowing north/northwest from the SM/PP Hill are incorporated into the westerly flow direction and are transported out of Mound Plant via the tributary valley. Groundwater flow to the south of Mound Plant Site is southwesterly, and groundwater gradients to the west, within the floodplain of the Great Miami River, are relatively small.

Man-made influences on the mean groundwater flow include pumping at Mound Plant production wells 0071, 0076, and 0271. This activity forms a groundwater low on the western edge of Area B and induces a southwesterly flow component on the generally western flow direction. Further influence is caused by Miamisburg Municipal Well #3 (0912), which, when pumping, induces a groundwater low to the northwest of Area B; however, no long-term effects have been observed. In addition, further pumping occurs at the Hutchings Power Station of the Dayton Power and Light Company, located about 1.5 miles south of Mound Plant on the west bank of the Great Miami River. The company uses six high-capacity wells (1,500 gallons per minute). The drawdown caused by such a well field could conceivably provide a sufficient hydraulic gradient to induce flow under the river from the east to the west bank. However, the river may represent a partial hydraulic barrier to such flow (Dames and Moore 1973), and the relatively high transmissivity of the Buried Valley aquifer would probably preclude such a condition. Analysis of modeling and aquifer tests conducted in this area support the

perception that it is unlikely that contamination could pass from the east to the west bank of the Great Miami River.

The groundwater table is generally highest in the spring (March through May) and lowest in late summer (August and September). However, the overall configuration of the water table is generally similar throughout the year, indicating that seasonal influences do not produce marked differences in groundwater flow directions.

2.2.5.1. Groundwater Recharge

Natural recharge to the groundwater system occurs primarily in three ways: groundwater flux across the northeastern and eastern boundary, through the Buried Valley aquifer associated with the Great Miami River, and through infiltration of precipitation. The conceptual groundwater flow map suggests that groundwater levels are lowest in a region between the Mound Plant and the Great Miami River. Within this region, groundwater flow is southerly and subparallel to the river. The higher groundwater levels to the east result from recharge from precipitation, infiltration, and percolation at the topographically higher area. The higher groundwater levels to the west result from groundwater recharge by the river. A region of reduced recharge by precipitation may exist between the river and the plant site as a result of urban development and surface drainage controls. This conceptual model suggests that the river, by elevating groundwater levels in its vicinity, is effectively a barrier to westward groundwater flow from the plant site. The magnitude of this groundwater mound is expected to change as a function of river stage, and would decrease with distance from the river. However, by effectively raising the base level of the groundwater discharge point, the fluctuating water levels beneath the river may be evident throughout the Mound Plant monitoring well systems.

2.2.6. Groundwater Uses

This section provides a background description of the municipal, industrial, and domestic users of groundwater and cistern water in the vicinity of Mound Plant, and of the Mound Plant water supply. The municipal and residential water investigation is actually a part of the site-wide hydrogeology investigation, and is intended to focus on downgradient water users.

2.2.6.1. Municipal and Industrial Water Users

Six municipal water supplies are located within a 5-mile radius of Mound Plant, including Miamisburg, West Carrollton, Franklin, Germantown, the Springboro Water District, and the Montgomery County Sanitary District (Dames and Moore 1973). Four Miamisburg municipal wells, all located west of the

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This section provides a background description of the municipal, industrial, and domestic users of groundwater and cistern water in the vicinity of Mound Plant, and of the Mound Plant water supply. The municipal and residential water investigation is actually a part of the site-wide hydrogeology investigation, and is intended to focus on downgradient water users.

2.2.6.1. Municipal and Industrial Water Users

Six municipal water supplies are located within a 5-mile radius of Mound Plant, including Miamisburg, West Carrollton, Franklin, Germantown, the Springboro Water District, and the Montgomery County Sanitary District (Dames and Moore 1973). Five Miamisburg municipal wells, all located west of the

Great Miami River, are upstream of Mound Plant. These four wells would probably not be affected by Mound Plant because they are hydraulically upgradient of the aquifer adjacent to Mound Plant and because the river may act as a partial recharge barrier (Dames and Moore 1973). The Miamisburg municipal well field pumped 691.57 million gallons in 1992.

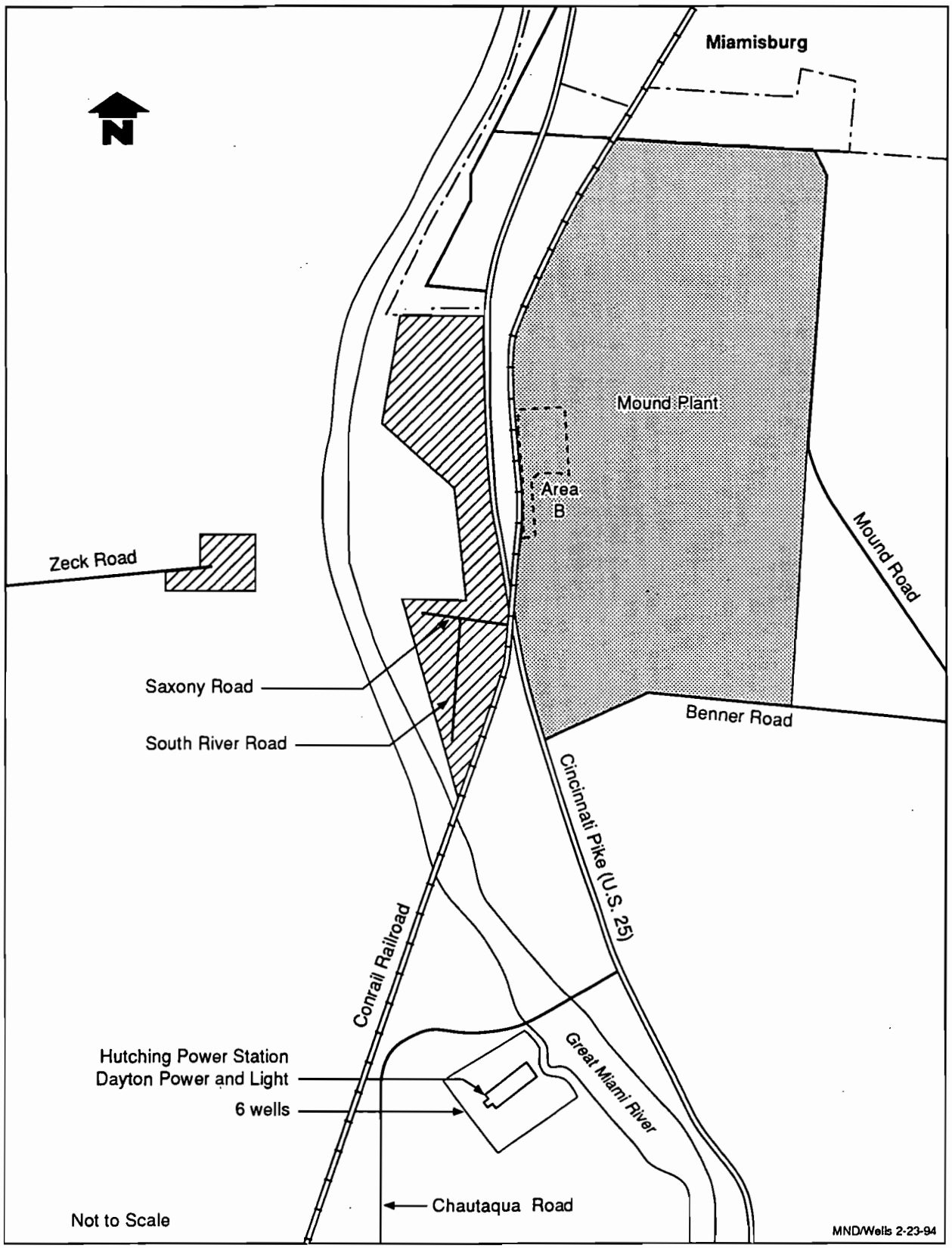
There are two other, minor production wells in the vicinity of the plant. Well 0912 (the former Miamisburg Production Well No. 2), located just west of Area B, is pumped as needed to control tritium levels in the Buried Valley aquifer. Over the last 5 years, well 0912 has been pumped a total of 18 days. No pumping occurred in 1992 and 1993. No long-term pumping effects have been observed. When it is in service, it would create a potentiometric low northwest of Area B and locally induce a northwesterly groundwater flow.

In addition, Miamisburg Production Well No. 3 (well 0913) is located at the Miamisburg Municipal Park, north of Area B. This well is used to fill the municipal swimming pool on an as-needed basis. Pumping rates and durations are not available, but there appears to be no effect from this well on the monitor wells in the vicinity of Area B.

The Hutchings Power Station of the Dayton Power and Light Company is the only industrial water user in close proximity to Mound Plant. The power station is located about 1.5 miles south of Mound Plant on the west bank of the Great Miami River (Figure 2.5). Six high-capacity wells (1,500 gallons per minute [gpm]) are in use at the power station (Dames and Moore 1973). Since the river acts as a partial recharge barrier and these wells are on the opposite side of the river, the wells are unlikely to be affected by Mound Plant. Wells at the Dayton Power and Light Hutching Power Station pumped 208 million gallons in 1992.

2.2.6.2. Domestic Wells

There are three areas of private wells hydraulically connected to the aquifer in the vicinity of Mound Plant (Figure 2.4). These areas are located west of the Conrail Railroad line. In 1979, some homes in this area were dependent on shallow wells in the valley alluvium for their water supplies (DOE 1979). In January 1988, residences that used groundwater from wells 0901, 0902, 0903, 0905, 0906, 0907, and 0908 (Figure 2.6) were connected to Miamisburg city water due to local organic contamination. Mound Plant maintains an inventory of these older wells and monitors all of them (except 0908) monthly for tritium. Well 0904, which is still a domestic source, is also monitored. The wells taken out of service are now believed to supply nonpotable water for area users. Well 0909 (Figure 2.6) is a well that services the Miami Conservancy District maintenance building. No chemicals have been detected in well 0909. South of these wells, on Saxony Road and South River Road, is an



Private well area

Figure 2.5. Location of domestic and industrial wells near Mound Plant.

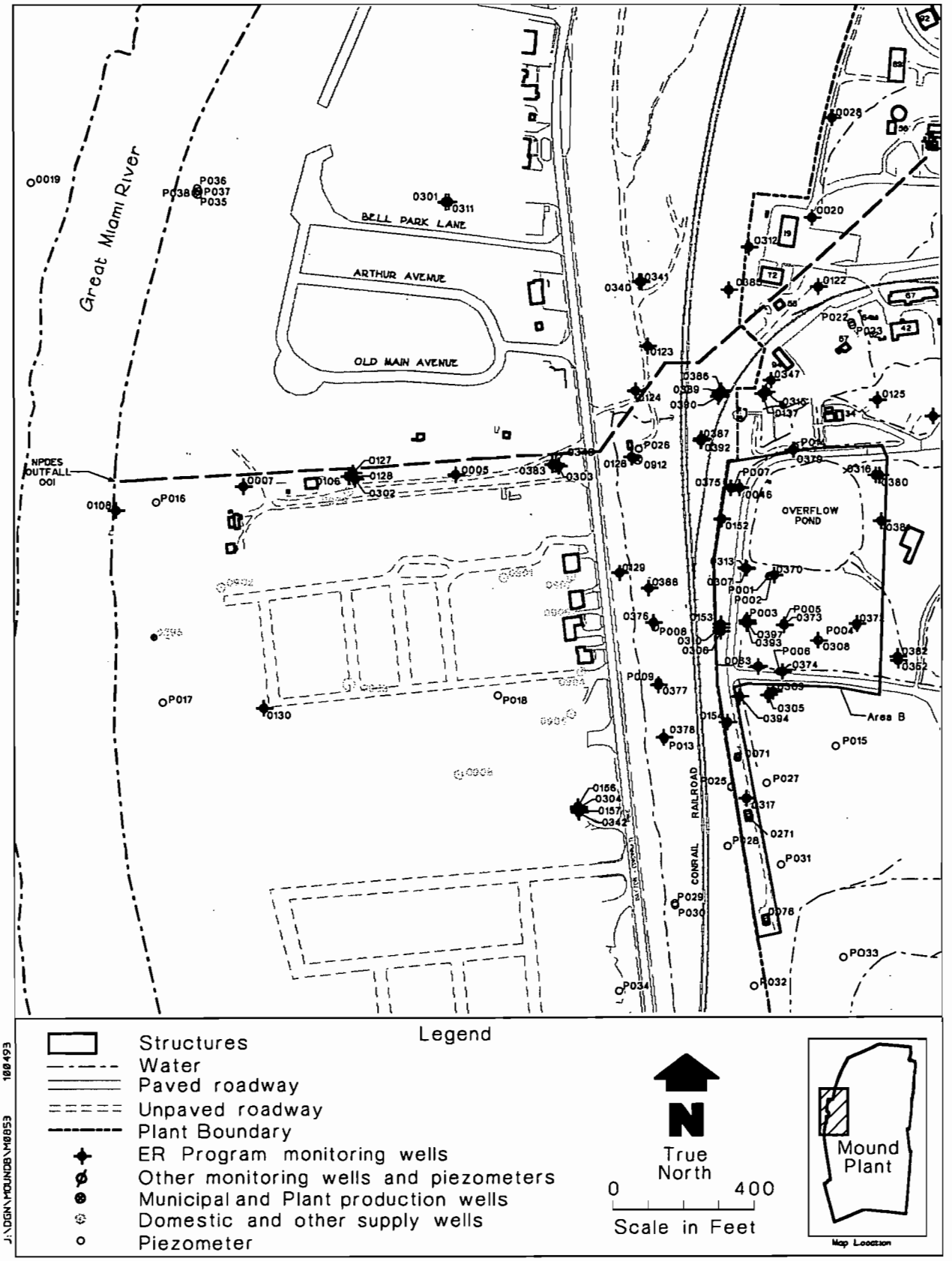


Figure 2.6. Residential, Mound Plant production and ER monitoring wells.

area nine domestic wells that have not been sampled. Three of these wells are scheduled to be sampled as part of the Operable Unit 9 Residential Well Sampling Program (EG&G 1993c). The city of Miamisburg is considering connecting these residences to the municipal supply.

2.2.6.3. Mound Plant Water Supply

Three production wells (0071, 0271, and 0076; Figure 2.6) supply water to Mound Plant for industrial and potable use from a source in glacial outwash deposits (Dames and Moore 1973). These wells are located within the boundaries of Mound Plant and have a localized effect on the general direction of groundwater flow. Production Well 1 (0071) has been taken off line because of increasing levels of volatile organic chemicals in the discharge water. Production well 3 (0076) is now the primary source of process and potable water for the plant. Well 2 (0271) is pumped as required to provide a supplemental source of plant water. A summary of 1991 Mound Plant sampling results is shown in Tables II.3 and II.4.

Groundwater flow is generally from west to east in the vicinity of the Mound Plant production wells 0071, 0271, and 0076. Direct pumping rates and quantities of the water from the Mound Plant production wells are not known. However, 400,000 to 500,000 gallons are treated daily by the Mound Plant softening system. Since most pumped water is directed through these softeners, this is a good estimate of actual quantities of water pumped. Based on February 1988 water levels, approximately 1.5 ft of drawdown was observed between the river and well 0154 (adjacent to Mound Plant production wells). Less than 0.2 ft of drawdown was observed between well 0913 (Miamisburg 3) and monitoring well 0118. The small amount of observed drawdown indicates that the aquifer has the capacity to transmit large amounts of water. Additional information about the Mound Plant production well field is contained in the Site hydrogeology section of this RI report.

2.2.7. Surface Water Occurrence and Flow

There are several surface water bodies and drainage structures associated with Area B: the drainage ditch located west of Area B, running along the eastern side of the paved road; the french drains located under the site sanitary landfill; and the overflow pond and adjacent spillways and retention basins. The french drains are designed to collect water from underneath and to the east of the landfill and transmit it west to a drainage ditch. These drains could be a concentrated subsurface recharge source.

Drainage on the Mound Plant Site is collected by an interconnecting series of retention basins, the plant drainage ditch, and the overflow pond in Area B. During periods of high flow, when the retention

Table II.3. Volatile Organic Concentrations in Onsite Production Wells in 1991

Location	Number of Samples	Minimum	Maximum	Average	MCL[a]
		µg/L			
Well No. 1 (0071)					
1,2-Dichloroethene (total)	67	1.50	18.80	5.66	70[b]
Trichloroethene	67	1.75	6.50	3.39	5
Trichloromethane	67	0.00	1.00	0.01	100
Tetrachloroethene	67	0.00	0.90	0.36	5
Well No. 2 (0271)					
1,2-Dichloroethene (total)	63	1.20	6.50	2.75	70[b]
Trichloroethene	63	1.90	5.90	4.02	5
Trichloromethane	63	0.00	0.50	0.02	100
Tetrachloroethene	63	0.00	1.90	0.93	5
Well No. 3 (0076)					
1,2-Dichloroethene (total)	22	0.00	5.00	1.17	70[b]
Trichloroethene	22	0.00	4.60	1.37	5
Trichloromethane	22	0.00	0.00	0.00	100
Tetrachloroethene	22	0.00	0.80	0.06	5

Ref: EG&G 1992.

[a]MCL - Maximum Contaminant Level, based on Primary Drinking Water Standards.
[b]MCL for *cis* = 70 µg/L, *trans* = 100 µg/L.

Table II.4. Contaminant Concentrations in Onsite Production Wells in 1991

Location	Number of Samples	Tritium* (10^{-6} μCi/mL)			Average as a Percent of EPA Standard
		Minimum	Maximum	Average[b,c]	
Well No. 1 (0071)	51	2.1	4.6	3.5 ± 0.2	17.5
Well No. 2 (0271)	50	1.5	3.7	2.5 ± 0.2	12.5
Well No. 3 (0076)	34	0.4	3.4	1.5 ± 0.2	7.5

[a]Average environmental level not subtracted from the data. The EPA standard of 20 x 10^{-6} μCi/mL assesses total concentration, including background.
[b]Error limits are estimates of the standard error of the estimated means at the 95% confidence level.
[c]Lower detection limit for tritium in onsite well water is 0.5 x 10^{-6} μCi/mL.

Location	Number of Samples	Plutonium-238* (10^{-12} μCi/mL)			Average as a Percent of 4% DOE DCG[c]
		Minimum	Maximum	Average[a,b,c]	
Well No. 1	12	-4.48	8.7	2.15 ± 2.63	0.13
Well No. 2	12	-8.08	11.17	0.72 ± 3.06	0.05
Well No. 3	9	-3.65	9.23	0.59 ± 2.79	0.04

*Average environmental level has been subtracted from the data.
[a]Error limits are estimates of the standard error of the estimated means at the 95% confidence level.
[b]Lower detection limit for plutonium-238 in drinking water is 17.4 x 10^{-12} μCi/mL.
[c]4% of the DOE-derived concentration guideline for plutonium-238 in drinking water is 1,600 x 10^{-12} μCi/mL.
DCG - derived concentration guideline

Location	Number of Samples	Uranium-233, -234* (10^{-9} μCi/mL)			Average as a Percent of 4% DOE DCG[c]
		Minimum	Maximum	Average[a,b,c]	
Well No. 1	12	0.12	0.23	0.19 ± 0.02	1.0
Well No. 2	12	0.17	0.28	0.21 ± 0.02	1.1
Well No. 3	8	0.15	0.26	0.22 ± 0.03	1.1
		Uranium-238 (10^{-9} μCi/mL)			
Well No. 1	12	0.11	0.21	0.17 ± 0.02	0.7
Well No. 2	12	0.15	0.25	0.19 ± 0.02	0.8
Well No. 3	8	0.12	0.21	0.19 ± 0.02	0.8

*Average environmental level has been subtracted from the data.
[a]Error limits are estimates of the standard error of the estimated means at the 95% confidence level.
[b]Lower detection limit for monthly uranium-233, -234 is 0.03 x 10^{-9} μCi/mL. The LDL for uranium-238 is 0.03 x 10^{-9} μCi/mL.
[c]4% of the DOE-derived concentration guidelines for uranium-233, -234 in drinking water is 20 x 10^{-9} μCi/mL. 4% of the DOE DCG for uranium-238 in drinking water is 24 x 10^{-9} μCi/mL.

DCG - derived concentration guideline

Ref: EG&G 1992.

basins are filled to capacity, excess water flows into the overflow pond by way of a spillway located at the north side of the overflow pond.

2.3. AIR QUALITY

An extensive air quality surveillance program, including 20 air quality monitoring stations, is in existence at the Mound Plant. This monitoring is being conducted by plant personnel. Airborne radionuclides and particulates are being monitored. Sampling occurs on a scheduled basis for plutonium-238, tritium, uranium, and particulates. A more detailed discussion of onsite and offsite air monitoring is presented in the Operable Unit 9, Site-Wide Work Plan (DOE 1992b). This section will focus on air sampling and quality relevant to Area B.

2.3.1. Radionuclides

The onsite air sampling network consists of five sampling stations used for sampling tritium oxide, plutonium-238, and particulates (Figure 2.7). Note that air-monitoring stations 214 and 215 are in close proximity to Area B. Summaries of 1991 results from these two stations are shown in Table II.5.

Two types of samples are collected at each sampling station. One is a particulate air sample used to determine particulate concentration and for plutonium-238 analysis. The other, collected from a bubbler-type sampler, is for tritium oxide analysis. Plutonium-238 analyses are performed on a monthly composite for three sampling locations, and on quarterly composites for the other offsite locations. Particulate and tritium concentrations are determined on a weekly basis.

Tritium (oxide) in the air is collected in solution. Tritium oxide, rather than elemental tritium, is sampled and analyzed because about half of the tritium emission is in the oxide form, and the derived air concentration is much more restrictive (25,000 times) for tritium oxide than for elemental tritium.

2.3.2. Compliance with National Emissions Standards

Since 1985, Mound Plant has been computing and reporting to EPA the results of environmental monitoring and modeling of the effective dose equivalent to the public from ambient air. This is performed to comply with the Clean Air Act, 40 CFR 61 - Subpart H - National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities. These reports include the monitored doses as well as the doses calculated using the computer code AIRDOS-EPA and CAP-88 for the radionuclides plutonium-238, plutonium-239, tritium, uranium-234, and uranium-238. According to data collected by previous investigations (EG&G 1989a; DOE 1979), the impact related

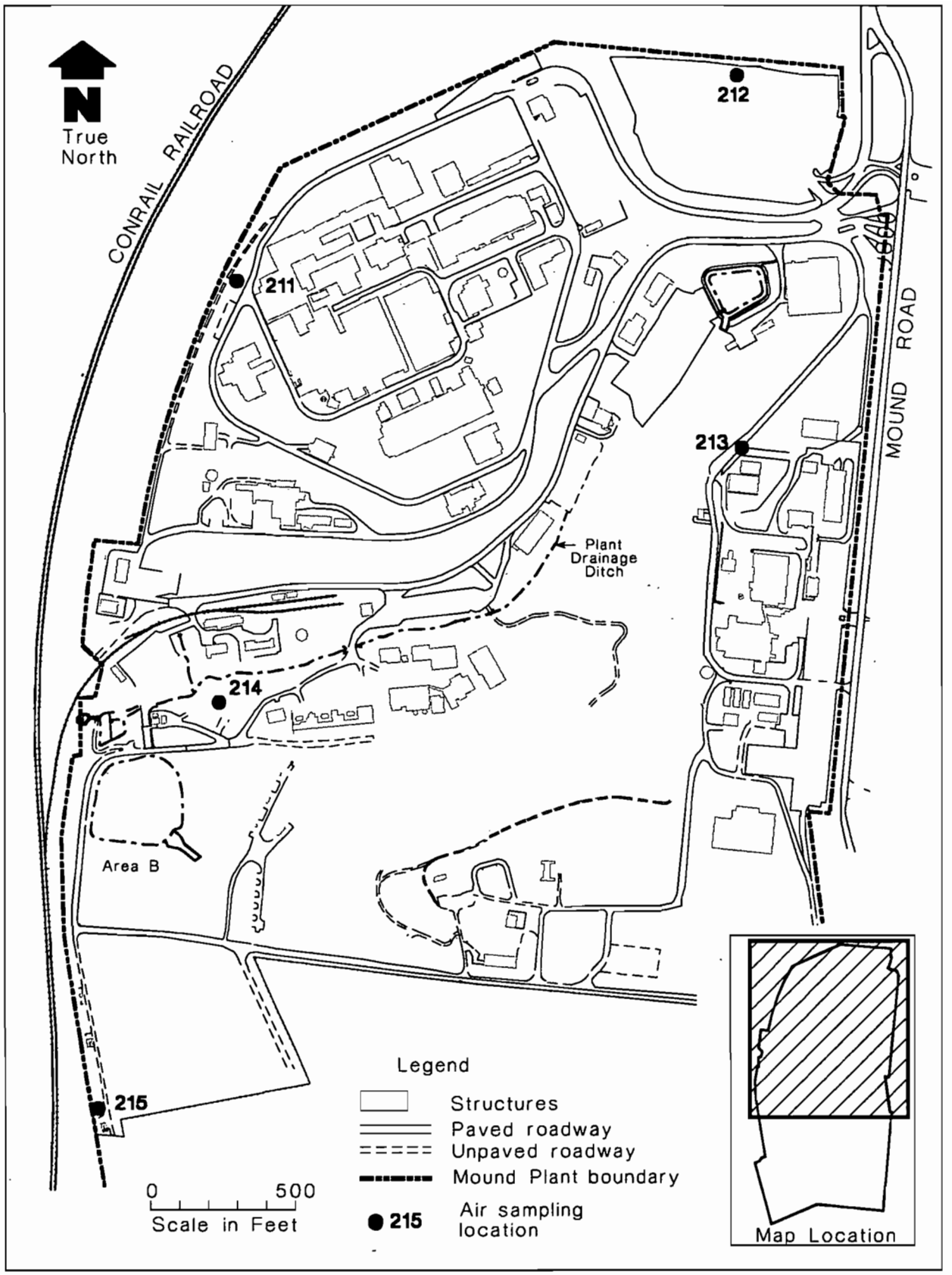


Figure 2.7. On-plant air sampling network, 5 locations.

Table II.5. Incremental Concentrations[a] of Contaminants in Air at Sampling Locations in 1991

Location*	Number of Samples	Plutonium-238[a] (10^{-18} µCi/mL)			Average as a Percent of DOE DCG[d]
		Minimum	Maximum	Average[b,c]	
214	12	2.27	24.65	7.7 ± 3.75	0.03
215	12	1.2	27.73	6.82 ± 4.78	0.02

[a]Average environmental level has been subtracted from the data.
[b]Error limits are estimates of the standard error of the estimated means at the 95% confidence level.
[c]Lower detection limit for monthly values of plutonium-238 in air is 0.7 x 10^{-18} µCi/mL; for quarterly values, 0.2 x 10^{-18} µCi/mL.
[d]DOE-derived concentration guideline for plutonium-238 in air is 30,000 x 10^{-18} µCi/mL.
*Onsite sampling locations are shown in Figure 2.7.

Location*	Number of Samples	Tritium Oxide[a] (10^{-12} µCi/mL)			Average as a Percent of DOE DCG[d]
		Minimum	Maximum	Average[b,c]	
214	51	-3.06	28.69	9.97 ± 2.66	0.01
215	51	-9.88	31.45	6.18 ± 2.66	0.006

[a]Average environmental level has been subtracted from the data.
[b]Error limits are estimates of the standard error of the estimated means at the 95% confidence level.
[c]Lower detection limit for tritium oxide in air is 16 x 10^{-12} µCi/mL.
[d]DOE-derived concentration guideline for tritium oxide in air is 100,000 x 10^{-12} µCi/mL. This value has been adjusted to include the fraction of tritium oxide that is absorbed through the skin as part of the inhalation pathway.
*Onsite sampling locations are shown in Figure 2.7.

Location*	Number of Samples	Plutonium-239, -240[a] (10^{-18} µCi/mL)			Average as a Percent of DOE DCG[d]
		Minimum	Maximum	Average[b,c]	
214	12	-0.27	0.43	-0.05 ± 0.18	[e]
215	12	-0.34	0.17	-0.03 ± 0.13	[e]

[a]Average environmental level has been subtracted from the data.
[b]Error limits are estimates of the standard error of the estimated means at the 95% confidence level.
[c]Lower detection level for monthly values of plutonium-239, -240 in air is 0.3 x 10^{-18} µCi/mL. Lower detection level for quarterly values of plutonium-239, -240 in air is 0.1 x 10^{-18} µCi/mL.
[d]DOE-derived concentration guidelines for plutonium-239, -240 is 20,000 x 10^{-18} µCi/mL.
[e]Below environmental level.
*Onsite sampling locations are shown in Figure 2.7.

Ref: EG&G 1992.

to air emissions from Mound Plant is considered to be small or negligible. The existing air quality monitoring network was designed for and is deemed sufficient to characterize emissions from current plant operations.

2.4. CLIMATOLOGY

The goal of the meteorological monitoring is to characterize the meteorological conditions at the Site in order to evaluate atmospheric contaminant transport, contaminant dispersion, and potential areas of contaminant deposition. Mound Plant is currently operating an onsite meteorological monitoring station designed to collect measurements of wind speed, direction, temperature, precipitation, barometric pressure, and solar radiation. Data on barometric pressure and solar radiation are not currently collected. Conditions of atmospheric stability are calculated from the standard deviation of wind speed and direction. The following subsections summarize what is known about the climatology and meteorology of the area.

The climate of the area is continental, with moderate extremes in temperature. Summers are rather warm and humid, with an average daily maximum of 86.9°F. The relative humidity ranges from 50 percent in the winter to 85 percent in the summer. Winters are moderately cold, with an average of about 2 days of subzero weather and frequent periods of extensive cloudiness. The average daily minimum temperature in January is 17.5°F. Autumns are predominantly cool and dry. Spring is the wettest season. Severe weather is mostly associated with heavy thunderstorms in the summer, resulting in occasional damaging winds and local flash flooding.

Tornadoes occur in the region, but not frequently, and most have paths that are short and narrow. The interplay between general atmospheric processes and topography is minimal; however, the lifting of moist air masses over the hills of the southern half of Ohio tends to increase the yield of rainfall, especially in winter and spring (MRC 1985a). The probability of a tornado hitting the Site in any given year is calculated to be about 10^{-4}, a frequency of once every 840 years. On April 3, 1974, a tornado at Xenia, Ohio (approximately 25 miles northeast of Mound Plant) was one of the most severe recorded in the United States.

Essentially all of Ohio is subject to potentially damaging hailstorms two or three times per year. There is no hailstorm season as such, but the peak frequency (less than one per month) for the region occurs during April. The most commonly reported hailstones are 1/2- to 3/4-inch in diameter and cause little or no property damage. However, much larger stones are associated with the more severe thunderstorms. Hail 1 inch in diameter and larger will cause heavy damage to roofs, will pit thin steel surfaces (of automobiles, for example), and may break windows.

2.4.1. Precipitation

Precipitation is common in all seasons. The average annual rainfall equivalent is about 40 inches, including about 27 inches per year of snow. The maximum 24-hour rainfall recorded in Dayton is 4.56 inches. Tables II.6 and II.7 give the normal monthly precipitation data for Miamisburg and the regional maximum monthly totals, respectively (DOE 1979).

Ice storms in the form of freezing rain or sleet occur occasionally in the region. One or two occur each winter; however, they usually result in such a slight accumulation of glaze ice that they have little or no effect other than slight inconveniences to traffic. Moderate to heavy ice storms occur about once every 4 or 5 years and can be quite damaging to utility lines and trees, in addition to causing traffic hazards.

2.4.2. Winds

The surface wind flow at Dayton is predominantly from the southwest quadrant. Average annual wind speeds range from about 7 to 10 miles per hour (mph). A study conducted to evaluate air pollution potentials in urban areas showed that the lowest wind speeds and the lowest mixing heights (the height above the surface through which relatively vigorous vertical mixing occurs) and, therefore, the greatest potential for air pollution, occur on summer mornings in Dayton. The "fastest mile" on record at Dayton is 78 mph. (The "fastest mile" is the highest wind speed lasting for any time interval during which a length of air one mile long passes a wind instrument.)

Onsite meteorological data wind speed, direction, and atmospheric stability are being collected continuously at Mound Plant. The meteorological tower is 160 ft above the ground and is located at T Building. Figure 2.8 used onsite data to show the wind direction and frequency for Mound Plant.

Table II.6. Monthly Precipitation in Miamisburg, Ohio

Month	Normal[a] (in)	Number of Days Greater Than 0.5 in[b]
Jan	2.32	2
Feb	2.33	2
Mar	3.39	2
Apr	3.83	2
May	4.51	3
Jun	3.30	4
Jul	4.28	2
Aug	3.53	1
Sep	2.96	2
Oct	2.76	1
Nov	3.15	2
Dec	2.82	2
Annual	39.18	25

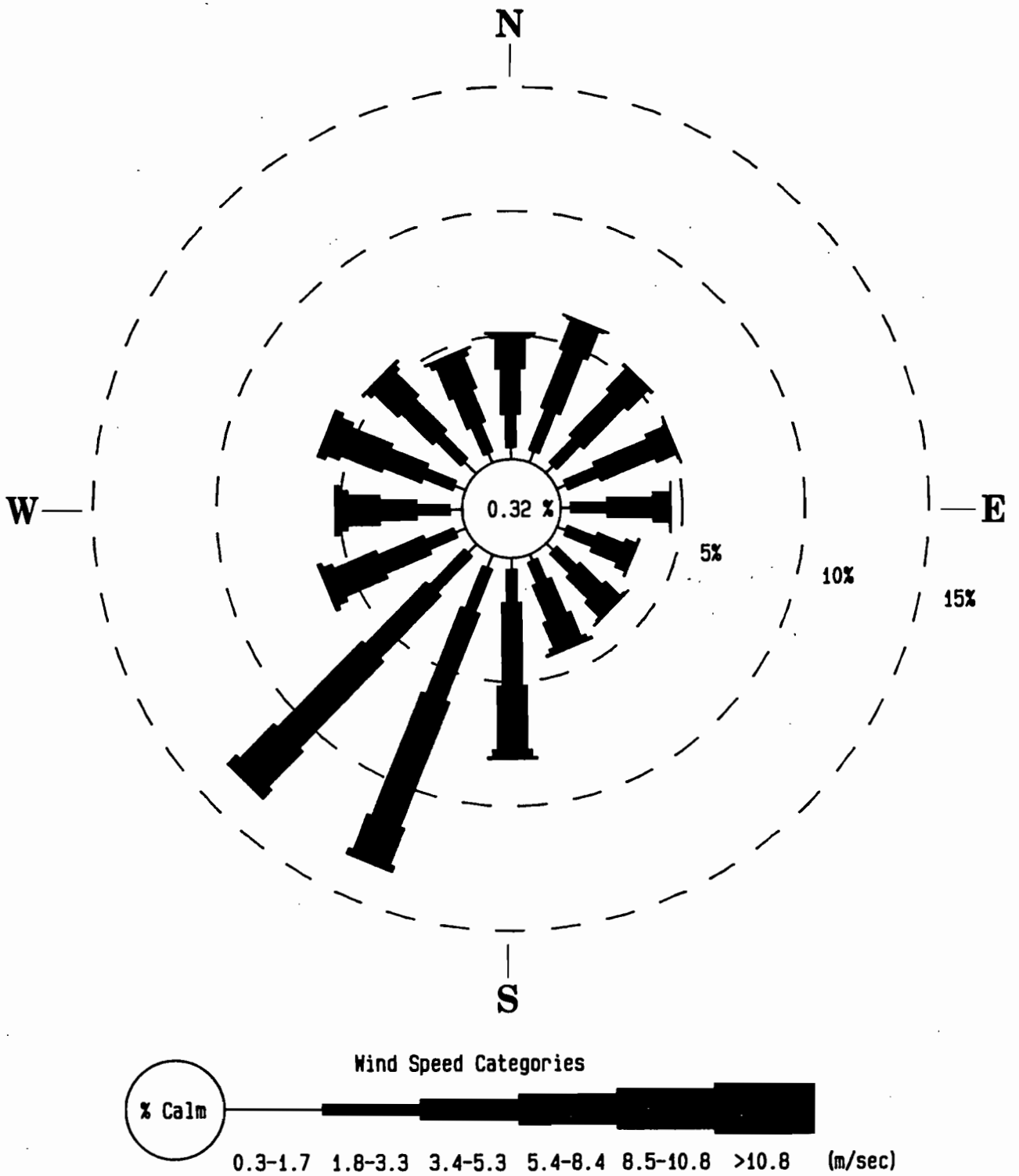
Reference: DOE 1979; Owenby and Ezell 1992
[a]30-year record compiled through 1990
[b]10-year record compiled through 1975

Table II.7. Maximum Monthly Precipitation at Miamisburg, Dayton, and Cincinnati, Ohio

Month	Miamisburg[a] (in)	Dayton[b] (in)	Cincinnati[c] (in)
Jan	7.17	12.41	13.68
Feb	5.14	4.57	6.24
Mar	5.70	8.89	10.94
Apr	5.82	6.69	8.62
May	11.13	9.70	8.81
Jun	10.22	8.77	9.07
Jul	10.16	8.94	10.02
Aug	9.68	7.62	6.54
Sep	7.93	6.91	5.86
Oct	7.10	7.08	9.51
Nov	8.23	6.67	6.46
Dec	8.53	8.64	6.94

Reference: DOE 1979; MDC 1993

[a]27-year record compiled through 1992
[b]60-year record compiled through 1992, Abbe Observatory
[c]42-year record compiled through 1975



Data set is 91.1% complete.

Source: Mound Plant environmental monitoring data.

MND/OU1/RIR-02/9-24-93

Figure 2.8. Annual wind rose for Mound Plant, 1992.

3. FIELD INVESTIGATION

3.1. ORGANIZATION AND DEVELOPMENT OF THE FIELD PROGRAM

As discussed in section 1, the Operable Unit 1 RI has been carried out in stages, beginning in 1986. In 1991, as technical memoranda dealing with certain aspects of Operable Unit 1 were being developed, certain gaps in the available data were identified. The purpose of the current field program was to close these data gaps to allow the RI to be completed. A Proposal for Additional Work was drafted and submitted for regulatory approval (DOE 1992a). After the work plan was approved, field work began with preparations for a soil gas survey. The following sections will describe the most recent, as well as former, stages of field work.

This field program was also carried out in sequential steps, each step providing data for subsequent steps. They were:

- Completing a soil gas survey to identify hot spots, confirm siting for soil samples and monitor wells, and confirm or refute the need for a removal action for subsurface VOCs;
- Surface soil sampling to characterize near-surface chemical and radiological conditions;
- Subsurface soil sampling to characterize chemical, radiological, and geotechnical conditions within and adjacent to Area B;
- Installation and monitoring/sampling of piezometer and monitor wells to characterize groundwater conditions; and
- Conducting a long-term aquifer test to describe hydraulic conditions within the adjacent aquifer system.

As the data from the subsurface investigation (soil sampling and monitor well installation) became available, the long term aquifer test was redesigned (DOE 1994) and resubmitted for regulatory approval.

After the monitor wells were installed, all new wells were sampled for the same parameter list as the balance of the ongoing monitoring program.

3.2. IMPLEMENTATION OF THE FIELD PROGRAM AND SUMMARY OF FIELD WORK PERFORMED

Mound Plant personnel began a periodic water sampling program for VOCs in 1984. Under the ER Program, an RI was started in 1987 and focused on observations of groundwater contamination. VOCs have been detected and monitored in the groundwater since 1986 (DOE 1992a).

3.2.1. Time Sequence of Work Performed

To date, three formal stages of the RI have been completed, followed by a program of additional field work. Stage 1, which was completed in 1987, consisted of sampling existing wells at Mound Plant to assess the adequacy of the existing groundwater monitoring network and performing a soil gas survey to aid in optimally locating new wells. Stage 2 consisted of the installation and sampling of new monitoring wells to fill in data gaps and replace old wells. The well installation was completed in late 1987; sampling began in December 1987. Stage 3 consisted of new well installations and further groundwater sampling. The Stage 3 well installations were finished in late 1989; sampling began in January 1990. After Stage 3 was complete, additional work was proposed to more fully characterize the extent of possible contamination at Area B and to determine if an unacceptable threat to human health or the environment exists. As part of the additional work conducted from late 1992 to early 1993, an additional soil gas survey was performed, surface and subsurface soil samples were collected, and more monitoring wells were installed. Sampling of the newly installed monitoring wells was conducted in March and April 1993.

3.2.2. Identification and Role of Subcontractors

Two separate drilling companies (Bowser and Morner, Inc. and Northstar Drilling Co.) were subcontracted by Roy F. Weston, Inc. (WESTON) to complete various stages of the RI field work. Bowser and Morner, Inc. was subcontracted to install Stage 2 and Stage 3 monitoring wells. Northstar Drilling Co. was subcontracted to install exploratory borings, piezometer, and monitoring wells during the additional work stage of the RI. Each subcontractor provided equipment and personnel to perform drilling, downhole sample collection, and well or piezometer installation and development.

The subcontractor for the soil gas surveys was Hydro Geo Chem, Inc. This firm provided the field apparatus to drive (push) sampling probes to the desired depth and provided a mobile laboratory for sample analysis.

3.3. DRILLING, BOREHOLE, AND WELL INSTALLATION PROGRAM

New monitoring wells were installed during Stage 2 and Stage 3, and as part of the additional work stage of the RI. The rationale supporting the installation of these wells is described in further detail in subsection 1.3.2.1. Specifications for Mound Plant monitoring wells and boreholes installed prior to the inception of the ER Program are also described in the Operable Unit 9, Site Scoping Report: Volume 2 - Geologic Log and Well Information Report (DOE 1992g).

3.3.1. Number of Wells and Boreholes Installed

As part of Stage 2 of the RI, 28 new monitoring wells were installed during October and November of 1987. Stage 3 of the RI included the installation of 20 new monitoring wells between August and December 1989. Between late 1992 and early 1993, three exploratory borings, 12 piezometer, and 15 monitoring wells were installed as part of the additional field work stage of the RI. Table III.1 lists all exploratory borings, piezometer, and monitoring wells completed during the ER Program, as well as the specific start and completion dates for each. The corresponding location of each installation is shown in Figure 3.1.

In addition to the Operable Unit 1 installations, monitoring wells and piezometer were installed as part of the Operable Unit 9, Site-Wide, Remedial Investigation. Specifications of these wells and piezometer are provided in the Operable Unit 9, Remedial Investigation/Feasibility Study, Hydrogeologic Investigation Well Information Report (DOE 1994). The Operable Unit 9 installations in the vicinity of Operable Unit 1 are also shown on Figure 3.1.

All Operable Unit 1 and Operable Unit 9 installations were surveyed under the Operable Unit 9, Site-Wide RI. The survey data are presented in Appendix A.

3.3.2. Footage Summary

Depth specifications for Stage 2 and Stage 3 monitoring well installations are described in the Operable Unit 9, Site Scoping Report: Volume 2 - Geologic Log and Well Information Report (DOE 1992g). Depth specifications for exploratory borings, piezometer, and monitoring wells installed during the additional field work stage of the RI are shown in Tables III.2 and III.3.

3.3.3. Drill Rig(s) and Drilling Techniques

Most Stage 2 and all Stage 3 monitoring well installations were made in areas of unconsolidated materials and involved the use of a cable-tool drilling rig. The cable-tool rig used a spud bit to advance the boring; casing was driven behind the bit to maintain an open borehole. In most well boreholes, split-spoon drive samples were collected at 5-ft intervals; some were retained for geochemical analysis. The samples were logged visually for lithology to characterize the subsurface stratigraphy.

Six Stage 2 monitoring wells were installed in areas that are predominately underlain by bedrock. In these areas, an air-rotary drilling rig was used. The air rotary rig was equipped with a continuous core barrel that was used for the collection of bedrock samples at variable depths in two of the well borings.

Table III.1. ER Program Exploratory Borings, Piezometers, and Monitoring Wells

Program Interval	Location I.D.	Type of Installation	Date Started	Date Completed
RI Stage 2	0111	Monitoring Well	11/16/87	11/17/87
	0112		11/18/87	11/18/87
	0113		11/14/87	11/16/87
	0114		11/03/87	11/11/87
	0115		11/10/87	11/10/87
	0116		10/27/87	11/02/87
	0117		12/01/87	12/02/87
	0118		10/19/87	10/20/87
	0119		11/13/87	11/13/87
	0120		12/02/87	12/04/87
	0121		11/11/87	11/12/87
	0122		11/18/87	11/19/87
	0123		10/06/87	10/07/87
	0124		10/12/87	10/13/87
	0125		11/10/87	11/10/87
	0126		10/15/87	10/16/87
	0127		10/02/87	10/02/87
	0128		09/28/87	09/30/87
	0129		11/04/87	11/05/87
	0130		11/06/87	11/06/87
	0138		10/27/87	10/28/87
	0154		10/03/87	10/04/87
	0155		10/05/87	10/05/87
	0156		10/26/87	10/27/87
	0157		10/20/87	10/26/87
	0158		11/09/87	11/09/87
	0159		10/18/87	10/18/87
	0160		10/17/87	10/18/87
RI Stage 3	0301	Monitoring Well	08/05/89	08/09/89
	0302		09/05/89	09/15/89
	0303		08/30/89	09/06/89
	0304		09/16/89	09/20/89
	0305		08/21/89	08/22/89
	0306		08/31/89	09/02/89
	0307		09/02/89	09/04/89
	0308		08/28/89	09/04/89
	0309		08/18/89	08/21/89
	0310		08/14/89	08/16/89
	0311		08/03/89	08/04/89
	0312		12/12/89	12/13/89
	0313		09/04/89	09/04/89
	0314		08/02/89	08/03/89
	0315		08/06/89	08/07/89
	0316		08/04/89	08/05/89
	0317		08/16/89	08/18/89
	0318		08/08/89	08/09/89
	0319		08/20/89	08/23/89
	0320		08/15/89	08/19/89

Table III.1. (2 of 2)

Program Interval	Location I.D.	Type of Installation	Date Started	Date Completed
RI Additional Work	B001	Exploratory Boring	11/04/92	11/04/92
	B002		11/03/92	11/03/92
	B003		11/03/92	11/03/92
	P001	Piezometer	11/08/92	11/09/92
	P002		11/09/92	11/22/92
	P003		11/07/92	11/07/92
	P004		11/10/92	11/18/92
	P005		11/21/92	11/21/92
	P006		10/25/92	10/25/92
	P007		10/22/92	10/23/92
	P008		02/17/93	02/20/93
	P009		02/23/93	02/23/93
	P013		02/22/93	02/23/93
	P014		10/24/92	10/24/92
	P015		10/26/92	10/26/92
	0370	Monitoring Well	12/07/92	12/07/92
	0372		01/04/93	01/07/93
	0373		12/14/92	12/15/92
	0374		12/05/92	12/06/92
	0375		12/08/92	12/08/92
	0376		03/05/93	03/05/93
	0377		03/04/93	03/04/93
	0378		03/03/93	03/03/93
	0379		12/04/92	12/05/92
	0380		12/16/92	12/17/92
	0381		01/07/93	01/08/93
	0382		12/15/92	12/16/92
	0393		11/19/92	01/05/93
	0394		11/20/92	12/03/92
	0397		12/06/92	12/06/92

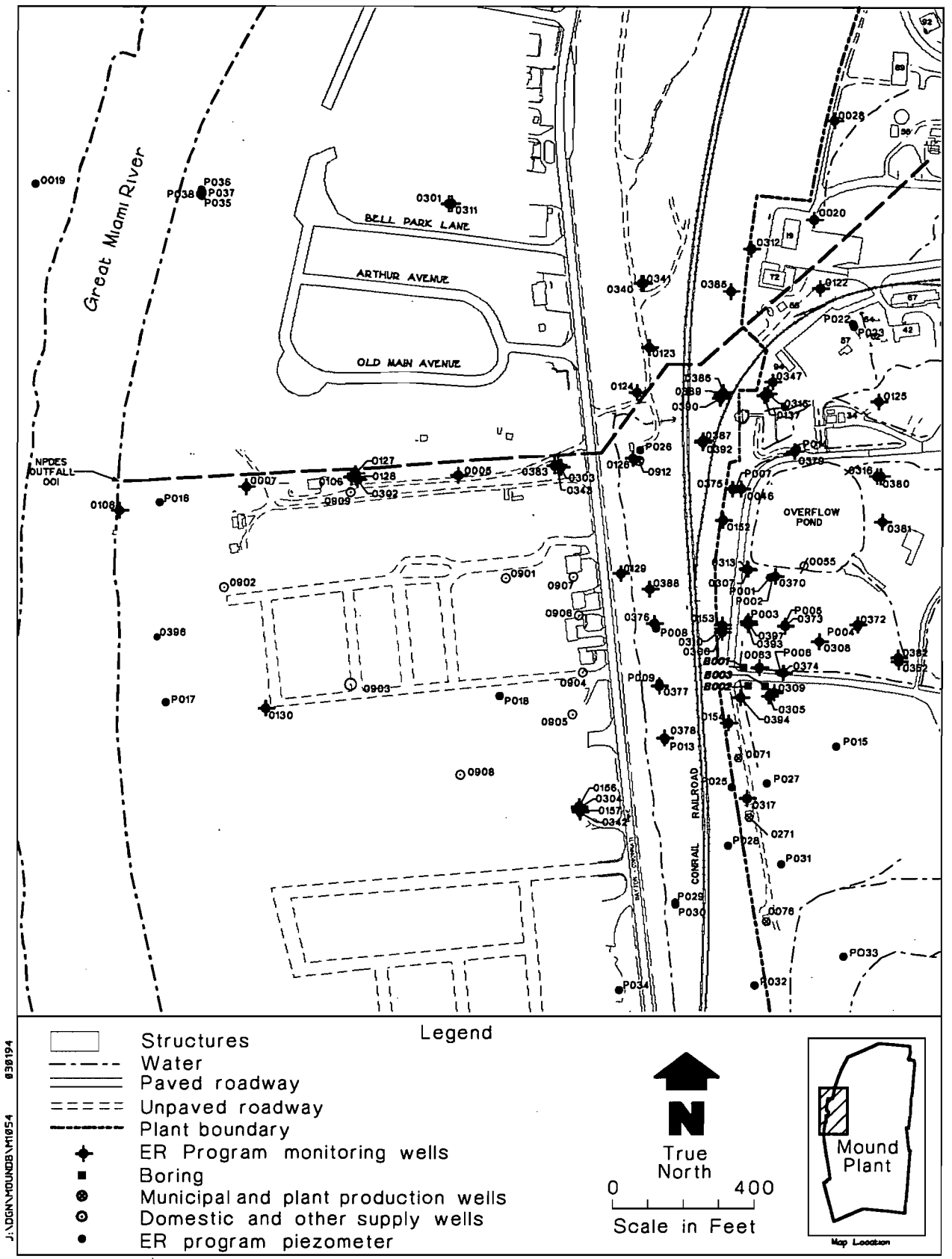


Figure 3.1. Location of ER Program exploration borings, piezometers, and monitoring wells.

Table III.2. Exploratory Boring and Piezometer Specifications for Additional Work Phase Installations

Piezometer Location I.D.	Total Depth (ft below ground surface)			Well Construction and Stemming Material Intervals (ft below ground surface)					Formation of Completion	Comments
	Borehole	Surface Casing	Monitoring Well/ Piezometer Casing	Well Screen	Riser Pipe	Filter Pack	Bentonite Seal	Bentonite Cement Grout		
B001	40.0	NA	NA	NA	NA	NA	NA	0.0-40.0	NA	
B002	25.0	NA	NA	NA	NA	NA	NA	0.0-25.0	NA	
B003	41.5	NA	NA	NA	NA	NA	NA	0.0-41.5	NA	
P001	50.0	NA	45.0	35.0-44.3	0.0-35.0	33.0-45.0	28.0-33.0	0.0-33.0	Outwash	
P002	63.0	48.5	62.8	60.0-62.3	0.0-60.0	57.5-62.8	53.0-57.5	0.0-53.0	Shale/Limestone	Telescoped completion
P003	39.0	NA	34.0	24.0-33.4	0.0-24.0	21.5-39.0	17.0-21.5	0.0-17.0	Outwash	
P004	63.5	32.5	62.2	52.2-61.5	0.0-52.2	51.0-62.2	48.0-52.0	0.0-48.0	Shale/Limestone	Telescoped completion
P005	67.0	NA	62.9	52.9-62.2	0.0-52.9	49.5-63.0	46.5-49.5	0.0-46.5	Outwash	
P006	31.8	NA	31.1	21.8-31.1	0.0-21.8	19.3-31.8	16.0-19.3	0.0-19.3	Outwash	
P007	40.0	NA	30.9	20.9-30.3	0.0-20.9	17.5-30.9	15.5-17.5	0.0-15.5	Outwash	
P008	61.0	NA	25.0	15.0-24.3	0.0-15.0	13.0-25.0	8.0-13.0	0.0-8.0	Outwash	
P009	81.0	NA	55.0	54.3-56.6	0.0-54.3	53.5-57.0	48.0-53.5	0.0-48.0	Outwash	
P013	110.0	NA	24.0	14.0-23.3	0.0-14.0	10.0-24.0	10.0-14.0	0.0-10.0	Outwash	
P014	45.0	NA	40.6	30.6-39.9	0.0-30.6	27.5-40.6	25.0-27.5	0.0-25.0	Outwash	
P015	55.0	NA	55.0	45.0-54.3	0.0-45.0	42.0-55.0	40.0-42.0	0.0-40.0	Outwash	
Total Footage	706.3	81.0	528.5							

Table III.2. (Page 2 of 2)

Additional Construction Specifications for Exploratory Borings.

Standard Borehole Diameter - 6.25 inches
Standard Core Barrel Diameter - 3.5-inch I.D; 4.0-inch O.D.
Backfill - cement/bentonite grout mixture

Additional Construction Specifications for Piezometers.

Standard Borehole Diameter - 6.25 inches
Standard Core Barrel Diameter - 3.5 inch I.D; 4.0-inch O.D.
Surface Casing Borehole Diameter - 10.5 inches
Surface Casing - 10.0-inch I.D; 10.5 inch O.D. (Piezometer P002)
- 7.0 inch I.D; 7.5 inch O.D. (Piezometer P004)
Well Screen - PVC; 2.0-inch O.D; 0.01-inch slot
Riser Pipe - PVC; 2.0-inch O.D.
Centralizers - stainless steel; positioned at base of well screen, above top of well screen, and at 50-ft intervals to top of riser pipe
Filter Pack - 20/40 silica sand
Seal - 0.25-inch bentonite chips
Backfill - cement/bentonite grout mixture
Protective Casing - 7.0-inch O.D. mild steel with lockable lid and weephole
Well Cap - PVC slip-on
Well Pad - 6- by 6-ft, 4-inch-thick concrete apron; contains surveyor's pin stamped with piezometer location ID
Monitoring Well Specifications

Table III.3. Monitoring Well Specifications for Additional Work Phase Installations

Monitoring Well Location I.D.	Total Depth (ft below ground surface)			Well Construction and Stemming Material Intervals (ft below ground surface)					Formation of Completion	Comments
	Borehole	Surface Casing	Monitoring Well/Piezometer Casing	Well Screen	Riser Pipe	Filter Pack	Bentonite Seal	Bentonite/ Cement Grout		
0370	50.0	NA	40.0	30.0 -39.6	0.0 -30.0	28.5 -40.0	24.0 -28.5	0.0 -24.0	Outwash	
0372	62.0	32.0	61.7	52.0 -61.6	0.0 -52.0	50.5 -62.0	44.5 -50.5	0.0 -44.5	Shale/Limestone	
0373	65.0	NA	63.0	53.4 -62.9	0.0 -53.4	50.0 -63.0	46.0 -50.0	0.0 -46.0	Outwash	
0374	35.0	NA	29.0	19.0 -28.6	0.0 -19.0	18.0 -35.0	14.0 -18.0	0.0 -14.0	Outwash	
0375	35.0	NA	27.0	17.0 -26.6	0.0 -17.0	15.0 -35.0	12.0 -15.0	0.0 -12.0	Outwash	
0376	25.2	NA	25.2	15.2 -24.8	0.0 -15.2	11.0 -25.2	8.0 -11.0	0.0 -8.0	Outwash	
0377	25.0	NA	24.6	14.9 -24.6	0.0 -14.9	11.0 -25.0	80.0 -11.0	0.0 -8.0	Outwash	
0378	25.0	NA	23.0	13.3 -23.0	0.0 -13.3	10.0 -24.0	7.0 -10.0	0.0 -7.0	Outwash	
0379	40.0	NA	40.0	30.0 -39.6	0.0 -30.0	28.0 -40.0	25.0 -28.0	0.0 -25.0	Outwash	
0380	62.0	NA	61.0	51.4 -61.0	0.0 -51.4	48.0 -62.0	45.0 -48.0	0.0 -45.0	Shale/Limestone	
0381	37.0	NA	37.0	27.4 -37.0	0.0 -27.4	26.0 -37.0	22.0 -26.0	0.0 -22.0	Shale/Limestone	
0382	35.0	NA	35.0	25.4 -35.0	0.0 -25.4	22.0 -35.0	15.5 -22.0	0.0 -15.5	Shale/Limestone	
0393	50.0	39.0	49.0	43.7 -48.3	0.0 -43.7	42.7 -49.7	35.7 -42.7	0.0 -35.7	Shale/Limestone	Telescoped completion
0394	65.0	50.0	59.0	54.4 -59.0	0.0 -54.4	52.5 -60.0	45.0 -52.5	0.0 -45.0	Shale/Limestone	Telescoped completion
0397	30.0	NA	30.0	20.0 -29.6	0.0 -20.0	18.0 -30.0	15.0 -18.0	0.0 -15.0	Outwash	Formerly monitoring well 0371
Total Footage	464.2	89.0	439.8							

Table III.3. (Page 2 of 2)

Additional Construction Specifications for Monitoring Wells.

Standard Borehole Diameter - 8.25 inches
Standard Core Barrel Diameter - 5.5-inch I.D; 6.0-inch O.D.
Surface Casing Borehole Diameter - 10.5 inches
Surface Casing - 10.0-inch I.D; 10.5-inch O.D.
Well Screen - stainless steel; 4.0-inch O.D; 0.01-inch slot
Riser Pipe - stainless steel; 2.0-inch O.D.
Centralizers - stainless steel; positioned below at base of well screen, above top of well screen, and at 50 ft intervals to top of riser pipe
Filter Pack - 20/40 silica sand
Seal - 0.25-inch bentonite chips
Backfill - cement/bentonite grout mixture
Protective Casing - 8.0-inch O.D. mild steel with lockable lid and weephole
Well Cap - dedicated bladder pump assembly
Well Pad - 6- by 6-ft, 4-inch-thick concrete apron; contains surveyor's pin stamped with well location ID

Sample recoveries were poor since air was the only medium used to advance the core barrel. Near surface, split-spoon drive samples were collected within weathered bedrock zones in one of these borings. Most of the samples collected were logged visually for lithology; some were retained for tritium analysis. The air rotary rig then was equipped with a button bit and was used to drill and install four additional monitoring wells. Two of these wells were clustered with one of the wells previously installed; no samples were collected from either well boring. The other two wells were installed at separate locations and samples of drill cuttings from each boring were logged for lithology. In one of these well borings, cuttings samples were retained and submitted for extraction procedure (EP) toxicity, plutonium, and tritium analyses.

During the additional work stage of the RI, a rotosonic drilling rig was used to install all exploratory borings, piezometer, and monitoring wells. The rotosonic drilling technique provided the capability to 1) collect continuous core without the use of circulating drilling fluids, 2) obtain soil samples for geochemical and geotechnical analysis at selected intervals, 3) adequately characterize the subsurface stratigraphy to the top of bedrock, 4) determine zones of contamination and identify drilling problems, and 5) select completion depths for each proposed piezometer or monitoring well. The rotosonic rig uses sonic vibration to drive a 4-inch diameter core barrel (for piezometer completions) or a 6-inch diameter core barrel (for monitoring well completions) at 5- to 10-ft intervals. Larger diameter casing (6.25-inch for piezometer completions and 8.25-inch for monitoring well completions) is then advanced over the core barrel to equal depth to maintain an open borehole. The core barrel is withdrawn and the core sample recovered. This process is repeated to the total depth of the borehole. The continuous core collected was lithologically logged and then sampled for geochemical and geotechnical parameters.

Telescoped completions were implemented in three monitoring wells and two piezometers to prevent the communication of potential contaminants from the source area to noncontaminated strata. A cable-tool drilling rig was used to install surface casing in three telescoped monitoring well completions and one telescoped piezometer completion. The rotosonic rig was used to install surface casing in one telescoped piezometer completion.

3.3.4. Well Design and Well Construction Details

Well design and construction details for Stage 2 and Stage 3 monitoring well installations are described in the Operable Unit 9, Site Scoping Report: Volume 2 - Geologic Log and Well Information Report (DOE 1992g). Well design and construction details for exploratory borings, piezometer, and monitoring wells installed during the additional work stage of the RI are shown in Tables III.2 and III.3.

3.3.5. Field Measurements and Data Acquisition

Field measurement and data acquisition methods and protocols were implemented during Stage 2, Stage 3, and the additional work stage of the ER Program RI, according to the requirements of the Mound Plant ER Program SOPs. Data were measured, acquired, and compiled through health and safety monitoring, soil and rock boring and logging, subsurface soil sampling, and piezometer and monitoring well installation. The SOPs applicable to the RI field investigations are listed in Table III.4.

3.4. SAMPLING PROGRAM FOR SOIL GAS, GROUNDWATER, AND SOIL

3.4.1. Soil Gas Sampling

Soil gas survey sampling activities were conducted from September 11 to 29, 1992. WESTON subcontracted Hydro Geo Chem, Inc. to perform the work under the supervision of WESTON personnel. A total of 96 samples (60 environmental and 36 quality control) was collected during field activities. Environmental samples included primary and replicate soil gas, and confirmatory soil samples. Quality control (QC) samples included ambient and field blanks, trip blanks, and duplicate samples. Confirmatory soil samples were collected to verify the presence of VOCs detected in soil gas samples. Samples collected during the soil gas survey are identified in Table III.5.

Field and analytical activities associated with this sampling were performed in accordance with requirements specified in the following documents:

- Area B, Operable Unit 1, Proposal for Additional Field Work: Volume I - Text and Quality Assurance Program Plan, September 1992 (DOE 1992a);
- Area B, Operable Unit 1, Proposal for Additional Field Work: Volume II - Health and Safety Plan, June 1992 (DOE 1992a); and
- Hydro Geo Chem, Inc., SOP for Volatile Organic Sampling and Analyses in Soil Gas, Soils, Water, and Atmosphere by Modified EPA 8021 (HGC 1992).

Field activities associated with soil sample collection were monitored by a Mound Plant health physics technician.

The collection of soil gas samples was facilitated by pneumatically advancing subsurface sampling assemblies at selected locations to predetermined depths. The subsurface sampling assemblies were constructed from 5-ft long, 1-3/8-inch outside diameter, threaded, hollow steel drill rods, tipped with a detachable steel drive point. After the subsurface sampling assembly was advanced to the

Table III.4. Mound Plant ER Program SOPs Applicable to Operable Unit 1

SOP Number	Revision Number	Title
1.1	2	General Instructions for Field Personnel
1.3	1	Sample Control and Documentation
1.4	2	Sample Containers and Preservation
1.5	1	Guide to the Handling, Packaging, and Shipping of Samples
1.6	2	General Equipment Decontamination
1.7	1	Sampling for Removable Alpha Contamination
1.8	1	Personnel Decontamination - Level D Protection
1.9	1	Personnel Decontamination - Level C Protection
1.10	0	Personnel Decontamination - Level B Protection
1.12	0	Air Particulate Sampling with a Real-Time Aerosol Monitor
1.15	1	Guide to Waste Management (currently under review)
2.1	1	Presample Purging of Wells
2.2	2	Field Measurements on Ground and Surface Water Samples
2.3	3	Sampling Monitoring Wells with a Bladder Pump
2.4	1	Sampling Monitoring Wells with a Bucket-Type Bailer
2.7	1	Sampling Commercial/Municipal/Domestic Wells
2.8	0	Sampling for Volatile Organics
3.1	1	Water Level Measurement
3.3	0	Operational Check of Pressure Transducers Used in Measuring Water Levels in Wells
3.4	0	Aquifer Pumping Test
4.1	2	Soil Boring
4.1.1	0	Methods to Control Communications of Subsurface Contaminants with Groundwater
4.2	1	Rock Boring
4.3	1	Monitoring Well Installation
4.4	1	Monitoring Well Development
4.7	0	Piezometer Installation
4.8	1	Piezometer Development
5.1	1	Soil and Rock Borehole Logging and Sampling
5.2	3	Soil Sampling with a Spade and Scoop
5.3	2	Subsurface Solid Sampling with Hand Auger and Thin-Wall Sampler
5.8	1	Soil Sampling with a Stainless Steel Surface Soil Sampler
6.1	1	Health and Safety Monitoring of Combustible Gas Levels
6.2	1	Health and Safety Monitoring of Organic Vapors with a Photoionization Detector
6.4	1	Total Alpha Surface Contamination Measurements
6.7	0	Near Surface and Soil Sample Screening for Low-Energy Gamma Radiation Using the FIDLER
6.11	1	Beta-Gamma Radiation Measurements
6.15	0	Measurement of Gamma-Ray Fields Using a Sodium Iodide (NaI) Detector
6.16	0	Heat Stress Monitoring

Table III.5. Summary of Operable Unit 1 Soil Gas Survey Samples

Sample Number			Location Description	Sample Matrix	Sample Depth (feet)	Date Sampled	Analyses Performed
Facility Identifier	Location Identifier	Sample Identifier					
MND61	SG01	0001	Historic Landfill Trench (northern reach)	Soil Gas	10	11SEPT92	VOCs
MND61	SG01	3001	Ambient Blank	Air	N/A	11SEPT92	VOCs
MND61	SG01	4001	Equipment Blank	Air	N/A	11SEPT92	VOCs
MND61	SG01	0002	Historic Landfill Trench (northern reach)	Soil Gas	20	11SEPT92	VOCs
MND61	SG01	1002	Duplicate of MND61-SG01-0002	Soil Gas	20	11SEPT92	VOCs
MND61	SG02	0001	Historic Landfill Trench (northern reach)	Soil Gas	10	11SEPT92	VOCs
MND61	SG02	0002	Historic Landfill Trench (northern reach)	Soil Gas	20	11SEPT92	VOCs
MND61	SG03	0001	Historic Landfill Trench (northern rsach)	Soil Gas	10	11SEPT92	VOCs
MND61	SG03	0002	Historic Landfill Trench (northern reach)	Soil Gas	20	11SEPT92	VOCs
MND61	SG04	0001	Historic Landfill Trench (northern reach)	Soil Gas	10	11SEPT92	VOCs
MND61	SG04	2001	Trip Blank	Air	N/A	11SEPT92	VOCs
MND61	SG04	0002	Historic Landfill Trench (northern reach)	Soil Gas	20	11SEPT92	VOCs
MND61	SG04	1002	Duplicate of MND61-SG04-0002	Soil Gas	20	11SEPT92	VOCs
MND61	SG05	0001	Historic Landfill Trench (southern reach)	Soil Gas	35	12SEPT92	VOCs
MND61	SG05	1001	Duplicate of MND61-SG05-0001	Soil Gas	35	12SEPT92	VOCs
MND61	SG05	3001	Ambient Blank	Air	N/A	12SEPT92	VOCs
MND61	SG05	4001	Equipment Blank	Air	N/A	12SEPT92	VOCs
MND61	SG05	0002	Historic Landfill Trench (southern reach)	Soil Gas	45	12SEPT92	VOCs
MND61	SG06	0001	Historic Landfill Tranch (southern reach)	Soil Gas	35	12SEPT92	VOCs
MND61	SG06	2001	Trip Blank	Air	N/A	12SEPT92	VOCs

Table III.5. (page 2 of 5)

Sample Number			Location Description	Sample Matrix	Sample Depth (feet)	Date Sampled	Analyses Performed
Facility Identifier	Location Identifier	Sample Identifier					
MND61	SG06	0002	Historic Landfill Trench (southern reach)	Soil Gas	38	12SEPT92	VOCs
MND61	SG07	0001	Historic Landfill Trench (southern reach)	Soil Gas	35	12SEPT92	VOCs
MND61	SG07	0002	Historic Landfill Trench (southern reach)	Soil Gas	45	12SEPT92	VOCs
MND61	SG07	1002	Duplicate of MND61-SG07-0002	Soil Gas	45	12SEPT92	VOCs
MND61	SG07	0003	Historic Landfill Trench (southern reach)	Soil Gas	50	29SEPT92	VOCs
MND61	SG07	2003	Trip Blank	Air	N/A	29SEPT92	VOCs
MND61	SG08	0001	Historic Landfill Trench (southern reach)	Soil Gas	35	13SEPT92	VOCs
MND61	SG08	2001	Trip Blank	Air	N/A	13SEPT92	VOCs
MND61	SG08	0002	Historic Landfill Trench (southern reach)	Soil Gas	45	13SEPT92	VOCs
MND61	SG08	1002	Duplicate of MND61-SG08-0002	Soil Gas	45	13SEPT92	VOCs
MND61	SG09	0001	Historic Landfill Trench (southern reach)	Soil Gas	35	13SEPT92	VOCs
MND61	SG09	0002	Historic Landfill Trench (southern reach)	Soil Gas	45	13SEPT92	VOCs
MND61	SG10	0001	Historic Landfill Trench (southern reach)	Soil Gas	35	13SEPT92	VOCs
MND61	SG10	3001	Ambient Blank	Air	N/A	13SEPT92	VOCs
MND61	SG10	4001	Equipment Blank	Air	N/A	13SEPT92	VOCs
MND61	SG10	0002	Historic Landfill Trench (southern reach)	Soil Gas	45	13SEPT92	VOCs
MND61	SG10	1002	Duplicate of MND61-SG10-0002	Soil Gas	45	13SEPT92	VOCs
MND61	SG11	0001	Perforated Drain Pipe	Soil Gas	Surface	NC	VOCs
MND61	SG12	0001	French Drain (north of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG12	3001	Ambient Blank	Air	N/A	15SEPT92	VOCs
MND61	SG12	4001	Equipment Blank	Air	N/A	15SEPT92	VOCs

Table III.5. (page 3 of 5)

Sample Number			Location Description	Sample Matrix	Sample Depth (feet)	Date Sampled	Analyses Performed
Facility Identifier	Location Identifier	Sample Identifier					
MND61	SG12	0002	French Drain (center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG12	1002	Duplicate of MND61-SG12-0002	Soil Gas	5	15SEPT92	VOCs
MND61	SG12	0003	French Drain (south of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG13	0001	French Drain (north of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG13	0002	French Drain (center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG13	0003	French Drain (south of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG14	0001	French Drain (north of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG14	0002	French Drain (center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG14	1002	Duplicate of MND61-SG14-0002	Soil Gas	5	15SEPT92	VOCs
MND61	SG14	0003	French Drain (south of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG15	0001	French Drain (north of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG15	2001	Trip Blank	Air	N/A	16SEPT92	VOCs
MND61	SG15	0002	French Drain (center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG15	0003	French Drain (south of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG15	0013	First Resampling of MND61-SG15-0003	Soil Gas	5	16SEPT92	VOCs
MND61	SG15	5003	French Drain (south of center)	Soil	5	16SEPT92	VOCs
MND61	SG15	3023	Ambient Blank	Air	N/A	28SEPT92	VOCs
MND61	SG15	4023	Equipment Blank	Air	N/A	28SEPT92	VOCs
MND61	SG15	0023	Second Resampling of MND61-SG15-0003	Soil Gas	5	28SEPT92	VOCs
MND61	SG16	0001	French Drain (north of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG16	2001	Trip Blank	Air	N/A	15SEPT92	VOCs

Table III.5. (page 4 of 5)

Sample Number			Location Description	Sample Matrix	Sample Depth (feet)	Date Sampled	Analyses Performed
Facility Identifier	Location Identifier	Sample Identifier					
MND61	SG16	0002	French Drain (center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG16	0003	French Drain (south of center)	Soil Gas	5	15SEPT92	VOCs
MND61	SG17	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG17	3001	Ambient Blank	Air	N/A	14SEPT92	VOCs
MND61	SG17	4001	Equipment Blank	Air	N/A	14SEPT92	VOCs
MND61	SG18	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG19	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG19	1001	Duplicate of MND61-SG19-0001	Soil Gas	15	14SEPT92	VOCs
MND61	SG20	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG21	0001	Site Sanitary Landfill/Encapsulated Waste	Soil Gas	15	16SEPT92	VOCs, Oxygen, Methane, Carbon Dioxide
MND61	SG21	5001	Site Sanitary Landfill/Encapsulated Waste	Soil	15	16SEPT92	VOCs
MND61	SG21	1001	Duplicate of MND61-SG21-0001	Soil Gas	15	16SEPT92	VOCs, Oxygen, Methane, Carbon Dioxide
MND61	SG22	0001	Site Sanitary Landfill/Encapsulated Waste	Soil Gas	15	16SEPT92	VOCs, Oxygen, Methane, Carbon Dioxide
MND61	SG23	0001	West of Site Sanitary Landfill/Plant Boundary	Soil Gas	15	16SEPT92	VOCs
MND61	SG23	3001	Ambient Blank	Air	N/A	16SEPT92	VOCs
MND61	SG23	4001	Equipment Blank	Air	N/A	16SEPT92	VOCs
MND61	SG24	0001	West of Site Sanitary Landfill/Plant Boundary	Soil Gas	15	14SEPT92	VOCs
MND61	SG24	2001	Trip Blank	Air	N/A	14SEPT92	VOCs
MND61	SG25	0001	Site Sanitary Landfill Berm	Soil Gas	15	16SEPT92	VOCs
MND61	SG25	3001	Ambient Blank	Air	N/A	29SEPT92	VOCs

Table III.5. (page 5 of 5)

Sample Number			Location Description	Sample Matrix	Sample Depth (feet)	Date Sampled	Analyses Performed
Facility Identifier	Location Identifier	Sample Identifier					
MND61	SG25	4001	Equipment Blank	Air	N/A	29SEPT92	VOCs
MND61	SG25	0002	Site Sanitary Landfill Berm	Soil Gas	25	29SEPT92	VOCs
MND61	SG26	0001	Site Sanitary Landfill Berm	Soil Gas	15	16SEPT92	VOCs
MND61	SG27	0001	Site Sanitary Landfill Berm	Soil Gas	15	16SEPT92	VOCs
MND61	SG27	0011	First Resampling of MND61-SG27-0001	Soil Gas	15	28SEPT92	VOCs
MND61	SG27	2011	Trip Blank	Air	N/A	28SEPT92	VOCs
MND61	SG27	0021	Second Resampling of MND61-SG27-0001	Soil Gas	15	29SEPT92	VOCs
MND61	SG27	5021	Site Sanitary Landfill Berm	Soil	15	29SEPT92	VOCs
MND61	SG27	0002	Site Sanitary Landfill Berm	Soil Gas	25	28SEPT92	VOCs
MND61	SG27	1002	Duplicate of MND61-SG27-0002	Soil Gas	25	28SEPT92	VOCs
MND61	SG28	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG29	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG29	1001	Duplicate of MND61-SG29-0001	Soil Gas	15	14SEPT92	VOCs
MND61	SG30	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs
MND61	SG31	0001	Site Sanitary Landfill Berm	Soil Gas	15	14SEPT92	VOCs

N/A - Not Applicable
NC - Not Collected
VOCs - Volatile Organic Compounds

predetermined depth, the assembly was retracted 6 inches to release the detachable drive point and expose the desired subsurface horizon for sampling. A regulated vacuum pump was attached to the subsurface sampling assembly via flexible tubing and stainless steel fittings, and the entire sampling train was purged to ensure that a representative soil gas sample would be collected. Contaminants were retained on activated carbon, contained within a glass and stainless steel cartridge. This sample cartridge was inserted into the sample train following purging. The amount of soil gas passing through the sample cartridge was regulated using a computerized mass-flow controller. At locations within the site sanitary landfill where concentrations of methane, oxygen, and carbon dioxide were measured, a hand-held infrared gas analyzer was connected to the sampling probe following collection of the soil gas sample.

Soil samples were collected by advancing a pilot hole utilizing a subsurface sampling assembly (as described above) fitted with a non-detachable steel drive point to a depth 1 ft above the predetermined sampling depth. The subsurface assembly was then extracted from this pilot hole and a 12-inch long, 1-1/4-inch outside diameter ring sampler housing three 4-inch long, 1-inch diameter, stainless steel sleeves was attached to the subsurface assembly and advanced down the pilot hole an additional 1 ft past the originally achieved depth. Following withdrawal of the sampling assembly from the hole, the stainless steel sleeves were immediately removed from the sampler, capped, and sealed.

Analyses of soil and soil gas samples were performed in an onsite mobile laboratory. Gas chromatographic techniques were used to identify and measure concentrations of target VOCs. Collected soil and soil gas samples were analyzed for the following VOCs:

- Chloroethene (vinyl chloride)
- 1,2-*trans*-DCE,
- Trichloromethane (chloroform),
- 1,1,1-Trichloroethane (1,1,1-TCA),
- Tetrachloromethane (carbon tetrachloride),
- Benzene,
- 2-Butanone, and
- TCE.

Four supplemental VOCs, listed below, were added to the original analyte list on the second day of sampling activities. The eight original analytes were identified as contaminants of concern for Area B

and made up the basic program. The analytes that were added had been contaminants of concern for the then recently concluded soil gas study in Operable Units 2 and 5.

- Fluorotrichloromethane (Freon-11),
- 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113),
- 1,2-*cis*-DCE, and
- PCE.

Since these parameters are of less importance to the Operable Unit 1 study and because they were an informal addition to the approved program, calibration procedures for these four analytes were not as rigorous as for the original eight analytes. Calibration for the original eight analytes was based on a three-point calibration procedure. Calibration for the four supplemental analytes was based on a one- or two-point calibration.

In addition to the above referenced analytes, soil gas samples collected from within the site sanitary landfill were analyzed for methane, carbon dioxide, and oxygen using hand-held field instrumentation.

Analytical results obtained from the soil gas survey are presented in Appendix A (HGC 1992).

QC measures implemented during field activities were in accordance with the relevant SOPs. Sample collection equipment was decontaminated between each use and daily field blanks were taken before sampling. Duplicate samples were collected at 10 percent of the sampling locations. The field chemist ran a system blank and performed instrument calibration at the beginning of each day.

Following analysis, a portion of the soil gas data underwent a data review to identify systematic errors or problems that could impact the useability of the data. The data review evaluated one randomly selected soil gas sample from each day of analysis, together with all calibration data. Results of the data review indicated that the data were usable for their intended purpose.

All soil gas survey sampling locations were surveyed for horizontal and vertical position by a land surveyor registered in the state of Ohio. Horizontal positions, reported in the Ohio State Plane Coordinate System, are shown in Table III.6. The soil gas sampling locations are depicted in Figure 3.2.

Table III.6. Land Survey of Operable Unit 1 Soil Gas and Surface Soil Sampling Sites

Mound Lab Miamisburg, Ohio			
Sample Point	Northing	Easting	Elevation
SG26	596826.44	1495038.37	716.37
SG12	596773.09	1495033.40	707.66
SG25	596751.05	1495027.57	706.85
SG13	596749.56	1495027.96	706.86
SG14	596724.32	1495024.01	706.88
SG27	596701.69	1495013.71	705.93
SG15	596700.18	1495013.59	706.15
SG16	596676.21	1495009.76	705.74
SL06	596596.28	1494999.03	704.19
SG24	596664.66	1494952.53	704.08
SG23	596762.50	1494951.82	703.96
SG05	596774.47	1495134.40	737.56
SG06	596756.84	1495133.55	737.89
SG07	596739.67	1495133.14	738.36
SG08	596722.20	1495134.10	738.79
SG09	596704.10	1495131.51	738.88
SG10	596687.14	1495129.68	738.92
SG19	596667.42	1495181.01	748.42
SL02	596708.10	1495201.67	751.79
SG21	596706.90	1495209.45	752.57
SL01	596731.20	1495254.62	755.80
SL03	596668.39	1495261.44	754.54
SG22	596699.67	1495317.09	755.15
SL04	596703.21	1495322.34	755.00
SG20	596652.86	1495363.87	751.54
SG17	596766.11	1495174.83	744.84
SL08	596791.93	1495177.45	734.71
SG18	596757.66	1495373.17	746.63
HUB	596680.76	1495377.03	752.51
SG31	596649.08	1495428.83	740.31
SG30	596581.55	1495372.10	738.08
SL10	596804.90	1495418.01	739.66
SL09	596776.87	1495266.21	741.92
SG11	596840.57	1495175.72	712.93
SG04	596831.91	1495120.27	716.75
SG03	596829.62	1495111.01	716.98
SG02	596829.28	1495102.02	717.17
SG01	596827.81	1495093.44	717.73
SL05	596791.04	1495029.48	706.84
SL12	596109.78	1495074.10	713.58
SL13	596112.04	1495364.28	723.18
SG28	596559.77	1495087.35	705.12
SG29	596547.42	1495221.35	712.98
SL07	596558.76	1495294.19	715.00
SL11	5968530.82	1495439.05	733.55

[1]This table provides the land survey data associated with the Operable Unit 1 Soil Gas Survey and Surface Soil Sampling activities. Land surveying of sampling locations for both activities was conducted n 17 September 1992 by Shaw, Weiss, & DeNaples of Dayton, Ohio. all land survey activities were performed by a surveyor registered in the state of Ohio. Sample locations SG01 through SG31 are identified with the Soil Gas Survey, while locations SL01 through SL13 are identified with suface soil sampling. The location identified as "HUB" was a temproary benchmark established by the land surveyor atop the site sanitary landfill. Horizontal coordinates are posted in the Ohio State Plane Coordinate System. Elevations are posted in feet above mean sea level.

3.4.2. Groundwater Sampling

Prior to the installation of the additional work stage monitoring wells, groundwater samples were collected quarterly (October/November 1990 through September 1992) from a series of monitoring wells, seeps, and test pits at the Mound Plant. Groundwater data collected from these sampling events are documented in the Cumulative Groundwater Monitoring Data Report through Fourth Quarter, FY92, Volumes I and II (DOE 1993a).

From March 28 to April 2, 1993, WESTON personnel collected groundwater samples from 15 monitoring wells installed as part of the Operable Unit 1 additional work. The location of each monitoring well is shown in Figure 3.3. A total of 24 samples (15 environmental and nine QC) were collected during field activities (Table III.7). Field and analytical activities associated with this sampling event were performed in accordance with requirements specified in the following documents:

- Operable Unit 1, Area B, Groundwater Monitoring and Mapping QAPP, May 1992 (DOE 1992h);
- Operable Unit 1, Mound Plant Quarterly Groundwater Monitoring and Mapping Health and Safety Plan, March 1993 (DOE 1993e); and
- Mound Plant ER Program SOPs identified in the health and safety plan referenced above.

Dedicated bladder pumps were installed in each monitoring well. The pumps were cleaned and certified clean at the factory. The manufacturer's statement of certification accompanied each bladder pump unit.

Prior to sample collection, each well was purged to remove stagnant water from the well bore in sufficient quantities to provide for a representative water sample as specified in the relevant Mound Plant ER Program SOP. During the purge cycle, water removed from the well was directed into a flow-through bath where it was continuously monitored for field parameters that included pH, conductivity, dissolved oxygen, reduction/oxidation potential, and temperature. Upon completion of the purge cycle, a fresh aliquot of water was removed and tested for alkalinity. Following alkalinity testing, groundwater samples were collected directly from a dedicated discharge tube into appropriate sample containers. The samples were preserved (if required), and the containers were tightly sealed, labeled, affixed with a custody seal, and stored on ice in a sampling cooler.

Sample containers used to collect radiological samples were provided through International Technologies (IT) Analytical Services Laboratory. All other containers were provided through WESTON

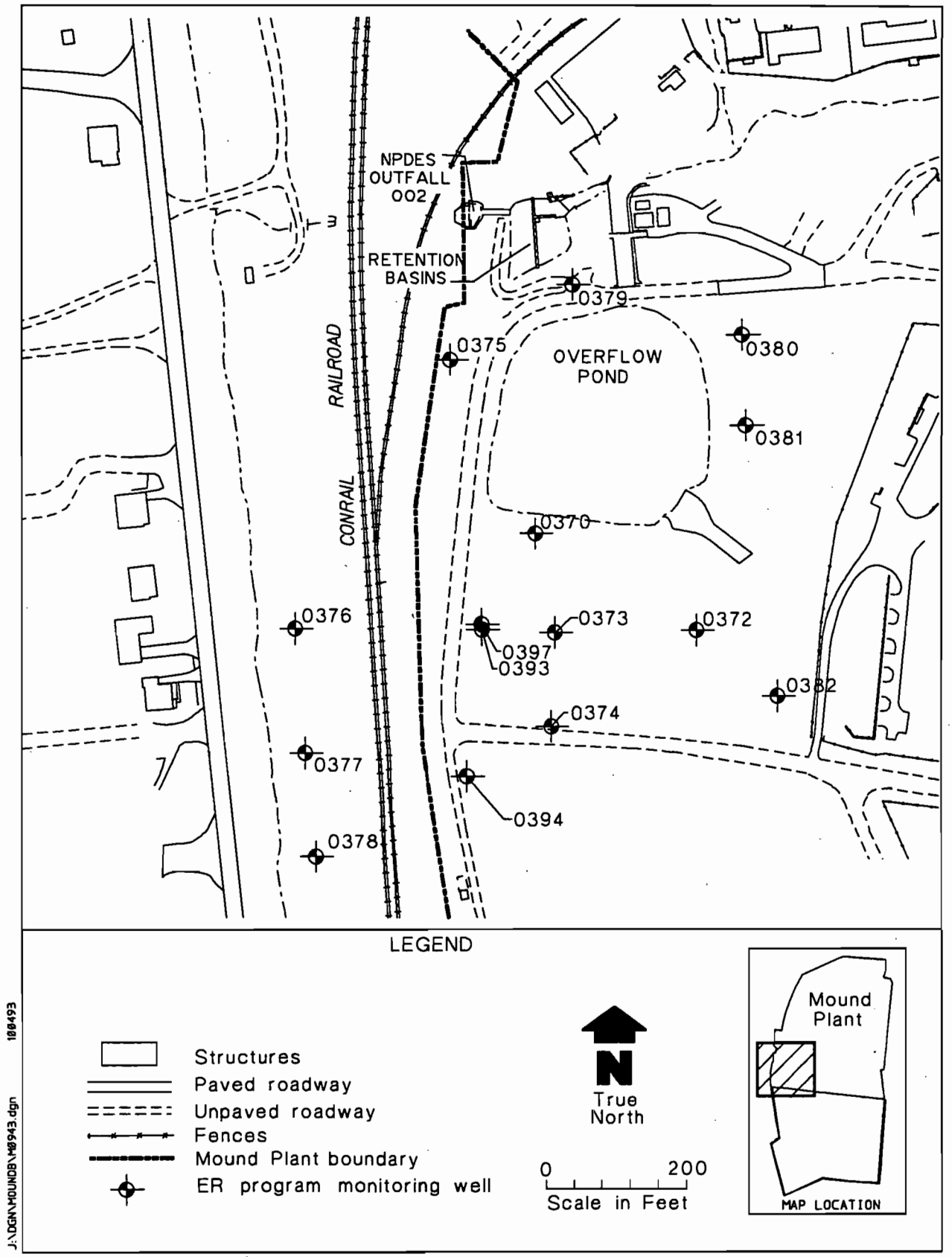


Figure 3.3. Locations of Operable Unit 1 additional work stage monitoring wells.

Table III.7. Summary of Samples Collected During March 1993 Groundwater Sampling Event

Location ID	Sample ID	Date Collected	VOCs	Semivolatiles	Pesticides/PCBs	Anions	TAL Metals	Tritium	Radionuclides	Sample Type
0376	0001	03-29-93	1	1	1	1	1	1	1	Environmental
0377	0001	03-29-93	1	1	1	1	1	1	1	Environmental
0377	1001	03-29-93	1	1	1	1	1	1	1	Duplicate
0378	0001	03-28-93	1	1	1	1	1	1	1	Environmental
0379	0001	03-29-93	1	1	1	1	1	1	1	Environmental
0379	2001	03-30-93	1							Trip blank
0370	0001	03-31-93	1	1	1	1	1	1	1	Environmental
0397	0001	03-31-93	1	1	1	1	1	1	1	Environmental
0397	1001	03-31-93	1	1	1	1	1	1	1	Duplicate
0372	0001	03-30-93	1	1	1	1	1	1	1	Environmental
0373	0001	03-30-93	1	1	1	1	1	1	1	Environmental
0375	0001	03-31-93	1	1	1	1	1	1	1	Environmental
0380	0001	03-31-93	1	1	1	1	1	1	1	Environmental
0371	2001	04-01-93	1							Trip blank
0374	0001	04-01-93	1	1	1	1	1	1	1	Environmental
0374	0001	04-01-93	1	1	1	1	1	1	1	Matrix spike
0374	0001	04-01-93	1	1	1	1	1	1	1	Matrix spike duplicate
0381	0001	04-01-93[a]	1			1	1	1	1	Environmental
0382	0001	04-01-93	1	1	1	1	1	1	1	Environmental
0393	0001	04-01-93	1	1	1	1	1	1	1	Environmental
0374	3001	04-01-93	1							Ambient blank
0394	0001	04-02-93	1	1	1	1	1	1	1	Environmental
0379	2001	04-02-93	1							Trip blank
0800	3001	04-02-93	1							Sample bank blank
		Sample Totals	24	18	18	19	19	19	19	

Note: Radionuclide sample collected from monitoring well 0381 on 04-14-93

Analytics Lionville Laboratory. The containers provided by each laboratory were cleaned and certified clean by the manufacturer according to EPA standards. The manufacturer's statement of certification and analytical results accompanied each sample container lot. Collected samples were transported under full chain-of-custody documentation, via overnight delivery, to each respective laboratory. Prescribed analytical parameters are listed in Table III.7. Chain-of-custody forms for this sampling event and for the surface and subsurface soil sampling events (to be described in subsequent subsections) are provided in Appendix B.

A small aliquot of water removed from each well was provided to the Mound Plant Water Screening Facility for tritium and gross alpha screening prior to sample shipment. Results from the water screening were used to determine sample shipping classification and accompanied the water sample to the analytical laboratory.

QC samples were collected and submitted for analysis to assess field QC. These samples included three trip blanks, two field duplicates, one ambient blank, and one sample bank blank. The collection of equipment/rinsate blanks was not required because each bladder pump unit was certified clean and dedicated to a specific monitoring well. Trip blanks were prepared by the WESTON personnel using American Society of Testing Material (ASTM) Type II water. Trip blanks were placed in the sample coolers prior to sample collection and accompanied sample shipments containing samples to be analyzed for VOCs. Trip blanks were also analyzed for VOCs. Field duplicates were analyzed for the same parameters as the environmental samples. Ambient blanks were analyzed for VOCs. In addition to these field QC samples, a matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were analyzed to evaluate matrix effects and bias of an analytical method in a given sample matrix. QC samples are included in Table III.7.

The water level indicator probe was decontaminated prior to presample purging of each well to prevent the cross-contamination between wells. Personnel decontamination was performed before leaving the work area for breaks and at the end of each day. Decontamination of the water level probe consisted of a wash with a solution of Alconox and distilled water, followed by a rinse with distilled water, a rinse with methanol, and a final rinse with distilled water. Hexane was not used during equipment decontamination, as specified in the appropriate Mound Plant ER Program SOP. Groundwater purged from each monitoring well and decontamination solutions were retained and placed in polyethylene drums. The drums were labelled, then transported to and staged within the Mound Plant investigation-derived material staging area.

3.4.3. Surface Soil Sampling

On 15 and 16 December 1992, WESTON personnel collected surface soil samples from 13 predetermined locations (Figure 3.4) within Area B. A total of 22 samples (13 environmental and 9 QC) were collected during field activities (Table III.8). Field and analytical activities associated with this sampling were performed in accordance with requirements specified in the following documents:

- Area B, Operable Unit 1, Proposal for Additional Field Work: Volume 1 - Text and QAPP, September 1992 (DOE 1992a);
- Area B, Operable Unit 1, Proposal for Additional Field Work: Volume II - Health and Safety Plan, September 1992 (DOE 1992a); and
- Mound Plant ER Program SOPs identified in the above-referenced documents.

Field activities associated with soil sample collection were monitored by a Mound Plant health physics technician.

Prior to sample collection, the horizontal and vertical position of each sampling location was identified in the field by a professional land surveyor registered in the State of Ohio. Sample collection coordinates and elevations are provided in Table III.9. Soil samples were collected from each location at depths of approximately 0.2 to 0.5 ft below existing grade and were analyzed for all parameters with the exception of the Target Compound List (TCL) VOCs. Samples for VOCs were collected at a depth of approximately 0.5 ft below existing grade. A hand shovel was used to clear surface vegetation and access the sampling interval. Excavated materials were placed adjacent to the sampling location and replaced following sample collection. The soil sample was collected with a stainless steel trowel, placed in a stainless steel mixing bowl, and mixed by hand to homogenize the sample material. The soil was then placed into the appropriate sample containers. Soils collected for TCL VOCs analyses were placed directly into the appropriate laboratory containers without homogenization, to minimize losses from volatilization.

On 16 December 1992, a representative from the OEPA observed the sample collection procedures used by WESTON and collected a split soil sample from location SL13.

A portion of each soil sample was provided to the Mound Plant Soil Screening Facility for plutonium-238 and thorium-232 screening purposes prior to sample shipment. Results from soil screening were used to determine sample shipping classification and accompanied the soil samples to the analytical laboratory.

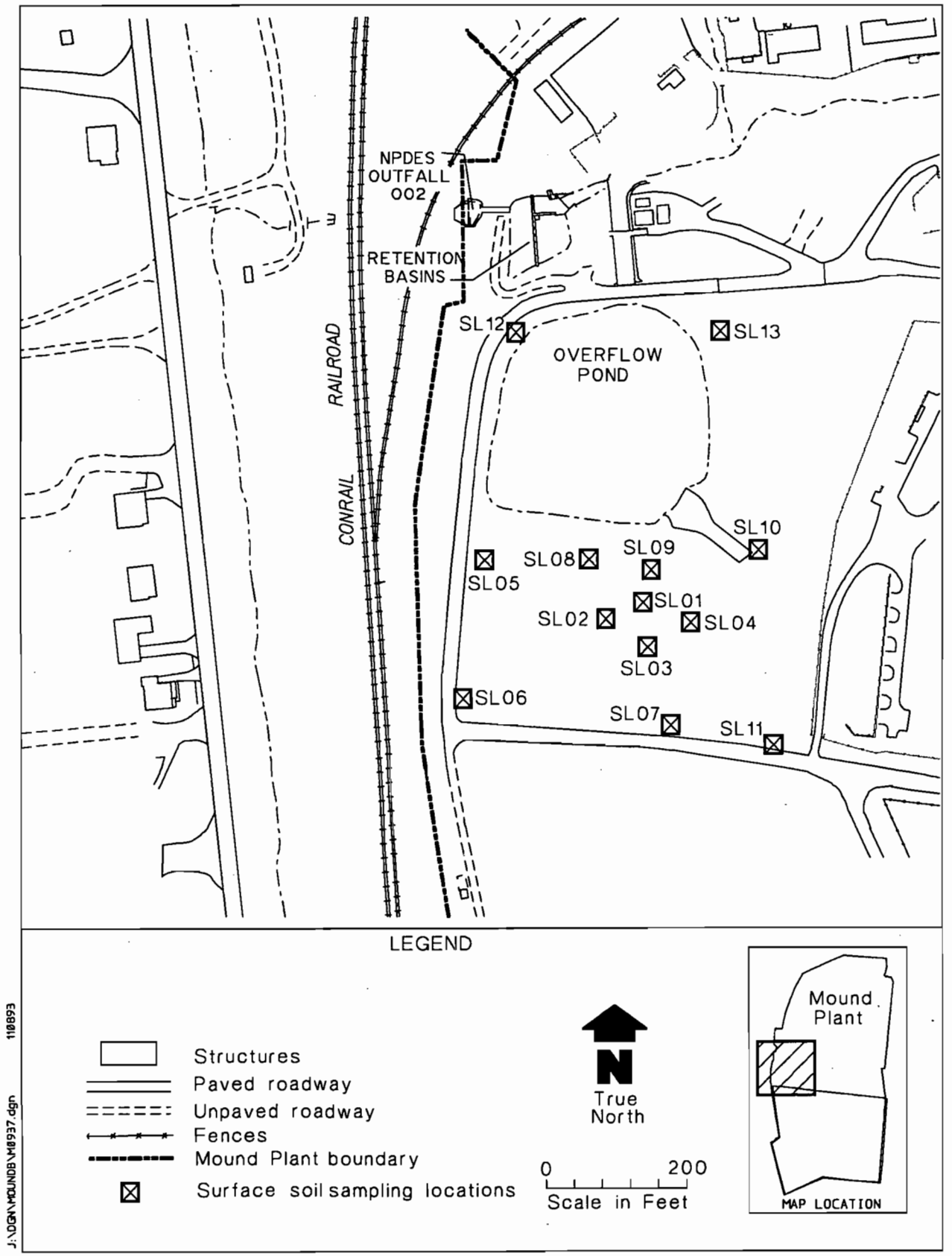


Figure 3.4. Locations for collection of surface soil samples.

Table III.8. Summary of Samples Collected During Surface Soil Sampling Activities, Operable Unit 1, Area B

Sample Designation	Sample Description/Location[a]	Sample Depth (ft)[b]	Date Collected	Analytical Parameters
MND23-SL01-0001	Environmental sample (soil), location SL01	0.2 - 0.5	15 Dec 1992	TCL volatile organic compounds TCL semivolatile organic compounds TCL pesticides/PCBs TAL inorganics Common anions (fluoride, nitrate/nitrite, chloride, sulfate) Total organic carbon Alkalinity Gamma spectrometry Strontium-90 Americium-241 Radium-226 Isotopic plutonium Isotopic uranium Isotopic thorium Tritium pH (matrix spike and matrix spike duplicate sample not analyzed for pH)
MND23-SL02-0001	Environmental sample (soil), location SL02		15 Dec 1992	
MND23-SL02-1001	Duplicate of MND23-SL02-0001 (soil), location SL02		15 Dec 1992	
MND23-SL03-0001	Environmental sample (soil), location SL03		15 Dec 1992	
MND23-SL04-0001	Environmental sample (soil) and matrix spike/matrix spike duplicate (soil), location SL04		15 Dec 1992	
MND23-SL05-0001	Environmental sample (soil), location SL05		15 Dec 1992	
MND23-SL06-0001	Environmental sample (soil), location SL06		15 Dec 1992	
MND23-SL07-0001	Environmental sample (soil), location SL07		16 Dec 1992	
MND23-SL08-0001	Environmental sample (soil), location SL08		15 Dec 1992	
MND23-SL09-0001	Environmental sample (soil), location SL09		16 Dec 1992	
MND23-SL10-0001	Environmental sample (soil), location SL10		16 Dec 1992	
MND23-SL10-1001	Duplicate of MND23-SL10-0001 (soil), location SL10		16 Dec 1992	
MND23-SL11-0001	Environmental sample (soil), location SL11		16 Dec 1992	
MND23-SL12-0001	Environmental sample (soil), location SL12		16 Dec 1992	
MND23-SL13-0001	Environmental sample (soil), location SL13		16 Dec 1992	
MND23-SL06-4001	Equipment/rinsate blank (water) collected immediately prior to sampling location SL06	Not applicable	15 Dec 1992	TCL volatile organic compounds TCL semivolatile organic compounds TCL pesticides/PCBs TAL inorganics Common anions (fluoride, nitrate/nitrite, chloride, sulfate) Total organic carbon Alkalinity Gamma spectrometry Strontium-90 Americium-241 Radium-226 Isotopic plutonium Isotopic uranium Isotopic thorium Tritium
MND23-SL13-4001	Equipment/rinsate blank (water) collected immediately prior to sampling location SL13		16 Dec 1992	
MND23-SL02-2001	Trip blank (water)	Not applicable	15 Dec 1992	TCL volatile organic compounds
MND23-SL09-2001	Trip blank (water)		16 Dec 1992	TCL volatile organic compounds
MND23-SL02-3001	Ambient blank (water), collected during soil sampling at location SL02		15 Dec 1992	TCL volatile organic compounds

[a]Soil sampling locations are shown on Figure 3.4.
[b]Soil samples for all analytical parameters, with the exception of TCL volatile organic compounds, were collected from approximately 0.2 to 0.5 ft below ground surface. Soil samples for TCL volatile organic compounds were collected at a depth of approximately 0.5 ft below ground surface.
TCL - Target Compound List
TAL - Target Analyte List
PCBs - polychlorinated biphenyls

Table III.9. Land Survey Data, Operable Unit 1, Area B, Surface Soil Sampling

Sample Location[a]	Ohio State Plane Coordinates		Elevation (feet above mean sea level)
	Northing	Easting	
SL01	596731.20	1495254.62	755.80
SL02	596708.10	1495201.67	751.79
SL03	596668.39	1495261.44	754.54
SL04	596703.21	1495322.34	755.00
SL05	596791.04	1495029.48	706.84
SL06	596596.28	1494999.03	704.19
SL07	596558.76	1495294.19	715.00
SL08	596791.93	1495177.45	734.71
SL09	596776.87	1495266.21	741.92
SL10	596804.90	1495418.01	739.66
SL11	596530.82	1495439.05	733.55
SL12	597109.78	1495074.10	713.58
SL13	597112.04	1495364.28	723.18

[a]Sample locations are shown on Figure 3.4

As specified in the proposal of additional work QAPP (DOE 1992a), QC samples were collected and submitted for analysis to assess field QC. These samples included two equipment/rinsate blanks, two trip blanks, two field duplicates, and one ambient blank. Equipment/rinsate blanks were collected following equipment decontamination and were analyzed for the same parameters as the environmental samples, with the exception of pH. Trip blanks were prepared by the analytical laboratory and placed in the shipping coolers containing samples for TCL VOCs. Trip blanks were themselves analyzed for TCL VOCs. Field duplicates were analyzed for the same parameters as the environmental samples, with the exception of pH. Ambient blanks were analyzed for TCL VOCs. In addition to these field QC samples, a MS sample and a MSD sample were analyzed to evaluate matrix effects and bias of an analytical method in a given sample matrix. QC samples are included in Table III.8.

Personnel and equipment were decontaminated during the sampling to prevent the cross-contamination of samples and sampling locations, to protect field personnel, and to prevent the spread of contamination within Mound Plant and offsite. Equipment decontamination consisted of a wash with a solution of Alconox and tap water, followed by a rinse with tap water, a rinse with methanol, and a final rinse with deionized water. Generated decontamination solutions were retained and placed in a polyethylene drum within the Mound Plant investigation-derived material staging area.

3.4.4. Subsurface Soil Sampling

Subsurface soil samples were collected as part of the Operable Unit 1, Proposal for Additional Work exploratory borehole, piezometer, and monitoring well installation program. The investigation was conducted from October 22, 1992 through March 5, 1993. WESTON subcontracted North Star Drilling Co. to perform borehole drilling and well installation under the supervision of WESTON personnel. WESTON personnel collected subsurface soil samples from three exploratory boring locations, 12 piezometer locations, and 15 monitoring well locations (Figure 3.5). A total of 258 geochemical samples (187 environmental and 71 QC) were collected during the field activities (Appendix A, Table A5). Subsurface samples were also collected for geotechnical and clay mineralogy analyses. Field and analytical activities associated with subsurface sampling were performed in accordance with requirements specified in the following documents:

- Area B, Operable Unit 1, Proposal for Additional Field Work: Volume 1 - Text and QAPP, September 1992 (DOE 1992a);
- Area B, Operable Unit 1, Proposal for Additional Field Work: Volume II - Health and Safety Plan, September 1992 (DOE 1992a); and
- Mound Plant ER Program SOPs identified in the above-referenced documents.

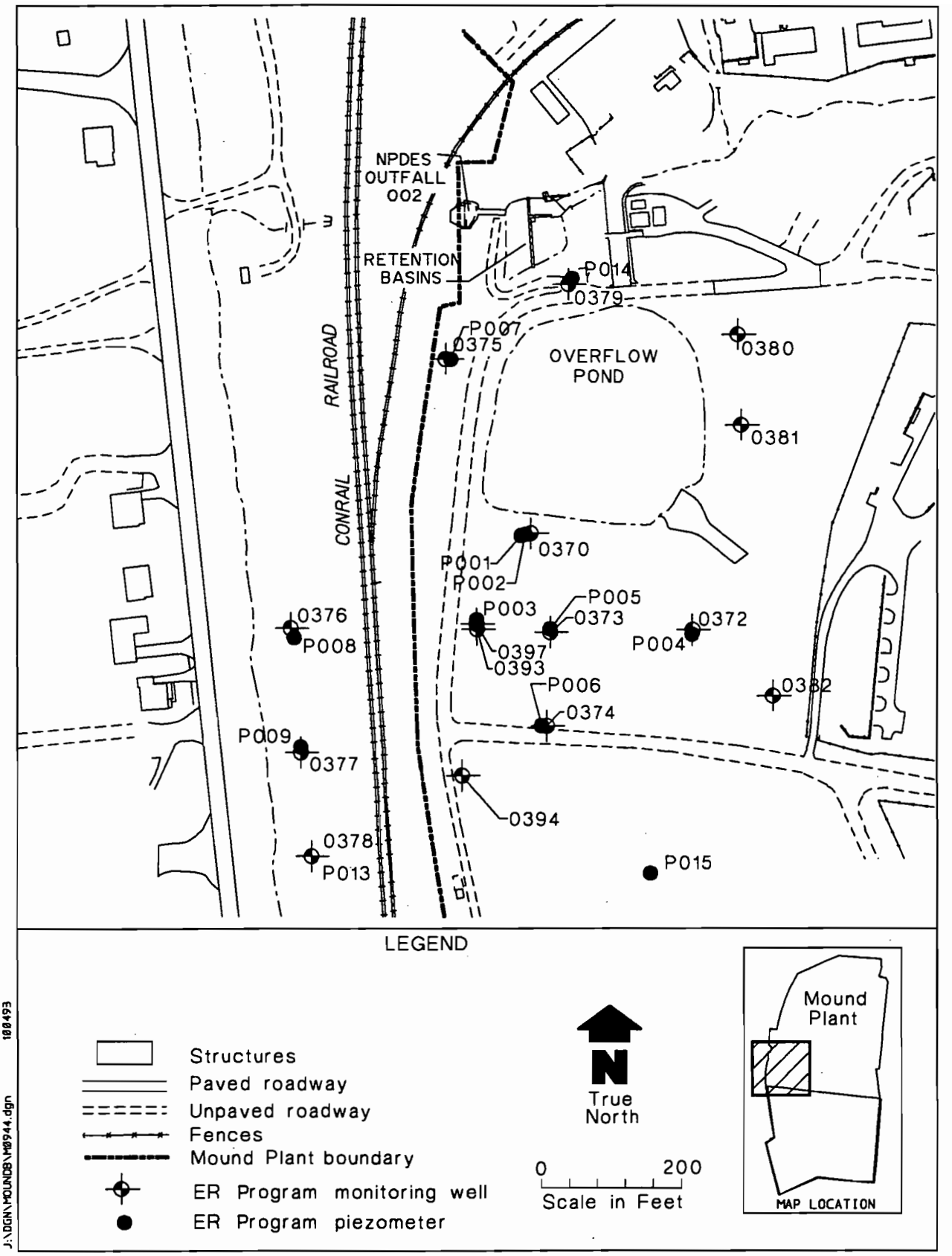


Figure 3.5. Locations of exploratory piezometer and monitoring well borings that were sampled during the Operable Unit 1 additional work stage program.

Field activities associated with subsurface soil sample collection were monitored by a Mound Plant health physics technician.

A rotosonic drilling rig was used to install all exploratory borings, piezometer, and monitoring wells and provided the capability to collect continuous core without the use of drilling fluids. Rotosonic drilling techniques are described greater detail in subsection 3.3.3. Geochemical samples were collected directly from the recovered core and placed into appropriate sample containers. All sample containers were tightly sealed, labeled, affixed with a custody seal, and stored on ice inside a sample cooler. All tested samples were collected at specific depth intervals from each boring as outlined in the Operable Unit 1, Proposal for Additional Field Work: Volume 1 (DOE 1992a). The last two digits of the sample ID indicate the approximate depth from which the samples were collected (Appendix A, Table A5).

Most sample containers were provided through IT Analytical Services Laboratory. In the initial stages of the sampling program, equivalent sample containers were also obtained from WESTON Analytics Stockton Laboratory. All containers were cleaned and certified as clean by the manufacturer according to EPA standards. The manufacturer's statement of certification and analytical results accompanied each sample container lot.

Collected samples, except for pH, were transported under full chain-of-custody documentation, via overnight delivery, to the IT Analytical Services Laboratory in Oak Ridge, Tennessee, for analyses. Soil samples collected to determine soil pH were analyzed in the field according to WESTON Operating Practice 21-15-9045.1, Inorganic Analysis Protocol Corrosivity by pH (Solid Matrix). Prescribed laboratory analytical parameters are listed in Appendix A, Table A5.

A portion of each soil sample was provided to the Mound Plant Soil Screening Facility for plutonium-238 and thorium-232 screening purposes prior to sample shipment. Results from soil screening were used to determine sample shipping classification and accompanied the soil samples to the analytical laboratory.

QC samples were collected and submitted for analysis to assess field QC. These samples included 19 equipment/rinsate blanks, 21 trip blanks, 21 field duplicates, 10 ambient blanks, and nine sample bank blanks. Equipment/rinsate blanks were collected following decontamination of the core barrel and were analyzed for the same parameters as the environmental samples. Trip blanks were prepared by the analytical laboratory. The trip blanks were placed in the sample coolers prior to sample collection and accompanied sample shipments containing samples to be analyzed for TCL VOCs. Trip blanks were themselves analyzed for TCL VOCs. Field duplicates were analyzed for the same parameters as

the environmental samples. Ambient blanks were analyzed for TCL VOCs. In addition to these field QC samples, a MS sample and a MSD sample were analyzed to evaluate matrix effects and bias of an analytical method in a given sample matrix. QC samples are included in Appendix A, Table A5.

Personnel and equipment were decontaminated during the sampling to prevent the cross-contamination of samples and sampling locations, to protect field personnel, and to prevent the spread of contamination within Mound Plant and offsite. Personnel decontamination was performed before leaving the work area for breaks and at the end of each day. Equipment decontamination consisted of a wash with a solution of Alconox and tap water, followed by a rinse with tap water, a rinse with methanol then hexane, and a final rinse with distilled water. Drill cuttings and excess grout were retained and placed in open-top steel drums. Drilling water and decontamination solutions were retained and placed in a polyethylene drums. Drums containing drill cuttings and grout were labelled, then transported to and staged within the Mound Plant investigation-derived material staging area. Drums containing drilling water and decontamination solutions were decanted into large bulk tanks.

3.5. LABORATORY PROGRAM

Since March 1992, all soil and groundwater samples were collected and analyzed according to the Operable Unit 1 QAPP and/or Operable Unit 9 Site-Wide QAPP. All chemical and radiological data generated with the analysis of soil samples during the additional work investigation were subjected to formal data validation to ensure the quality and usability of the data. All groundwater samples collected and analyzed for chemical parameters since October 1990 were also subjected to formal data validation. Groundwater and soil samples collected prior to October 1990, while not subjected to formal data validation, were analyzed in accordance with established and accepted laboratory procedures and methodology. All data are considered usable in the Operable Unit 1 investigation.

3.5.1. Identification of Laboratories

3.5.1.1. Soils Investigation (Additional Work)

Prior to final selection, each laboratory utilized during the soils investigation was subjected to an onsite audit. The audit addressed the overall laboratory operation as well as specific methods of analysis. The laboratory was reviewed for organization and personnel, laboratory documentation, sample receipt and storage, information management, and laboratory quality assurance (QA) program. Each area of analysis (i.e., volatiles, metals, etc.) was reviewed for general laboratory facilities, standards and reagents, sample preparation, instrumentation, methodology, calibration, data handling, data reduction, and report generation.

The laboratories selected for the Operable Unit 1 soils investigation were:

- Chemical and radiological: IT Analytical Services Laboratories in Oak Ridge, Tennessee; Knoxville, Tennessee; and St. Louis, Missouri.
- Geotechnical: Bowser-Morner, Dayton, Ohio; Lambda Research, Cincinnati, Ohio; Harding-Lawson Associates, Concord, California; and Aqua-Tech Laboratories, Marion, Ohio.

3.5.1.2. Operable Unit 1 Groundwater Sampling and Analysis

The audit selection procedures utilized for the soils investigation were applied to laboratory selection for the groundwater program, beginning with the March 1992 sampling event. Prior to March 1992, the chosen laboratories were reviewed to ensure that correct methodologies and QC procedures were followed. Since the October 1990 sampling event, all chemical data generated by the laboratory have been subjected to formal data validation. The laboratories used for the Operable Unit 1 groundwater investigation are listed in Table III.10.

3.5.2. Analytical Parameters

3.5.2.1. Soils (Additional Work)

The following subsections briefly describe the analytical methodology used to analyze both the soil samples and associated aqueous QC samples collected during the additional field work investigation. Table A3a in Appendix A presents the analytes determined and the corresponding quantitation limits.

Volatile Organic Compounds

Analyses were conducted in accordance with the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) Document No. OLM01.8 (EPA 1990b). This SOW uses gas chromatography/mass spectrometry (GC/MS) for compound separation and identification. This SOW was appended by Modification D (Appendix B of the Operable Unit 9 QAPP) (DOE 1992c) to include vinyl acetate as a target compound, ensuring continuity with previously used versions of the SOW, which listed vinyl acetate as a target compound.

Semivolatile Organic Compounds

Analyses were conducted in accordance with the EPA CLP SOW Document No. OLM01.8 (EPA 1990b). This SOW uses GC/MS for compound separation and identification. This SOW was appended

Table III.10. Laboratories Used for Operable Unit 1 Groundwater Investigation

Sampling Period	Laboratory	Analyses
January 1990	IT Laboratories	Chemical and Radiological
February 1990	IT Laboratories	Chemical and Radiological
March 1990	IT Laboratories	Chemical and Radiological
April/May 1990	IT Laboratories	Chemical and Radiological
July/August 1990	IT Laboratories	Chemical and Radiological
October/November 1990	IT Laboratories	Chemical and Radiological
January/February 1991	IT Laboratories	Chemical and Radiological
April/May 1991	IT Laboratories	Chemical and Radiological
July/August 1991	IT Laboratories	Chemical and Radiological
December 1991	WESTON Analytics IT Laboratories	Chemical Radiological
March 1992	WESTON Analytics Barringer Laboratories	Chemical Radiological
June 1992	WESTON Analytics Barringer Laboratories	Chemical Radiological
September 1992	WESTON Analytics IT Laboratories	Chemical Radiological
March 1993	WESTON Analytics IT Laboratories	Chemical Radiological

by Modification D (Appendix B of the Operable Unit 9 QAPP [DOE 1992c]) to include benzyl alcohol and benzoic acid as target compounds, ensuring continuity with previously used versions of the SOW, which listed these analytes as target compounds.

Pesticide/PCB Compounds

The CLP SOW Document No. OLM01.8 (EPA 1990b) was used for this analysis. This gas chromatographic method employs two different capillary columns for separation and an electron capture detector (ECD) for quantitation.

Metals

The CLP SOW Document No. ILM01.0 (EPA 1990d) was used for determining the Target Analyte List (TAL) of metals. Flame atomic absorption (AA) was used to detect potassium; furnace AA was used to detect antimony, arsenic, lead, selenium, and thallium; and cold vapor AA was used to detect mercury. All other elements were detected using inductively coupled plasma (ICP) atomic emission spectroscopy. Two additional elements were amended to the CLP SOW protocol by Modification A (DOE 1992c). These elements were bismuth (by furnace AA) and lithium (by ICP). Modification A also presented a four-fold concentration procedure to be employed to reach quantitation limits below the contract-required quantitation limit (CRQL) for aluminum, antimony, beryllium, and vanadium.

Dioxin/Furan Compounds

Analysis for identification and quantitation of all 2,3,7,8-substituted isomers and total isomer homologs (tetra through octa) for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans was conducted using methodology based on EPA SW-846 Method 8290 (EPA 1990e). This method uses high-resolution GC/MS to achieve separation and identification of the isomers. Specific cleanup procedures and QC criteria are presented in ER Program Change Notice Number 027 (see subsection 3.5.5).

Anions (Chloride, Fluoride, Sulfate, Nitrate-nitrite, Alkalinity)

Analyses were performed using colorimetry, based on EPA Methods 325.1/325.2 or 9250/9251 (EPA 1983) for chloride, 353.2 for nitrate-nitrite, and 375.2 for sulfate. Fluoride was detected using an ion-selective electrode, based on EPA Method 340.2. Alkalinity was determined using EPA Method 310.1, a titrimetric procedure. The soil samples were extracted with deionized water for the dissolution of

the anions prior to analysis (presented in the Statement of Work (SOW-006), Appendix C of the Operable Unit 9 QAPP (DOE 1992c).

Total Organic Carbon

Total organic carbon (TOC) analysis was conducted in accordance with EPA Methods 415.1/415.2 (EPA 1983) or SW-846 Method 9060 (EPA 1986a). The analysis consists of using pyrolysis to convert organic carbon to carbon dioxide, which is then detected by a nondispersive infrared detector. The sample preparation procedure for soil samples is presented in SOW-005, Appendix C of the Operable Unit 9 QAPP (DOE 1992c).

Radiological Parameters

Alpha spectrometry was used to determine the following specific isotopes: americium-241 (in water), radium-226 (in water), plutonium-238, plutonium-239/240, uranium-234, uranium-235, uranium-238, thorium-228, thorium-230, and thorium-232. Soil samples were prepared using acid digestion procedures to concentrate the isotopes of interest in an aqueous matrix. The alpha-emitting isotopes in these acid extracts and in water samples are precipitated from the aqueous solution. The precipitates are redissolved and subjected to a sequential separation of alpha isotopes by elution from anion/cation exchange resins. The separated alpha isotopes are counted using a surface barrier detector.

All strontium present in the sample was assumed to be strontium-90, due to the short half-life of strontium-89 and the knowledge of process at Mound Plant. Soil samples were subjected to acid digestion to remove interferences and concentrate the strontium as an aqueous matrix. Strontium-90 was precipitated from the aqueous samples and extracts. Interferences were reduced by continued precipitations of the strontium carrier. The beta activity of strontium-90 was determined with a gas flow proportional detector, immediately after removal of yttrium-90.

Gamma spectroscopy was used to determine the gamma radiation levels in water and soil samples. Particular isotopes of interest that were detected on the basis of gamma radiation include radium-226 (in soil), bismuth-210 metastable, americium-241 (in soil), cobalt-60, cesium-137, bismuth-207, polonium-210, and potassium-40. The methods used are based on procedures outlined in HASL-300 and in EPA Method 901.1.

Tritium was determined according to EPA Method 906.0 (EPA 1980) for water and soil samples. A cryogenic distillation procedure was used to isolate the tritium in soil moisture. Beta emissions were detected using a liquid scintillation method with a fluorescence detector.

Geotechnical

Selected soil samples were submitted for geotechnical measurements to determine physical and mechanical properties. The following parameters were measured by the specified procedure:

- Moisture content - ASTM D-2216 (ASTM 1991) - the weight loss upon drying at 110°C is used to calculate the moisture content.
- Organic content - ASTM D-2974 (ASTM 1991) - after drying, the sample is ashed; the organic content is determine by subtracting the ash content.
- Particle size analysis - ASTM D-422-63 (ASTM 1991) - sieves are used to separate soil particles into discrete size fractions.
- Bulk density - EM-1110-2-1906 (COE 1970).
- Atterberg Limits - ASTM D-4318 (ASTM 1991) - the results describe the liquid limit and plastic limit of the soil sample.
- Triaxial permeability - SW-846 method 9100.
- Total porosity - EM-1110-2-1906 (COE 1970)
- Capillary moisture - ASTM D-2325 (ASTM 1991) - procedure provides for the determination of capillary-moisture relationship as indicated by soil-moisture tension.
- Clay mineralogy - X-ray diffraction/fluorescence spectrometry - used to determine the chemical composition of the major soil constituents (in the minus-200 mesh fraction).

3.5.2.2. Groundwater

The following subsections briefly discuss the analytical methodology used to analyze groundwater samples collected between October 1990 and March 1993, as part of the quarterly groundwater monitoring program. Table A3b in Appendix A presents the analytes determined and the associated quantitation limits for the March 1993 sampling event. Summaries of the procedures and analyte lists for previous quarterly groundwater monitoring analyses can be found in the Cumulative Groundwater Monitoring Data Report (DOE 1993a) and in the applicable Operable Unit 1 and Operable Unit 9 QAPPs.

Volatile Organic Compounds

Analyses were performed using EPA SW-846 Methods 8010/8020 (EPA 1986a). The method was modified to incorporate a capillary column to provide separation; as per the method, dual detection was achieved with a photoionization detector (PID) and a Hall electrolytic conductivity detector.

Semivolatile Organic Compounds

Analyses were conducted in accordance with the EPA CLP SOW (EPA 1990b) applicable at the time of analysis. This SOW uses GC/MS for compound separation and identification.

Pesticide/PCB Compounds

During the course of the quarterly groundwater monitoring program, either EPA SW-846 Method 8080 or the CLP SOW document (EPA 1990b) applicable at the time of analysis was used for the determination of pesticides and PCBs. Method 8080 is a gas chromatographic method using ECD. The CLP SOW employs two different capillary columns for separation and an ECD for quantitation.

Metals

The CLP SOW Document Number ILM01.0 (EPA 1990d), or applicable version at the time of analysis, was used for determining the TAL of metals. Flame AA was used to detect potassium; graphite furnace atomic absorption was used to detect antimony, arsenic, lead, selenium, and thallium; and cold vapor AA was used to detect mercury. All other elements were detected using ICP atomic emission spectroscopy. Antimony was determined by ICP until the June 1992 sampling event, at which time graphite furnace atomic absorption was used to determine lower detection limits.

Anions/Cations

Analyses were performed using colorimetry, based on EPA Methods 325.1/325.2 for chloride, 353.2 for nitrate-nitrite, and 375.2 for sulfate (EPA 1983).

Radiological Parameters

Alpha spectrometry was used to determine the following specific isotopes in groundwater samples: americium-241, radium-226, plutonium-238, plutonium-239/240, uranium-234, uranium-235, uranium-238, thorium-228, thorium-230, and thorium-232. The alpha emitting isotopes are

precipitated from the water samples. The precipitates are redissolved and subjected to a sequential separation of alpha isotopes by elution from anion/cation exchange resins. The separated alpha isotopes are counted, using a surface barrier detector.

All strontium present in the sample was assumed to be strontium-90, due to the short half-life of strontium-89 and the knowledge of process at Mound Plant. Strontium-90 was precipitated from the samples and interferences were reduced by continued precipitations of the strontium carrier. The beta activity of strontium-90 was determined with a gas flow proportional detector, immediately after removal of yttrium-90.

Gamma spectroscopy was used to determine the gamma radiation levels in water samples. Particular isotopes of interest that were detected as gamma radiation include bismuth-210 metastable, cobalt-60, cesium-137, bismuth-207, polonium-210, and potassium-40. The methods used are based on procedures outlined in HASL-300 (DOE 1982) and in EPA Method 901.1.

Tritium was determined according to EPA method 906.0 (EPA 1980) for water samples. Beta emissions were detected using a liquid scintillation method with a fluorescence detector.

Actinium-227 was calculated using the thorium-227 value determined during alpha spectroscopy.

3.5.2.3. Aquifer Test Groundwater Samples

The following subsections briefly discuss the analytical methodology used to analyze groundwater samples collected during May/June 1993 as part of the aquifer test. Table A3c in Appendix A presents the analytes determined and the required minimum reporting limits for the aquifer test analyses.

During the aquifer test, samples were collected to serve two different purposes. First, to meet OEPA discharge regulations and requirements, samples were taken to monitor the halogenated volatile compounds and total organic carbon. These samples were analyzed on a fast turnaround basis of 72 hours so that the well discharge could be stopped within a reasonable time period if contaminant levels were exceeded. Secondly, samples were collected from the wells to be analyzed for both halogenated and aromatic volatile compounds. Portions of the data from the wells were subjected to validation to ensure data quality.

Volatiles

Groundwater samples collected as part of the aquifer test were analyzed for volatile halogenated and/or volatile aromatic compounds. All analyses were performed using EPA SW-846 Method 8010 and/or Method 8020 (EPA 1980), as applicable. The method was modified to incorporate a capillary column to provide separation; as per the method, dual detection was achieved with a PID and a Hall electrolytic conductivity detector. Positive detections were confirmed on a second, dissimilar GC column.

Total Organic Carbon

TOC analysis was conducted in accordance with EPA Method 415.1 (EPA 1983). The method uses pyrolysis to convert organic carbon to carbon dioxide, which is then detected by a nondispersive infrared detector.

3.5.3. Laboratory Quality Assurance/Quality Control Program

Internal QC checks for CLP analyses are specified in the SOW for organics and inorganics, including frequency and acceptance criteria. Internal QC checks for non-CLP analyses are those specified in the method and in the applicable Operable Unit 1/Operable Unit 9 QAPPs. Frequency of the checks, acceptance criteria, and corrective actions are based on guidance in the analytical method and established laboratory control limits. Definitions for the internal QC checks applicable to chemical and radiological laboratory analysis are as follows:

- Method Blank. The method blank is an artificial sample designed to monitor the introduction of artifacts into the analysis that could result from the sample preparation or analytical method. For aqueous sample analysis, reagent water is generally used as the matrix. For solid sample analysis other than radiological analyses, a purified solid matrix is used. The method blank is carried through the entire analytical scheme (extraction, concentration, and analysis). Method blanks are performed for all applicable analyses at a frequency stated in the analytical method or the QAPP. For CLP metals analyses, the method blank is referred to as the preparation blank.
- Sulfur Cleanup Blank. When sample extracts for pesticide/PCB analysis require a sulfur cleanup, a sulfur cleanup blank is performed. This method blank monitors for contamination from the sulfur cleanup steps.
- Instrument Blank. For pesticide/PCB analysis, reagent is analyzed to verify the gas chromatograph is free of contaminants.
- Background Check. A background check is performed for liquid scintillation analysis at a given count time and frequency to determine if the instrumentation is contaminated above a maximum acceptable level. For tritium analysis, the background check is performed once per day prior to sample analysis. The maximum acceptance level for system contamination is three standard deviations. If this limit has been exceeded, the problem is identified and corrected prior to sample analysis. For alpha and gamma spectrometry, background is

established once per month using a longer count time, in addition to a daily background check with a short count time, such as 10 minutes.

- Source Check. A source check is a check of the counting efficiency of the detector. The check determines the reproducibility. The check is performed once per day for liquid scintillation, tritium analysis, and gamma spectrometry.

- Method Spike/Blank Spike. A method spike is a method blank sample carried throughout the same process as the samples to be analyzed, with a known amount of standard added. The spike result of the sample provides information on how the method is performing. This QC check is performed for radiochemical analyses such as tritium and volatile organic analysis.

- Pulse Check. The pulse check is performed once per day on the alpha spectrometer to check count reproducibility. Peak counts at 5 meV must be within 3 standard deviations.

- Matrix Spike. Predetermined quantities of specific analytes are added to a sample matrix prior to sample extraction or digestion. Percent recoveries are calculated for each analyte to assess the analytical accuracy. MSs monitor the effects of the sample matrix on the analytical results. One MS for every 20 samples collected is performed for all applicable analyses (volatile organics, semivolatile organics, pesticides/PCBs, dioxin/furan, metals, chloride, nitrate, radionuclides, and TOC). The field sample to spike is selected by field personnel and is not a field blank sample (trip blank, equipment blank, or sample bank blank). This will ensure that a Mound sample matrix with possible analyte detections is spiked to obtain representative results of analytical accuracy.

- Matrix Spike Duplicate. A MSD of the same sample collected in the field will also be performed for every 20 samples collected. The MSD will assess the analytical and sampling precision by calculating a relative percent difference between the primary and duplicate spike recoveries.

- Surrogate Spike. Surrogate compounds are organic compounds similar to the analytes of interest in chemical composition and extraction and chromatographic properties, but are not normally found in environmental samples. These compounds are spiked into all field and laboratory samples (blanks, standards, and MSs) for volatile organic, semivolatile organic, and pesticide/PCB analyses as prescribed in the analytical method. Percent recoveries are calculated for each surrogate compound in each sample. These recoveries give an indication of the performance of the analytical method.

- Replicate Sample. A replicate sample is analyzed for given analyses by taking aliquots from a sample container to assess the precision of the analytical method. A relative percent difference (RPD) is calculated for the primary and replicate sample results. Replicate samples are analyzed for radionuclides, metals, and total organic carbon. Field personnel select the CLP metals sample to be analyzed as a replicate.

- Instrument Performance Check. GC/MS analyses require that the mass spectrometer be tuned prior to calibration and sample analysis. This is accomplished with analysis of a compound with similar properties but not commonly found in the environment. For tunings and mass calibration, 4-bromofluorobenzene, decafluorotriphenylphosphine, and perfluorokerosene are used for volatile organic, semivolatile organic, and dioxin/furan, and GC/MS analyses, respectively. Specific ion abundance criteria must be met, as defined in the appropriate method, before sample analysis begins.

- Initial Calibration. An instrument is calibrated initially with a series of standards at predetermined concentrations to identify the response factor of the instrument over the given concentration range. This is usually performed for most instruments when there has

been a change in instrument conditions or when the calibration check result is outside a defined acceptance criteria.

- Calibration Check. The initial instrument calibration is verified at regular intervals to account for potential instrument drift or other changes in instrument conditions. A standard with a concentration within the calibration range is analyzed for usually after 10 sample analyses (usually) or with a frequency defined in the CLP SOW or QAPP. The standard result is compared to the initial calibration, and a percent differences or RPD is calculated. If the result is not within the established acceptance criteria, then the analytical system is evaluated and recalibrated before continuing sample analysis. For CLP metal analyses, samples analyzed since the last acceptable standard must be reanalyzed.

- Retention Time Window. Retention times of target analytes for GC, and GC/MS analyses must be monitored for shifts during sample analysis. The allowed shift of retention time for a given analyte is the retention time window. Retention time windows are established according to the analytical method. Acceptance criteria are expressed as an established range (e.g., ±0.06 units) or for pesticide analysis as plus or minus three times the standard deviation of three retention times of the same compound. Shifts that occur outside the acceptance criteria indicate a change in the chromatographic system or an instrument problem and could lead to misidentifications unless corrective action is taken.

- Internal Standard. Internal standards are performed for volatile, semivolatile, and dioxin/furan GC/MS analyses and are used to ensure that system sensitivity and response are stable for every run. Internal standards consist of compounds that are similar in analytical behavior to the analytes and are added to the calibration standards. Response factors of these standards are used to quantitate sample results. Criteria for internal standard responses and retention times are defined in the method.

- Initial and Continuing Calibration Blanks. A blank consisting of reagent water is analyzed immediately after every initial and continuing calibration verification for CLP metal analyses, at a frequency of 10 percent or every 2 hours, whichever is more frequent.

- Laboratory Control Sample. A laboratory control sample is a standard solution of a certified concentration prepared by a source external to the laboratory performing the analysis and is used to measure the analytical accuracy. This QC check is performed for metals, volatile organics, chloride, and nitrate-nitrite analyses for every batch of analytical samples. The CLP SOW requires that the recovery of the laboratory control sample analysis for metals be within 80 to 120 percent. Manufacturer's specifications for acceptance criteria of the laboratory control sample are used for the other analyses.

- Initial Calibration Verification. After the ICP and AA systems are calibrated, the accuracy of the initial calibration is verified with the analysis of a calibration verification standard. The CLP SOW has established control limits for each system (ICP and AA: 90 to 110 percent of the true value; AA—cold vapor for mercury: 80 to 120 percent of true value). If control limits are exceeded, then the problem is identified and corrected, and the instrument is recalibrated.

- Continuing Calibration Verification. The initial calibration of ICP and AA systems is verified during each set of analyses at a frequency of 10 percent or every 2 hours, whichever is more frequent. The solution, as required by the CLP SOW, is either an EPA solution, a National Bureau of Standards SRM1643a solution, or a contractor-prepared standard. The control limits for this analysis are the same as for the initial calibration verification.

- Linear Range Check Standard. For ICP analysis, a standard at two times the contract-required detection limit or two times the instrument detection limit is analyzed at a frequency defined in the CLP SOW to verify the linearity near the contract-required

detection limit. For AA analysis, the CRDL Standard for AA (or CRA) is analyzed at a concentration at the contract-required detection limit or instrument detection limit.

- Interference Check Sample. An interference check sample is analyzed for the ICP analysis at a frequency defined in the CLP SOW to verify interelement and background correction factors. The interference check sample consists of one solution containing interferents, and a second containing analytes mixed with the interferents. The second solution must fall within ±20 percent of the true value. Corrective action, as defined in the CLP SOW, is taken if this criteria is not met.

- ICP Serial Dilution. A serial dilution is a series of different dilutions of a given sample and a comparison of sample results. An ICP serial dilution is performed on one sample from each group of samples of a similar matrix and concentration or for each sample delivery group, whichever is more frequent, as defined in the CLP SOW. Results of the analysis must agree within 10 percent. The analysis of serial dilutions gives an indication of potential chemical or physical interferences.

- Method of Standard Addition. The Method of Standard Addition is a method for quantitating furnace AA sample results to eliminate the effects of the sample matrix. A sample whose matrix is interfering with quantitation is spiked at three concentrations, and the results are used as a calibration curve to quantitate the sample results. The conditions under which standard addition is performed and how the sample results are qualified are defined in the CLP SOW.

- Linear Range Analysis. The linear range for ICP analyses is checked with a standard quarterly. The standard is analyzed with a routine analytical run. The results must be within ±5 percent of the true value. The concentration of the standard is the upper limit of the ICP linear range.

- Interelement Corrections. ICP interelement correction factors are determined prior to the start of CLP contract analyses and annually thereafter. The interelement corrections are for spectral interference due to aluminum, calcium, iron, and magnesium and are checked for all wavelengths used for each analyte.

- Low-Level Check Sample. For a low concentration analysis, a low-level standard is analyzed routinely to demonstrate that low levels can be accurately identified and quantified.

- Secondary Column Confirmation. For gas chromatographic analysis, a GC column with different coating or packing is used as a second analysis on samples with detections on the primary column. This second analysis confirms the presence or absence of the detected analyte.

- Performance Evaluation Sample. This check is a sample prepared external to the laboratory to assess the ability of the laboratory to accurately perform the analysis. The sample is prepared with known concentrations of analytes of interest.

- Qualitative Verification. The CLP SOW for organic analysis has requirements for verifying the identification of target compounds. This includes a comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound. The criteria to be met for proper identification are discussed in the CLP SOW.

Two performance evaluation samples were submitted to IT Analytical Services Laboratory during the course of the Operable Unit 9 hydrogeologic sampling and analysis program. One performance

evaluation sample was submitted by EPA and one double blind performance evaluation sample was submitted by WESTON.

Results and discussion of the EPA performance evaluation sample, submitted in February 1993, can be found in the EPA Evaluation Report (EPA 1993a). Primary concerns addressed in the report focused on high reported naphthalene values and the need for precautionary checks to interpret compounds with similar mass spectra. No positive detection above the contract-required detection limit (CRDL) was reported for these semivolatile compounds during the Operable Unit 1 investigation.

The WESTON performance evaluation sample was submitted in April 1993. The laboratory results were satisfactory for all Operable Unit 1 contaminants of concern, with the exception of TCE. The result for TCE was 15 percent below the advisory range. This result represents a single point and may not be relevant to Operable Unit 1 samples analyzed at the IT laboratory. All Operable Unit 1 volatile analyses were completed prior to submission of this performance evaluation sample; assessment of the data should be based on real-time QC checks (e.g., surrogate recovery, MS/MSD recovery). The validation of the Operable Unit 1 data was completed on this basis.

3.5.4. Data Validation

Review and validation of analytical data are carried out internally by the laboratory and externally by an independent third party. Data validation procedures give an indication of the quality, reliability, and potential error associated with the generated data.

3.5.4.1. Laboratory Data Validation

All laboratories utilized for the Operable Unit 1 investigations have an internal QA/QC program in place. While each laboratory program varies, all contain a QA/QC element. The QA/QC program includes, at a minimum, a review of calculations, comparison of QC sample results (e.g., surrogate recoveries) against laboratory-established control limits, and a review of the data report with the processed data.

Analyses performed under CLP protocol are reviewed and assigned laboratory data qualifiers as specified in the CLP SOW. These qualifiers provides an indication of concentration levels (J, UJ, U) or flag QC check outliers (e.g., B, E, *). The laboratory assigns these qualifiers during the internal data review process. The following data qualifiers are used per the applicable CLP SOW:

Organic Analysis - Volatiles, Semivolatiles, Pesticide/PCBs

U - Indicates compound was analyzed for but not detected.

J - Indicates an estimated value. This flag is used under the following circumstances: 1) when estimating a concentration for tentatively identified compounds; 2) when the GC or GC/MS (as applicable) identification criteria are met and the result is less than the CRQL but greater than zero.

N - Indicates presumptive evidence of a compound.

P - Used for a pesticide/PCB target analyte where there is greater than 25 percent difference for detected concentrations between the two GC columns.

C - Applies to pesticide results where identification has been confirmed by GC/MS.

B - Indicates the analyte was found in the associated blank as well as the sample.

E - Identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. Sample is usually diluted and re-analyzed.

D - Indicates compounds identified in an analysis at a secondary dilution.

A - Indicates that a tentatively identified compound is a suspected aldol-condensation product.

Inorganic Analysis - Metals

U - Indicates compound was analyzed for but not detected.

B - Reported value is less than the CRDL but greater than the instrument detection levels.

E - Reported value is estimated due to the presence of an interference.

M - Duplicate injection precision not met.

N - Spiked sample recovery not within control limits.

S - Reported value determined by Method of Standard Additions.

W - Post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50 percent of spike absorbance.

* - Duplicate analysis not within control limits.

+ - Correlation coefficient for the Method of Standard Additions is less than 0.995.

Normally, non-CLP data (radiological, anions, TOC, dioxin/furan) is not subject to data qualifiers, other than U as not detected; however, laboratory-defined qualifiers may be assigned.

3.5.4.2. Independent Formal Data Validation

All Operable Unit 1 data generated since October 1990, both groundwater (excluding radiological data) and soils, have been subjected to third party, independent data validation. Groundwater data validation was performed by C.C. Johnson & Malholtra of Lakewood, Colorado, and soils data validation was performed by WESTON.

Data validation procedures include a review of:

- completeness of the data package;
- sample extraction/analysis holding times;
- initial and continuing calibration;
- QC checks specified in the method or QAPP, including blanks, MS/MSDs, field and laboratory duplicates, and system performance; and
- the raw data, including calculations and verifying positive identification of analytes.

Data generated under the CLP SOW protocol were evaluated in accordance with the EPA functional guidelines (EPA 1988a,c). Results from non-CLP analyses (volatiles by 8010/8020, anions, dioxin/furans, and radiological) were validated in a similar manner to the EPA guidelines, as detailed in the Operable Unit 9 QAPP (DOE 1992c).

The validation process results in the qualification of data that do not meet specified QC parameters. The following qualifiers were applied, as applicable, to CLP and non-CLP validated data:

U - The analyte was analyzed for, but was not detected. The associated value is the sample quantitation limit.

J - The associated numerical value is an estimated quantity.

R - The data have been rejected and are unusable (compound may or may not be present) (appears as NA in Appendix A).

N - Presumptive evidence of presence of material.

NJ - Presumptive evidence of presence of material at an estimated quantity.

UJ - The analyte was analyzed for but was not detected. The sample quantitation limit is an estimated quantity.

3.5.4.3. Data Validation Results for Soils (Additional Work)

The following subsections briefly discuss the findings during data validation and the qualifications assigned to the data for soil samples collected during the additional work phase. All validated data generated during the soils investigation (additional work) are considered usable for their intended purpose, as qualified, with the exception of data points rejected during validation. Qualifications alert the data user that potential bias or error is associated with the results.

Tables have been included in Appendix A4 as a summary of the primary causes of qualifications. The qualifications presented were applied to selected samples and selected compounds. Complete and detailed summaries of qualified data are presented in the data validation reports.

Appendix A6 presents both qualified and non-qualified positive values for analytes detected during the analysis of field samples collected during the additional work. QC samples such as trip blanks, ambient blanks, and MS/MSDs have not been included in the appendix, but are discussed in the following subsections, as applicable. Vinyl chloride is listed in Appendix A6 by the IUPAC-preferred term of chloroethene.

<u>Anions (Chloride, Sulfate, Nitrate-Nitrite, Alkalinity, Fluoride)</u>

Eight soil samples for alkalinity analyses were not analyzed within the QAPP required holding time of 14 days. These samples were analyzed from one to five days outside of holding times. The impact of slightly exceeded holding times on the alkalinity analyses is indeterminable, but is not expected to be drastic.

Sufficient instrument calibration data were not available to the validators for four of the earliest laboratory batches of data. Thus, many results for alkalinity were qualified as estimated because calibration records of the pH meters were not provided in the data package. The potential error is indeterminable. The calibration coefficient for 21 of 87 sulfate analyses was found to be 0.994. The QAPP required calibration coefficient is 0.995. This may cause a slight negative bias in the sulfate results.

Several laboratory control sample recoveries were outside the specified range of 80 to 120 percent for fluoride, chloride, and sulfate. However, the highest recovery value was 126 percent, resulting in only a slight potential positive bias.

Several positive results were qualified as non-detects due to detection of the analytes in associated equipment rinsate blanks or method blanks. This qualification resulted in raising the quantitation limit for the analyte. Affected analytes include sulfate, nitrate, nitrite, and fluoride.

Field duplicates were collected to verify sampling precision. Agreement between the results were outside of the specified criteria for alkalinity (three sample sets), sulfate (one sample set), nitrate (one sample set), nitrite (one sample set), and chloride (two sample sets). The chloride, nitrate, and sulfate precision was 200 percent, the result of a positive above the detection limit and a non-detect value. Given the inhomogeneity of soil, variations in results are not unexpected.

These and additional qualifications noted in the analytical batches are summarized in Table A4a in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Dioxin/Furans

The most frequent qualification noted for dioxin/furan analyses was the change of a positive value for octachlorodibenzi-p-dioxin (OCDD) and 1,2,3,4,6,7,8-heptachloro dibenzo-p-dioxin to a non-detect, raising the detection limit for these compounds. The cause of this qualification was contamination in the associated method blanks. Given the persistence and stability of these compounds, slight traces of highly chlorinated dioxin/furans in the method blanks are not unexpected.

The internal standard recoveries for four compounds (OCDD, 1234678-HpCDD, 123478-HxCDF, and 1234678-HpCDF) were high in sample MND23-P003-0006. The area of the recovery standard, 123789-HxCDD, was low due to ion suppression. The area of the internal standards was apparently within normal limits. However, the internal standard recoveries were high when calculated with the low recovery standard area. Since the internal standard area was acceptable and this area is used in the analyte quantitation formula, the analyte results should not be significantly affected. The values have been qualified as estimated to note the associated problem of the recovery standard.

MS/MSD recoveries for OCDD and octachlorodibenzofuran were out of acceptable range for sample MND23-P004-0025. The OCDD MS recovery was 590 percent. The MSD recovery was -88 percent. This wide variability seems due to the non-homogeneity of soil and the relatively high concentration of native OCDD (1010 ppt). Since all other QC checks, including laboratory control sample results,

were acceptable, results for OCDD in associated samples were qualified as estimated. The octachlorodibenzofuran MS recovery was 10 percent and the MSD recovery was 18 percent. These very low recoveries are attributed to ion suppression during analysis. The reported value is possibly biased low by a factor of 5 to 10.

Extraction holding times for three samples were exceeded by 16 days. Given the persistence and stability of these compounds, no effect on the sample results is expected. One sample set, consisting of field and field duplicate samples, was estimated due to poor precision (200 percent RPD). The high RPD was the result of a non-detect value and a positive value slightly above the detection limit. Given the inhomogeneity of soils, this difference is not unexpected.

These and additional qualifications noted in the analytical batches are summarized in Table A4b in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Metals

The most significant qualification for metals analyses was the rejection of the majority of antimony results. The MS recovery of antimony was consistently low (less than 30 percent). Since almost all results for antimony were non-detects, the values were rejected. Any positive values were estimated.

Several values for chromium (13 samples), cobalt (eight samples), vanadium (eight samples), and barium (two samples) were rejected. Analysis of the associated Interference Check Samples indicated a potential for false positive results for these elements.

Many analyte quantitation limits were estimated due to contamination in the equipment rinsate blanks, preparation blanks, and/or calibration blanks. MS recoveries resulted in the qualification of several analytes. Low recoveries of the post-digestion spike of selenium were consistently noted.

The CRDL check standard recovery failed to meet criteria for several elements. The CRDL check standards verify adequate instrument response at the low end of the calibration curve. These and additional qualifications noted in the analytical batches are summarized in Table A4c in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Pesticide/PCB

Most data were accepted without qualification. Only Aroclor 1248 was consistently reported as a positive detection. Positive values for endosulfan sulfate, methoxyclor, and beta-BHC were reported

only once; all values were qualified as estimated. Surrogate recoveries were below the acceptable range for three samples, inferring a potential negative bias. Holding times were exceeded for three samples (maximum 2 days). For PCB compounds, no effect on sample results is expected; effects on pesticide quantitation limits are indeterminable, but not expected to be severe.

Results are calculated for pesticide/PCB compounds on both GC columns used. For several compounds, the percent difference between the two results was greater than 25 percent. Such values are qualified as estimated and the lower value is reported. The possibility exists for a low bias in the reported result. One result for beta-BHC was rejected in a field duplicate sample. Rejection was required due to a greater than 100 percent difference in results between the two columns, probably caused by co-eluting Aroclor 1248 interferences.

These and additional qualifications noted in the analytical batches are summarized in Table A4d in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Radiological

The majority of radiological data collected was acceptable and not qualified.

The thorium isotope results were consistently qualified as estimated due to low yields. Thorium-229 was used as a tracer; samples which had no measurable thorium activity showed very low recovery of the tracer (i.e., method blanks). In samples that had measurable thorium activity, the thorium present acted as a carrier for the tracer and recoveries of the tracer were acceptable (i.e., laboratory control sample). When very low recoveries occurred, the laboratory chose not to report any value. Through data validation, results were calculated in these instances for possible use in the project. These calculated values remain qualified as estimated and give a maximum value of the thorium concentrations. In one sample, the uranium isotope yield was also low and associated data were qualified as estimated. One sample and its field duplicate were outside of the criteria set for field duplicate results. This indicates the possible inhomogeneity of soil samples.

Tritium results for four samples were not reported by the laboratory due to matrix interferences (high organic content) during sample preparation.

These and additional qualifications noted in the analytical batches are summarized in Table A4e in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Semivolatiles

Initial and /or continuing calibration criteria were not met for several analytes, most commonly benzoic acid. Results for these compounds were estimated. Blank contamination by the common phthalate esters resulted only in raised detection limits for these analytes in certain samples. Five samples were analyzed outside of holding times, three at 2 days and two at 39 days. Potential bias of the results was indeterminable and the results were estimated.

These and additional qualifications noted in the analytical batches are summarized in Table A4f in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Total Organic Carbon

One sample was analyzed outside of holding time (20 days). The potential bias was indeterminable and the result was estimated. Three sample results were qualified as estimated because the results were outside the calibration range. Several sample results were qualified as estimated due to exceeded field duplicate criteria. Given the high amount of total organic carbon present in the samples and the inhomogeneity of soil samples, this difference was not unexpected.

These and additional qualifications noted in the analytical batches are summarized in Table A4g in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Volatiles

The most common reason for qualification of volatile data was blank contamination of the common laboratory contaminants dichloromethane and acetone. The result was an increase in the detection limit of these compounds.

Two other compound results frequently qualified as estimated were 2-hexanone and 4-methyl-2-pentanone, common laboratory contaminants. These two compounds have poor purging efficiencies due to their great solubility in water. Data qualification was due to failure to meet calibration criteria.

Three non-detect results for 1,1,2,2-tetrachloroethane were rejected because the calibration relative response factor (RRF) was less than the CLP SOW limit, even though the value was acceptable by criteria in the functional guidelines (EPA 1988a,c).

Results for 12 samples were qualified as estimated due to failure of one or more internal standards to meet acceptance criteria. Sample results for several compounds in one sample were estimated due to high MS/MSD recoveries and high RPDs among the field duplicates.

These and additional qualifications noted in the analytical batches are summarized in Table A4h in Appendix A. Detailed summaries can be found in the corresponding validation reports.

3.5.4.4. Groundwater Results

The following subsections discuss the findings during data validation and the qualification assigned to the data for groundwater samples. The qualifications presented were applied to selected samples and selected compounds. This discussion focuses only on the March 1993 sampling event, which consisted of sampling newly installed wells. As with other quarterly groundwater data, radiological data were not subjected to validation. Data validation results of previous sampling events are presented in the Cumulative Groundwater Report (DOE 1993a). All validated groundwater data are considered usable, as qualified, for their intended purpose.

Groundwater samples were collected by WESTON. Chemical analyses were performed by Weston Analytics Division laboratory; radiological analyses were performed by IT Analytical Services - Oak Ridge. Data validation of chemical data was performed by C.C. Johnson & Malhotra of Lakewood, Colorado, in a manner analogous to procedures prescribed in the EPA functional guidelines (EPA 1988a,c; DOE 1992c). The following subsections briefly discuss the findings during data validation and the qualifications assigned to the groundwater data. Tables have been included in Appendix A4 as a summary of the primary causes of qualifications. The qualifications presented were applied to selected samples and selected compounds. Complete and detailed summaries of qualified data are presented in the data validation reports (available upon request).

Appendix A7 presents the laboratory and validated data obtained for the newly installed groundwater well samples, including field and QC samples. Vinyl chloride is listed in Appendix A7 by the IUPAC-preferred term of chloroethene. Qualifications assigned during data validation are discussed in the following sections.

Volatiles

Volatile analyses were performed by SW-846 Methods 8010/8020 (EPA 1986a). Most compounds were qualified as estimated (J, UJ) due to exceeded initial or continuing calibration criteria. One of two surrogate recoveries was not within the specified criteria for several samples, resulting in estimated

values. Because at least one surrogate was within recovery limits, the data should be acceptable for use.

Field blanks were collected and analyzed. The trip blank contained low levels of 1,2-dichloroethane and the ambient blank contained a low level of trichloromethane.

The primary column analyses for four field samples (wells 0376-0379) and one trip blank were performed on an opened sample vial, which had been used for confirmation column analyses. Reanalysis of the unopened vial, on the primary column, was performed 3 to 5 days outside of holding time criterion. The compound 1,1,1-trichloroethane was detected in three field samples. Tetrachloromethane and PCE were detected in only one field sample and 1,2-dichloroethane was detected only in the trip blank. For these positive detections, the confirmation results were greater than the primary results, and the confirmation results will be reported.

These and additional qualifications noted in the analytical batches are summarized in Table A4i in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Semivolatiles

No detections were reported for semivolatile compounds. Calibration was generally acceptable except for isolated incidents of exceeded criteria for di-n-octylphthalate, 2,4-dinitrophenol, 4-nitroaniline, and N-nitrosodiphenylamine. The holding time for one extraction was exceeded by 1 day; all detection limits were estimated (UJ). It is doubtful that the exceeded holding time would have any impact on the results. Both di-n-octylphthalate and *bis*(2-ethylhexyl)phthalate were detected in the method blanks. These are common laboratory contaminants and the only effect was an increase in the detection limit for these compounds.

These and additional qualifications noted in the analytical batches are summarized in Table A4j in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Pesticide/PCBs

No detections were reported for any of the target compounds. Calibration was generally acceptable, except for slightly high initial calibration percent relative standard deviations for delta-BHC, 4,4'-DDE, and 4,4'-DDT. The detection limits for these compounds were estimated (UJ). Surrogate recoveries for DCB were outside of the specified range for three samples, resulting in an estimated qualification

of the detections limits for all compounds. All recoveries of the surrogate tetrachloro-m-xylene were within criteria and the results should be acceptable for use.

These and additional qualifications noted in the analytical batches are summarized in Table A4k in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Metals

Many results were estimated, as applicable, due to contamination detected in preparation or calibration blanks. Affected analytes included cadmium, copper, nickel, vanadium, zinc, chromium, iron, manganese, and aluminum. MS and post-digestion spike recoveries that exceeded specified criteria resulted in qualifications for arsenic, thallium, selenium, and antimony data. Duplicate results were also not within specified limits for zinc and aluminum.

These and additional qualifications noted in the analytical batches are summarized in Table A4l in Appendix A. Detailed summaries can be found in the corresponding validation reports.

Anions

Data for chloride, nitrate-nitrite, and sulfate were generally acceptable; however, all sulfate results were estimated due to slightly exceeded MS recoveries. The MS recovery of sulfate was 126 percent, while the upper limit was set at 120 percent.

These and additional qualifications noted in the analytical batches are summarized in Table A4m in Appendix A. Detailed summaries can be found in the corresponding validation reports.

3.5.4.5. Aquifer Test

As discussed in subsection 3.5.2.3, two types of samples were collected and analyzed for volatiles and/or TOC. Those samples analyzed on a fast turnaround basis could not be formally validated. The data were reviewed, before use, by checking method blanks and method blank spike and surrogate recoveries. All available data were determined to be of acceptable quality.

Samples collected from the wells were analyzed for organic volatiles by EPA Method 8010/8020 (EPA 1986a). CLP-like data packages were provided for 28 of the 44 field samples analyzed (64 percent) and these results were subjected to formal data validation. All data, with the exception of those data points rejected, are considered viable for their intended purpose.

Many compounds (approximately 33 to 67 percent) did not meet continuing calibration criteria and were qualified as estimated (J/UJ). The results for eight compounds in two samples were rejected because, at the end of the shift, the laboratory failed to analyze a daily calibration verification standard containing the eight compounds. Of the eight compounds, only Freon-113 has historically been of interest to the Operable Unit 1 area. No positive detections were made for the other seven compounds in any sample analyzed.

All results for sample MND20-0071-2013, a trip blank, were estimated (J/UJ) due to low recovery (57 percent) of the surrogate bromochloromethane. The recovery of the other surrogate, trifluorotoluene, was acceptable and the data should be usable. The surrogate recovery for bromochloromethane was high in two samples, resulting in estimation of those compounds reported as positive detections.

The positive results of several compounds were qualified as estimated due to tentative identification. The compounds were either not within the acceptable retention time windows or not contained in the daily/continuing calibration verification standard. These compounds were deemed probable if detected during the confirmation analysis. All affected compounds are historical contaminants in Operable Unit 1 and would not be unexpected.

A field duplicate was collected for sample MND20-0305-0005; all results were comparable with the exception of Freon-113 (58.5 percent RPD). No significant impact on data quality is expected.

These qualifications are summarized in Table A4n in Appendix A. Detailed summaries can be found in the corresponding validation reports.

3.5.5. Program Changes for Soils Investigation (Additional Work)

Prior to field sampling and laboratory analysis, the Operable Unit 1 additional work, Area B, QAPP was developed to define analytical methodology and QC. Once field sampling and laboratory analysis began, changes to the anticipated program were necessary to adapt to actual field conditions and modifications in analytical procedures and quantitation limits, or to omit unnecessary analyses. Each significant change to the field sampling plan (FSP) or QAPP was detailed in an ER Program Planned Change Notification. These Change Notifications are approved by the Project Manager and QA Officer and submitted to Mound, the EPA, and the OEPA. A brief summary of the changes or modification made to the FSP or QAPP is presented in Table III.11.

Table III.11. Summary of Modifications to the FSP or the QAPP, Additional Field Work

Program Change No.	Summary of Change
015	Removes iron and manganese as analyses for geotechnical samples. The end use of the data and the analytical methodology were not sufficiently defined.
016	For strontium analysis, it was assumed that all strontium present is in the form of Sr-90, given the short half-life of Sr-89. Thus, the determination of Yttrium-90 in the analysis procedure was not necessary.
017	Soil pH measurements were performed in the field due to holding time concerns if the samples were shipped to an off-site laboratory.
018	Actinium-227 was removed from the parameter list and was not determined.
019	The quantitation limit for mercury in soil was changed from 0.04 mg/kg to 0.1 mg/kg. The original value, listed in Table VI.1 of the QAPP, was the result of a mis-calculation. The quantitation limit for potassium-40 was changed from 20 pCi/L to 350 pCi/L. The revised number is more realistic given the natural occurrence of this radionuclide. The quantitation limit for alkalinity in water was set at 5 mg/L. This quantitation limit had been omitted from Table VI.1 of the QAPP. Quantitation limits for VOCs in aqueous QC samples would be the limits specified in the Operable Unit 9 QAPP. Confusion had developed between the methodology (CLP SOW OLM01.8) and Table VI.1, based on CLP SOW 2/88. The change notice was later modified in Change Notice 028.
020	Additional methods for the analysis of chloride were approved - SW9251 or E325.2. These were companion methods to those specified and should be equivalent for data comparability.
021	The holding time requirements for semivolatile and pesticide/PCB analyses were changed from 7 days to 14 days for extraction of soil samples. This change was consistent with the methodology and validation guidelines.
022	Laboratories were given the option of using either ICP or graphite furnace atomic absorption spectroscopy for the analysis of bismuth by Modification A to the CLP SOW. All specified QC and detection limits were required to be met.
023	Specifies that water samples for TOC analyses would be collected with zero headspace and preserved only with sulfuric acid. This change would ensure sample integrity and prevent possible instrument damage caused by hydrochloric acid.
024	The quantitation limit for alkalinity in soil was changed from 10 mg/kg to 50 mg/kg. The revised limit is more realistic.
025	Preparation and extraction of soil samples for tritium analysis will be based on cryogenic distillation, per revised laboratory SOP. This change was made to be consistent with standard laboratory procedures.

Table III.11. (page 2 of 2)

Program Change No.	Summary of Change
026	The corrective action specified in Table III.2 of the QAPP for exceeding %RPD criteria for TOC was changed. Given the high amount of TOC and the very small sample aliquots, the criteria were too restrictive. With this change, if samples within a batch consistently exceed criteria, only one sample must be reanalyzed to verify a matrix problem. The %RPD criteria were, in effect, removed.
027	Specifies that dioxin/furan analysis would be performed following method 8290 instead of method 8280. This change notice specifies required QC, cleanup procedures, and quantitation limits. Method 8290 provides increased specificity and lower detection limits than method 8280.
028	For volatile and semivolatile analyses, the compound target list and quantitation limits specified in CLP SOW OLM01.8 would be followed. Vinyl acetate, benzyl alcohol, and benzoic acid would be retained as target analytes to remain consistent with previous analysis methods.

CLP - (EPA) Contract Laboratory Program
ICP - inductively coupled plasma
PCB - polychlorinated biphenyl
QAPP - Quality Assurance Program Plan
QC - quality control
RPD - relative percent difference
SOP - Standard Operating Procedure
SOW - Statement of Work
TOC - total organic carbon
VOC - volatile organic compound

4. NATURE AND EXTENT OF CONTAMINATION

This section integrates the results of the previous investigations with the field investigation described in Section 3. The geologic setting, the hydrogeologic setting, and the occurrence of contaminants are each described.

4.1. SITE GEOLOGY

An understanding of the geology is important to set the context for groundwater flow and contaminant migration pathways in soils and subsurface deposits at Mound Plant. A general overview of the structure, stratigraphy, and glaciation of the region and site-specific geomorphology and lithology are presented in subsection 2.2. A detailed discussion of the Area B geological setting is presented in Appendix C. The supporting soil boring and lithologic log data are presented in Appendix D. A series of cross sections and two fence diagrams (Plates A and B) are presented to show the distribution of bedrock and Quaternary deposits in the vicinity of Area B. These plates are discussed in detail in Appendix C.

Cross section B-B_6 (Plate A) provides a good illustration of the subsurface sediments that underlie Area B. Due to the reworking of the original Fairmont and Miamian soil types, the dominant surface soil type that presently exists in Area B is Made Land. Extensive construction within Area B has introduced large quantities of fill material and significantly modified the surface topography. Relatively thick deposits of glacial till underlie the fill material and overlie a steep, westward dipping bedrock slope. Tongues of glacio-fluvial outwash extend eastward into the western portion of Area B, where they interfinger with the glacial till deposits. The outwash deposits gradually thicken west of Area B and form the eastern portion of the Buried Valley aquifer. Glacial till is relatively sparse in this area, occurring only as thin lens or stringers. The eastern periphery of the Buried Valley aquifer outwash deposits occupies the western half of Area B, thins eastward, and pinches out against the rising bedrock slope and overlying till deposits.

4.2. SITE HYDROGEOLOGY

The Buried Valley aquifer and its contiguous deposits constitute the primary water-bearing units within which groundwater readily flows in and from Area B. Therefore, adequate hydrologic and geochemical characterization of the Buried Valley aquifer and its contiguous deposits is required to define present contamination occurrence and to predict future contaminant migration originating from Area B.

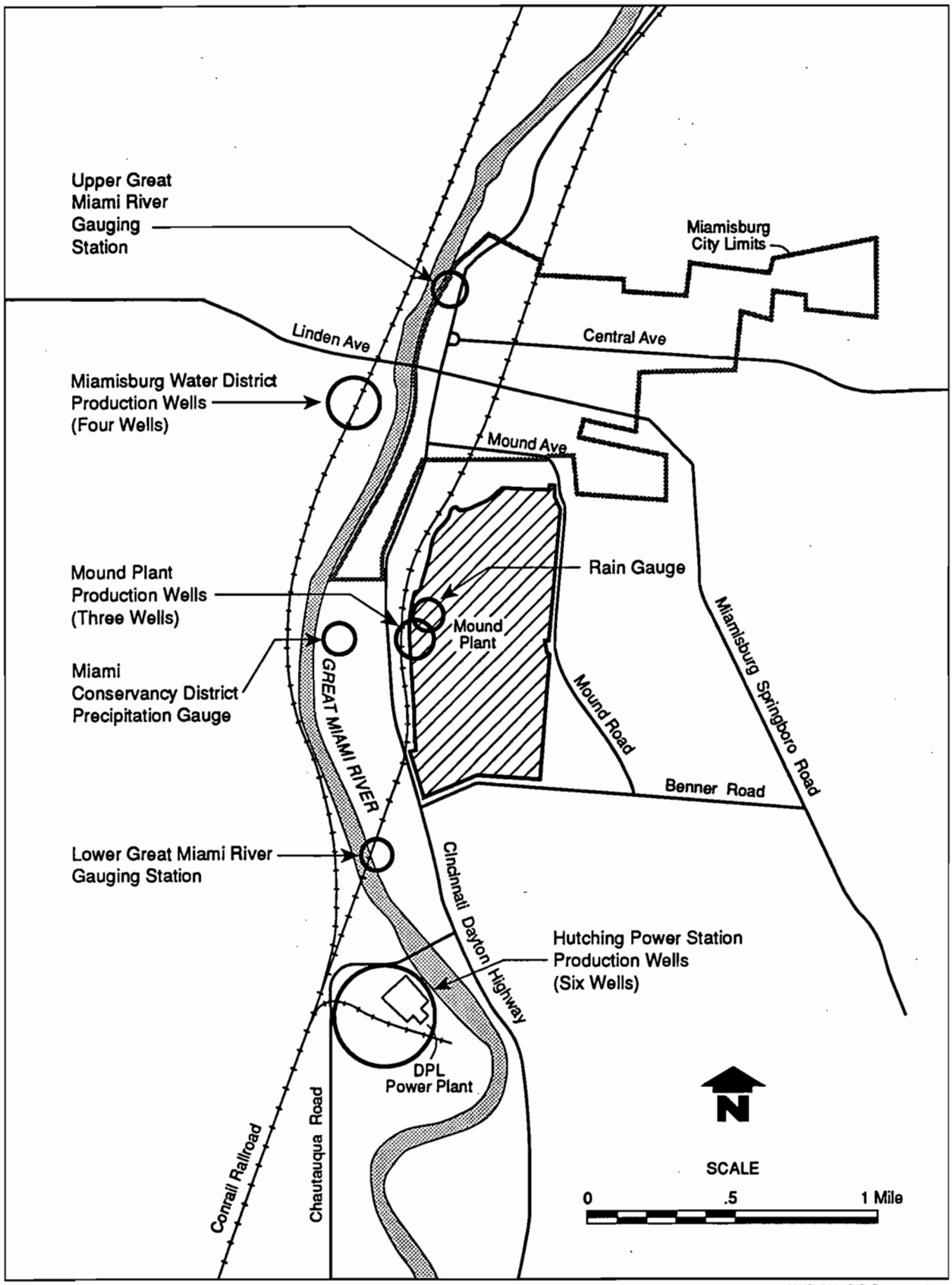
Subsections 4.2.1 and 4.2.2 present an analysis of groundwater flow and recharge, as interpreted from field data (including groundwater levels, precipitation, and river stage). Subsection 4.2.3 presents the aquifer description. Subsection 4.2.4 describes man-made influences on the site hydrogeology. Subsection 4.2.5 provides an analysis of time-series sampling. Subsection 4.2.6 provides a conceptual model that summarizes the site hydrogeology. Subsection 4.2.7 summaries the general groundwater chemistry.

The monitoring wells in and adjacent to Area B are shown in Figure 4.1. Daily precipitation and daily mean gauge height and river discharge for the Great Miami River are shown in Appendix E, Tables E1 and E2. Precipitation is measured at a Miami Conservancy District monitoring station west of Mound Plant near monitoring well 0106 (Figure 4.2). River levels are measured by the Miami Conservancy District at a gauge station approximately 1-1/2 miles northwest of Mound Plant, near the corner of North Miami Avenue and Ferry Street in Miamisburg (Figure 4.2). The gauge elevation is 678.60 ft above mean sea level (MSL).

4.2.1. Groundwater Flow

Average Annual Groundwater Levels

Figure 4.3 shows the averaged groundwater elevations at Mound Plant from mid-1992 through early 1993. Water level data collected in June, September, and December 1992, and March 1993 were averaged and used to construct the map. The data used to create the map are shown in Appendix E, Table E3. Averaged groundwater levels tend to smooth out seasonal variations and leakage from well 0055 during September 1992. The contour interval on this map changes to accentuate subtle water level changes. The wells included in the data base were not selected on the basis of well completion depth or the formation of completion. This approach is reasonable, considering that vertical gradients calculated for clustered wells completed at differing depths and formations of completion were minimal to nonexistent (subsection 4.2.3). However, when a bedrock groundwater elevation conflicted with an alluvial groundwater elevation, the bedrock elevation was eliminated from the contouring process. Bedrock wells are shown in bold-face type. Well 0108 was not included in the figure due to its location and to restrictions of plot scale (it is off the map to the north). Water measurements from 0121 were not included in the contouring because, from topographic interpretation, the well is likely to be on the other side of a drainage/groundwater divide from other Mound Plant monitoring wells. The wells with deleted groundwater level values had survey data that were suspect (S), the well was essentially dry (D), or the well was measured less than three times over the year interval. Wells measured less than three times were assumed to have groundwater levels that, when averaged, would not be representative of an average annual groundwater elevation. Based on the above criteria,



MND/OU1/RIR-Pump/2-10-94

Figure 4.2. Location of river stage and precipitation-measuring stations and active production wells in the vicinity of Mound Plant.

approximately 33 percent of the water level measurement was not used to generate this water level contour map. Most of the deletions were of the new monitoring wells, which were only measured once in March 1993. Because seasonal variations could not be accounted for with only one measurement, these wells were deleted from the average annual contour map. The contour map presented is believed to be a reasonable representation of typical groundwater conditions during the evaluated period.

Groundwater in the Buried Valley aquifer flows in a direction approximately at right angles (perpendicular) to the contour lines. Groundwater gradients of up to 0.05 ft/ft exist to the northeast of Area B within the tributary valley, and then decrease in the tributary valley to 0.01 ft/ft across the northern edge of Area B. Along the western margin of Area B, gradients decrease to approximately 0.0003 ft/ft. This gradient variability results from the slope of the underlying bedrock surface. Higher gradients exist in the sediments deposited on the relatively steep bedrock surface along the axis of the Mound Plant tributary valley, compared to the flat-lying sediments in the main portion of the Buried Valley aquifer.

In general, groundwater flow within and adjacent to Area B is either toward the west or southwest, as shown in Figure 4.3. Groundwater flow within the sediments of the tributary valley north of Area B is to the west and southwest, aligned with the valley topography. Relatively sparse groundwater level data have been collected south of Area B. Consequently, groundwater flow in this area is inferred from surface topography and the bedrock structural contour map to be in a southwesterly direction. Groundwater flow west of Area B within the floodplain of the Great Miami River is to the south.

Man-made influences that affect typical groundwater flow in the vicinity of Area B include 1) pumping activity at Mound Plant production wells 0071, 0076, and 0271, which creates a potentiometric low along the western edge of Area B and induces groundwater flow toward that low; 2) sporadic pumping at Miamisburg Municipal Well No. 2 (0912), which creates a potentiometric low northwest of Area B and locally induces a northwesterly groundwater flow; and 3) apparent historic leakage of surface water through the annulus of monitoring well 0055 (formerly located within the overflow pond), which caused abnormal recharge to the aquifer and created a potentiometric high in the central portion of Area B (Figure 4.6; Figures 4.5 to 4.8 present water level data for June, September, and December 1992, and March 1993). Well 0055 was properly abandoned on 21 September 1992, and no longer influences local groundwater levels.

In addition to the small-scale maps of the groundwater system, it is possible to examine the flow field within and immediately adjacent to Area B on a larger scale. Figure 4.4 shows the groundwater contours based on March 1993 data. With a 0.1-foot contour interval, the data are subject to a

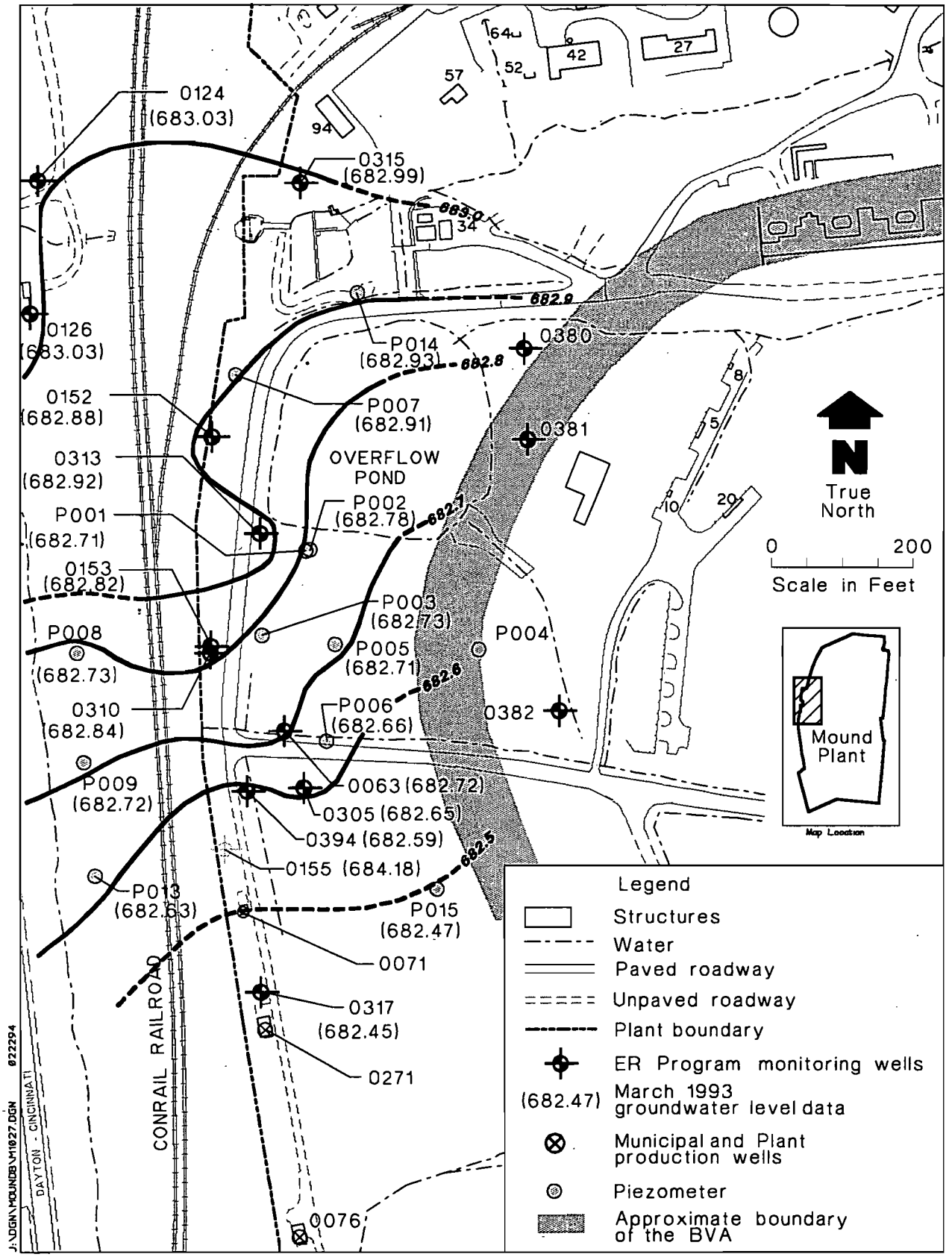


Figure 4.4 Area B local groundwater elevation, March 1993.

measurement error of nearly the same magnitude as the contour interval. This is the primary cause of the apparent irregularities. The map reveals a generally southward flow of water, toward the plant production wells. By inspection, the large- and small-scale maps are in general agreement.

Seasonal Variations

The data used to construct the maps shown in Figures 4.5 to 4.8 are contained in Appendix E, Tables E4a-E4d. The figures show that seasonal water level changes were greatest in wells in the western portion of the study area. The wells here display seasonal changes in elevation from 2 to 6 ft. The wells to the east display seasonal changes in elevation from 0 to 5 ft, with most changing 2 ft or less. The boundary between the two regimes is approximated by those wells with surface elevations below 725 ft. The 725-ft contour extends through the middle of Area B, where the unconsolidated thickness thins to less than 50 ft. These observations are taken as evidence that the groundwater regime to the west is dominated by the aquifer hydraulic system; that to the east, by the structure (as discussed below). Water levels are generally highest in the spring and lowest in the summer. However, the overall configuration of the water table is generally similar from season to season throughout the year, indicating that seasonal influences do not produce marked differences in groundwater flow directions.

Topographic and Bedrock Influences

Bedrock topography has a strong influence on surface topography which, in turn, has a strong effect on the water table elevations. The contour map of the annual average groundwater levels for June 1991 through March 1993 at Mound Plant was overlain on contour maps of surface topography (Figure 4.9) and bedrock (Figure 4.10) to determine topographic and bedrock influences on groundwater flow patterns. The two principal bedrock and topographic highs, the Main Hill to the north of Area B and the SM/PP Hill to the east of Area B, are separated by a well-developed tributary valley. The tributary valley dips steeply to the west/southwest at both the ground and bedrock surfaces in the northern half of Area B. Westward toward the Great Miami River floodplain, both the land surface and bedrock surface flatten out. Water levels in these areas strongly mimic the land surface and bedrock topography. Hydraulic gradients in the tributary valley are high to the northeast of Area B (0.05 ft/ft) and then decrease gradually west across the northern edge of Area B (0.01 ft/ft).

Groundwater flow patterns in the southern portion of Area B appear to be primarily influenced by the SM/PP Hill. The groundwater contour map suggests that water flows west from this topographic and bedrock high at high hydraulic gradients. At the base of the SM/PP Hill, hydraulic gradients decrease significantly.

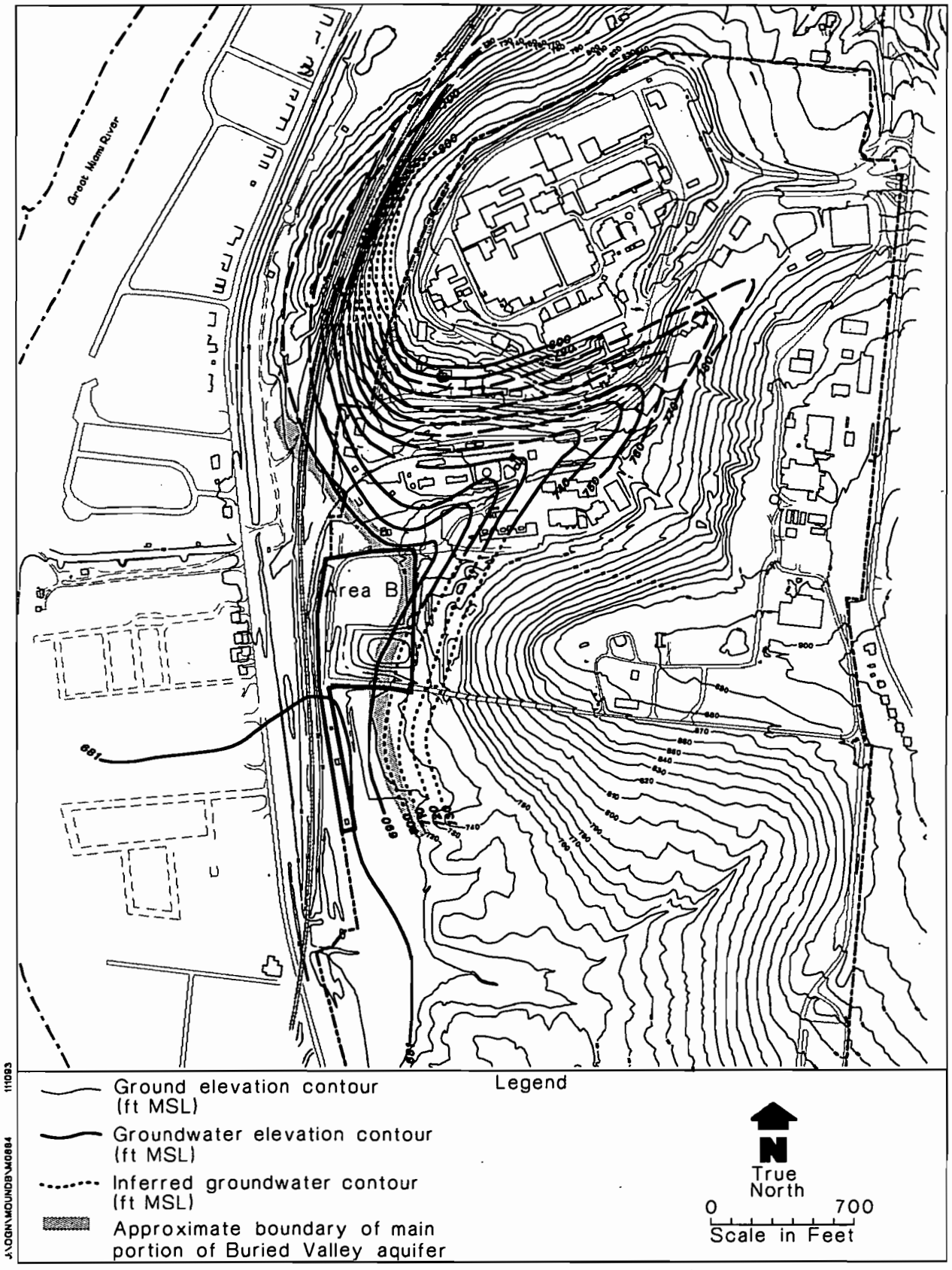


Figure 4.9. Average annual groundwater levels for June 1992 - March 1993 in relation to surface topography at Mound Plant.

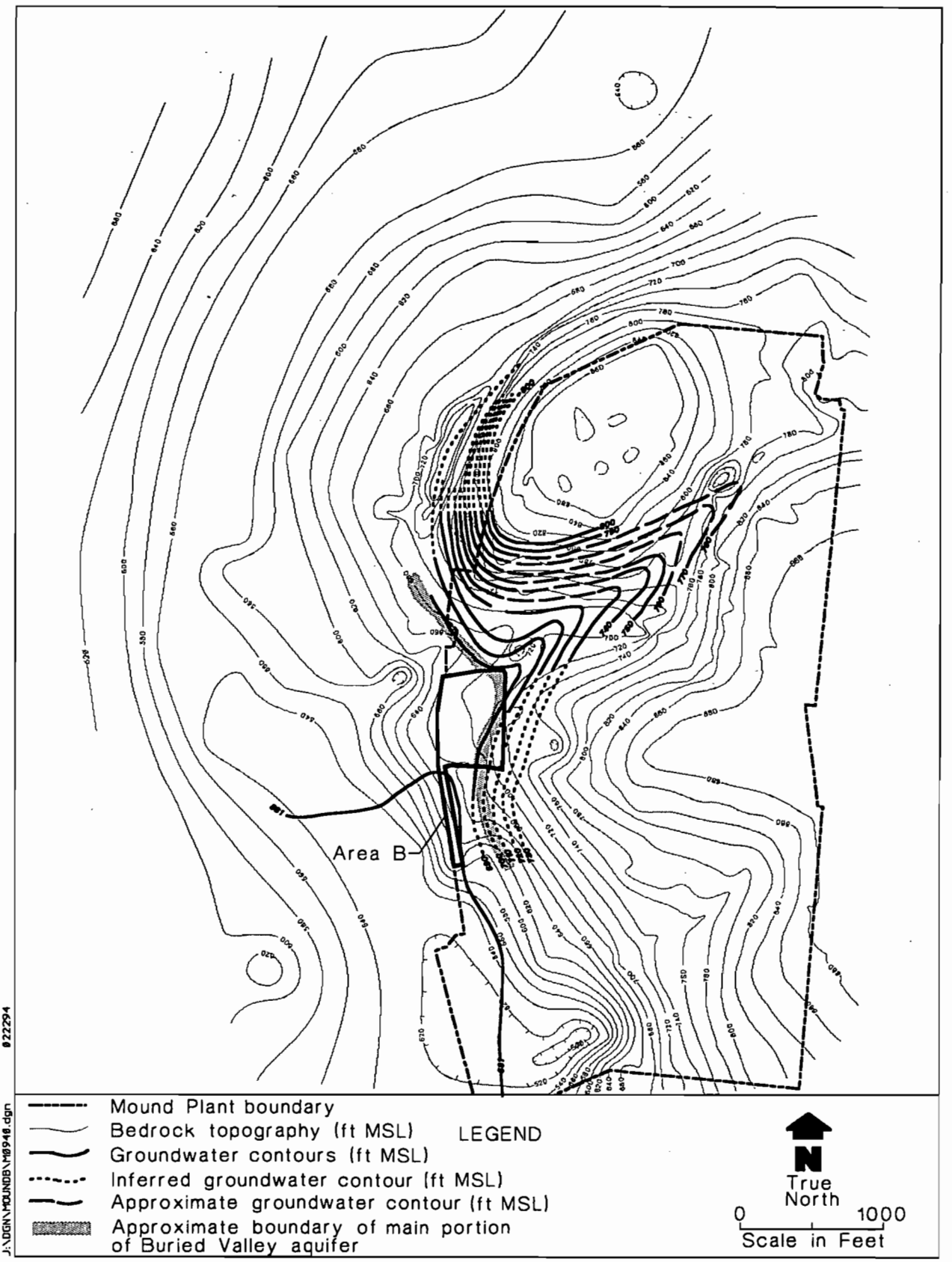


Figure 4.10. Average annual groundwater levels for June 1992 - March 1993 in relation to bedrock topography at Mound Plant.

4.2.2. Recharge to Area B Groundwater System

The groundwater contour map implies that there appear to be four possible sources of recharge to the Area B groundwater system:

- precipitation, infiltration, and percolation of runoff within the boundaries of Area B;
- flux due to changes in river stage, especially infiltration during high river stages (bank storage);
- groundwater flux across the eastern and northeastern boundaries of Area B; and
- percolation from surface water bodies within and adjacent to Area B.

Precipitation

Precipitation and subsequent infiltration is expected to be a minor source of groundwater recharge to Area B. Average rainfall in Montgomery County is approximately 37.5 inches per year, of which 6 inches a year or less actually contribute to groundwater recharge on a regional basis (Schairbaum and Frost 1988). At Area B, the fraction of precipitation contributing to the groundwater is believed to be less than the regional value due to man-made surface features, including paved roads and drainage structures that enhance surface drainage. The approximate area of Area B is 250,000 sq ft, so the total recharge from rainfall and infiltration should be less than 125,000 cubic feet (935,000 gallons), or about 2 days' pumpage for the plant water supply. Monthly precipitation totals range from 2.5 to 4.75 inches, with May and June having the highest average monthly precipitation of 4 to 4.75 inches, and October and December having the lowest totals, ranging from approximately 2.5 to 2.75 inches.

Flux Due to Changes in River Stage

Geologic information indicates that a continuous unconsolidated aquifer extends from the Great Miami River to the Area B hydrogeologic system. Comparison of groundwater elevations and river stage data (Appendix E, Tables E2 and E5) confirms that the water elevation in the river exceeds the mean groundwater elevation in Area B after regional precipitation events. (It was observed during data analysis from the 1993 aquifer test that the river acts as a recharge source to Area B, as elaborated upon below.) The regional decline is caused by a net deficit between flow into and flow from the Buried Valley aquifer in this area. Inflows include recharge from the river and from upgradient areas. Outflows include pumping, evapotranspiration, and flow out of the area. The volume of flow from the Great Miami River to the Buried Valley aquifer cannot be quantified, given the present database.

During the aquifer test, river stage fluctuated as much as 1.5 ft. The maximum rise in river stage of 1.5 ft occurred at the beginning of the aquifer test. Between day 15 and the end of the test, the river stage fluctuated from 0.5 to 1.2 ft higher than the baseline stage measured at the beginning of the test. There were five different intervals of higher stage, as shown in Figure 4.11. This rise in river stage resulted in a decrease in the average rate of groundwater level decline from 0.08 ft/day to 0.02 ft/day. The decrease was measured in wells not affected by the aquifer test: P035-P039, 0333, 0334, and 0159. A similar change was seen in all of the wells in the Buried Valley aquifer, regardless of completion depth. Lag time between measured peak river stage and the resulting rise in groundwater levels was calculated as approximately 12 to 24 hours.

Groundwater Flux Across the Eastern and Northeastern Boundaries

The water level data indicate that the aquifer under Area B is being recharged by groundwater flux from the northeast through fluvio-glacial and alluvial deposits and from the east through bedrock (Figure 4.3). The precise amount of inflow cannot be quantified, given the present database.

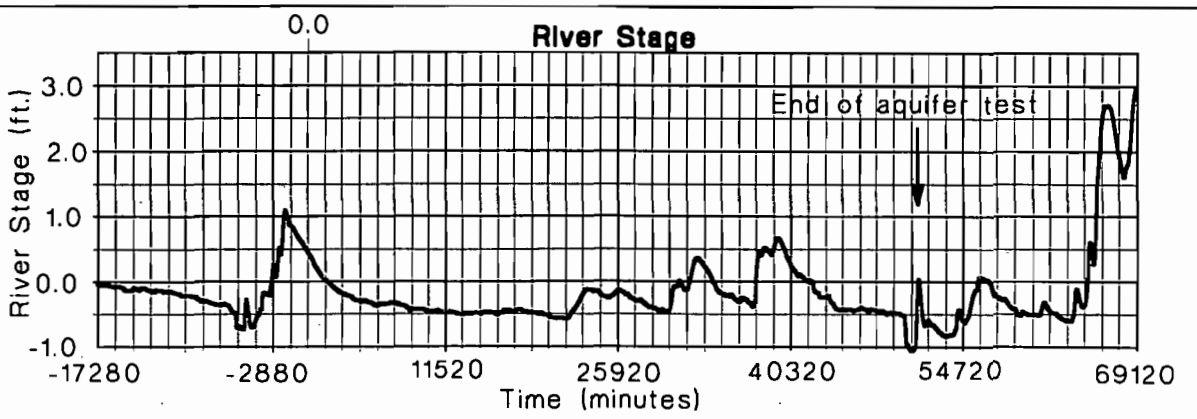
Percolation from Surface Water Features

Three surface water features (drainage ditches, french drains, and the overflow pond) present within Area B (Figure 4.12) could be recharge sources. Each is discussed below.

The drainage ditches that extend along the western and southern edges of the site sanitary landfill join at the southwestern corner of the site sanitary landfill and flow out to the southwest. This drainage carries all surface runoff from the western and southern faces of the site sanitary landfill. These unlined drainage ditches, especially the western ditch with its lower slope, can be recharge sources during runoff events.

The series of five, parallel east-to-west trending french drains installed under the site sanitary landfill is designed to transport infiltrating moisture away from the site. They collect groundwater from underneath and to the east of the site sanitary landfill and transmit it to the west. These french drains are not strictly surface water features because they do not come to the surface. Any water within them would discharge to the underlying groundwater system, immediately subjacent to the surface drainage ditch.

The third surface water feature, the overflow pond, has had a historical impact on the groundwater system, but this appears to have been corrected/remedied. The groundwater level map for June 1992 suggests that the Area B overflow pond may have been leaking and providing recharge to the groundwater system. This leakage could have occurred in three ways:



Note:

Each division on the time axis equals one day.
0.0 is the start of the pumping portion of the aquifer test.
50,400.0 is the end of the pumping portion of the aquifer test.

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Figure 4.11. River stage during May 1993 aquifer test.

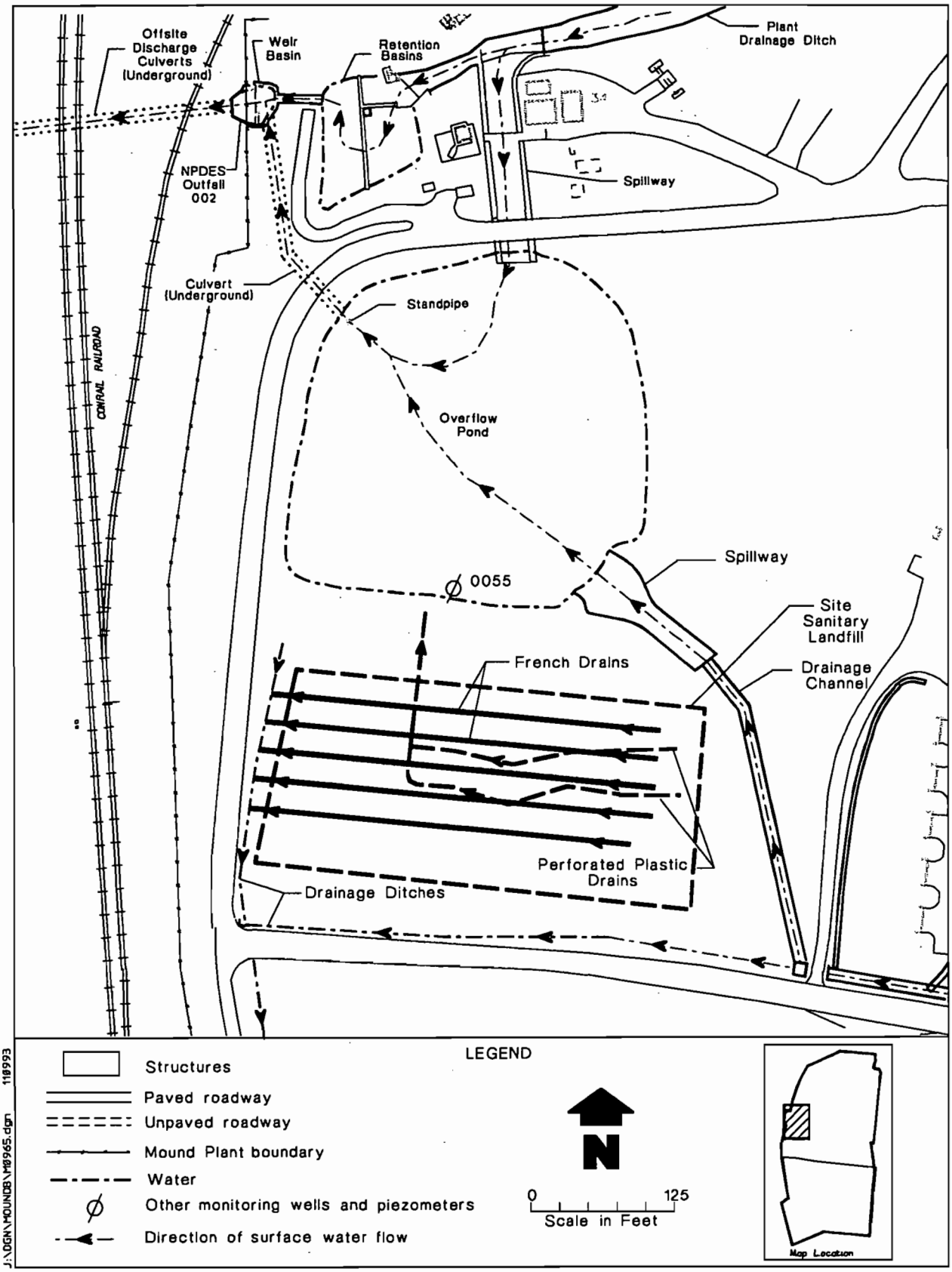

Figure 4.12. Man-made structures that influence hydrogeology in and adjacent to Area B.

- between the casing and the wellbore of monitoring well 0055 (formerly located in the overflow pond), due to a poor bentonite seal within the annulus of the well bore;
- through improperly abandoned test holes drilled into the bottom of the pond when it was initially constructed; and
- through the bottom of the pond.

Test borings in the overflow pond liner were cemented when abandoned. Therefore, it is assumed that the borings are not allowing leakage from the pond (Carfagno 1991). Comparison of water level measurements in 1988 for well 0055 (Table IV.1) versus groundwater levels in adjacent wells indicate that the annulus around well 0055 leaked when the water level in the pond exceeded the ground surface elevation of well 0055. Since the proper abandonment of well 0055 on 21 September 1992, water level maps (Figures 4.7 and 4.8) have not shown the groundwater mounding in the vicinity of the overflow pond. Accordingly, leakage through the undisturbed liner of the overflow pond is thought to be minimal.

4.2.3. Aquifer Description

Stratigraphic Implications

Analyses of the well cluster hydrographs, engineering properties, and aquifer test and slug test data indicate that stratigraphy has a strong influence on groundwater flow patterns at Mound. The primary groundwater flow and contaminant transport beneath the water table could occur within glacial outwash, glacial till, and bedrock. Of these lithologies, outwash and bedrock are the largest in volume extent, while till is present in lesser amounts. Because laboratory-derived hydraulic conductivities in the outwash are several orders of magnitude larger than conductivities in the till and are possibly even larger than those in bedrock, it appears that groundwater and contaminant flow away from Mound occurs primarily through the outwash (as discussed in a later section). Because highly permeable deposits of outwash sand and gravel overlying bedrock are present in and around Mound Plant (Plate A,) the outwash is capable of transporting significant volumes of groundwater. Groundwater levels in some of the well clusters (e.g., wells 0305 and 0309, and wells 0156, 0157, and 0304) indicate that groundwater from the outwash may be also recharging the till and bedrock layers, but groundwater in the bedrock has a much smaller volume and moves at a much slower velocity than it would in outwash because of the significantly lower permeability of the bedrock.

Table IV.1. 1988 Water Levels — Well 0055

Date	Time	Depth to Water (ft)	Static Water Elevation (ft)	Comments
01/28/88	11:01	37.29	675.71	Well 0055 not submerged
03/29/88	11:54	34.24	678.76	Well 0055 not submerged
04/28/88	12:04	34.74	678.26	Well 0055 not submerged
07/01/88	12:25	37.02	675.98	Well 0055 not submerged
07/28/88	11:10	37.15	675.85	Well 0055 not submerged
08/29/88	08:44	30.30	682.70	Well 0055 not submerged
09/30/88	08:54	36.35	676.65	Well 0055 not submerged
10/28/88	09:45	12.11	700.89	Well 0055 submerged (approx. 1 ft)
11/29/88	11:04	——	——	Water in pond too deep to measure Well 0055
12/21/88	09:39	33.20	679.80	Well 0055 not submerged

Note: Surface elevation at Well 0055 = 710 ft ASL
Casing elevation at Well 0055 = 713 ft ASL
Overflow pond elevation at maximum capacity = 713 ft ASL

Vertical hydraulic gradients calculated at all suitable well clusters at the Mound Plant are shown in Appendix F, Figures F1a-F1m. Positive gradients indicate downward flow; negative gradients indicate upward flow. Small vertical hydraulic gradients indicate a high degree of interconnection within the saturated, unconsolidated materials.

There is only one instance of vertical gradients being large enough to be reliably distinguished from measurement noise. Well cluster 343/383 (Figure F1b) is completed across till layers and displays a small downward gradient of 0.0153 ft/ft. All other vertical gradients can reliably be considered nil.

Aquifer Properties

The aquifer properties of interest are: the transmissivity (measured in ft^2 per day), which is a measure of the ability of the aquifer to carry water; the storativity (dimensionless), which is a measure of the ability of the aquifer to contain or store water; and the cone of influence (mapped as the extent of drawdown at a given time), which is a measure of the well-aquifer system's ability to capture water from a particular area. Several aquifer pump tests, together with both field slug and laboratory permeability tests, have been performed to define these properties. The most recent aquifer test, considered definitive, was conducted in 1993. The conduct and results of that test are described below. Results of other, earlier tests are compared to this test.

Description of the test: An aquifer test was performed at Mound Plant production well 1 (0071) during 14 May through 28 June 1993 to determine aquifer characteristics in and around Area B. Sixty-two wells and piezometers in the vicinity of Area B, both on and off the Mound Plant, were monitored for drawdown during the aquifer test (Figure 4.13). Two-thirds of these wells were monitored for the 2-week period immediately prior to the onset of the test to record the regional variation in the groundwater levels (Table IV.2). Table IV.2 shows the filter pack interval, static water levels at the start of the aquifer test, the formation of completion, and method used to measure drawdown within each well. All wells in the aquifer test area were shut down for more than 3 hours to allow water levels to recover before the test began. Precipitation, barometric pressure, and water levels within the overflow pond and river stage data were collected for the analysis of pumping test results. Flow from wells 0071 and 0076 was metered, although the meter at 0076 malfunctioned during the last half of the aquifer test. Pressure transducers and water level sounders were used to measure drawdown data.

Pre-test Calibration: On 7 May 1993, a Step-Drawdown Test was conducted in well 0071. This test was designed to determine the optimum pumping rate for the aquifer test. The test consisted of four pumping steps, with each step lasting approximately 1 hour. Figure 4.14 shows the drawdowns for each of the pumping steps. The four pumping rates and associated drawdowns boring each 58 minute

Table IV.2. Aquifer Test Monitoring Well Completion Data and Monitoring Period

Well Number	Formation of Completion	Distance from 0071 (ft)	Filter Pack Interval	Saturated Thickness	Aquifer Unit	Monitor Start Date	Monitoring Method
0071	GP/GC/GW/GC		2.0-53.5	27(e)	UBVA	5/2/93	*IN SITU*
0076	TS/GP/GM/CL/GW/SP	464.28	2.0-64.0	86(e)	UNK	5/2/93	*IN SITU*
0118	SM-SP	3,838.65	27.5-41.5	92	UBVA	3/26/93	Hand
0129	SM-SP	614.39	28.5-41.5	31(e)	UBVA	3/26/93	Hand
0130	SP	1,343.77	22.5-35.5	148(e)	UBVA	5/2/93	Telog
0152	SP/CL/GP/GC/SH	667.00	22.0-47.0	18	UBVA	3/26/93	Hand
0155	GM/SP/SW	91.11	19.0-32.7	32(e)	UBVA	5/2/93	*IN SITU*
0156	SM-SP/ML-GM/SP	472.05	23.0-36.5	149(e)	UBVA	5/2/93	Telog
0157	GP/SP/GP	474.13	48.3-61.8	149(E)	UBVA	5/2/93	Telog
0159	SP/GP	2428.30	17.0-32.0	43(e)	UBVA	5/2/93	Telog
0276	UNK	263.47	UNK	UNK	UNK	5/2/93	*IN SITU*
0301	ST-LS/ST/SH/ST-LS		26.0-37.0	Bedrock	Bedrock	5/13/93	Telog
0302	GC-GM/SP	1,329.06	105.0-120.6	118(e)	LBVA	5/2/93	Telog
0304	CL/SP-GP-GM	473.74	87.5-103.9	150(e)	LBVA	5/2/93	Telog
0306	GC/GC-GP/GC-SH	355.69	30.5-41.0	18	UBVA	5/2/93	*IN SITU*
0309	SH	207.30	43.5-53.0	Bedrock	Bedrock	5/2/93	*IN SITU*
0313	CL/GW	530.09	30.5-41.5	13(e)	UBVA	3/26/93	Hand
0317	SP\SM\SC-SM	116.01	47.5-63.5	40	UBVA	5/2/93	*IN SITU*
0320	CL/SW/SP-SW	1,345.85	27.0-43.5	160(e)	UBVA	3/26/93	Hand
0333	GP/SP-GP	4,228.94	63.0-75.0	143	LBVA	5/2/93	Telog
0334	GP	4,222.59	16.0-29.0	143(e)	UBVA	5/2/93	Telog
0342	SP-GP	473.79	145.0-160.0	150	LBVA	5/2/93	Telog
0343	ML/SM/SP	966.93	80.0-90.0	80	LBVA	5/2/93	Telog
0344	GP	811.41	162.0-175.5	156	LBVA	4/2/93	Hand
0353	TI/SH-LS	674.54	10.0-18.0	16	Bedrock	5/13/93	Telog
0354	CL/ST-LS	1,506.10	11.0-23.0	Bedrock	Bedrock	5/7/93	Hand

Table IV.2. (page 2 of 3)

Well Number	Formation of Completion	Distance from 0071 (ft)	Filter Pack Interval	Saturated Thickness	Aquifer Unit	Monitor Start Date	Monitoring Method
0377	SP/SM-SP/GP	301.26	11.0-25.0	63(e)	UBVA	5/2/93	Telog
0380	SH-LS	882.50	48.0-61.0	Bedrock	Bedrock	5/13/93	Telog
0382	SH/LS/SH	526.66	22.0-35.0	Bedrock	Bedrock	5/13/93	Telog
0393	ST-LS	374.62	42.0-50.0	Bedrock	Bedrock	5/2/93	*IN SITU*
0394	LS/GP/ST-LS	168.73	52.5-60.0	Bedrock	Bedrock	5/2/93	*IN SITU*
0912	UNK	879.06	UNK	UNK	UNK	5/2/93	Telog
P001	GP	512.89	33.0-45.0	11	UBVA	5/2/93	*IN SITU*
P003	TI/SP-GP/ST	387.91	21.6-39.0	12	LBVA	5/2/93	*IN SITU*
P004	LS/ST-SH/SH/SH-LS/SH	494.36	51.0-62.3	Bedrock	Bedrock	5/2/93	*IN SITU*
P005	FL/GM-GP	396.14	49.5-63.0	6	UBVA	5/2/93	*IN SITU*
P006	GP/SM-SP	215.79	19.5-31.8	9	UBVA	5/2/93	*IN SITU*
P007	SP/SM-SC/GP/SH/TI	752.64	17.5-30.5	11	UBVA	5/2/93	*IN SITU*
P008	GP	431.39	13.0-25.0	40	UBVA		Telog
P009	SP-GP	306.71	53.5-57.0	61	UBVA	5/2/93	Telog
P013	GP	213.87	12.0-24.0	94	UBVA	5/2/93	Telog
P014	TI/GP	881.75	27.5-40.5	8	UBVA	5/13/93	Telog
P015	GM-GP/SP/GM-GP	274.61	42.0-55.0	8	UBVA	5/13/93	Telog
P017	GP/SP/GP	1,625.34	17.0-25.0	152(e)	UBVA	5/2/93	Telog
P018	ML/GM/GP/SP	696.01	11.5-24.0	145	UBVA	5/2/93	Telog
P024	TI/LS	1,060.23	33.0-44.0	25	Bedrock	5/13/93	Telog
P025	GP	84.62	17.0-24.5	40(e)	UBVA	5/2/93	*IN SITU*
P027	SP/ML/SP	107.00	27.0-35.0	40(e)	UBVA	5/2/93	*IN SITU*
P028	TI/SP	274.25	21.0-28.0	51(e)		5/2/93	*IN SITU*
P029	SM/GP	443.15	20.0-28.0	154(e)	UBVA	5/2/93	Telog
P030	SP-GP/SP	447.64	80.0-89.0	154	LBVA	5/2/93	Telog

Table IV.2. (page 3 of 3)

Well Number	Formation of Completion	Distance from 0071 (ft)	Filter Pack Interval	Saturated Thickness	Aquifer Unit	Monitor Start Date	Monitoring Method
P031	SM/GP	320.89	22.0-30.0	74(e)	LBVA	5/2/93	*IN SITU*
P032	TI/GP	639.63	27.0-34.0	123(e)	LBVA	5/2/93	*IN SITU*
P033	GP/SP/GP/SP	630.08	17.0-25.0	83(e)	UBVA	5/2/93	*IN SITU*
P035	GP	2,187.78	18.0-25.0	93	UBVA	5/12/93	Telog
P036	GP	2,200.68	46.0-55.0	93	UBVA	5/12/93	Telog
P037	GP/SP/GP	2,192.61	78.0-85.0	93	LBVA	5/12/93	Telog
P038	GP/SP/TI	2,194.86	90.0-98.0	93	LBVA	5/12/93	Telog
P039	GP	1,358.79	13.0-20.0	45	UBVA	5/13/93	Telog
P040	GP/SP	1,755.37	35.0-42.0	45	UBVA	5/13/93	Telog
P041	GP/SP	1,766.77	45.0-52.0	45	LBVA	5/13/93	Telog
P042	ST	1,764.31	59.0-68.5	Bedrock	Bedrock	5/13/93	Telog

(e) - Estimated
CL - Lean clays, sandy or silty clays, or gravelly clays
FL - Fill material
GC - Clayey gravel or clayey sandy gravel soils
GM - Silty gravel or silty soils
GP - Gravel or sandy gravel, poorly graded
h - Hand measured, not analyzed
LBVA - Lower Buried Valley aquifer
LS - Limestone
ML - Silts, sands or, clayey fine sands
N - No
SH - Shale
SM - Silty sand or sand-silt mixtures
SP - Sand or gravelly sand, poorly graded
ST - Siltstone
SW - Sand or gravelly sand, well-graded
TI - Till
TS - Topsoil, undifferentiated
U - Unknown
UBVA - Upper Buried Valley aquifer
Y - Yes
UNK - Unknown

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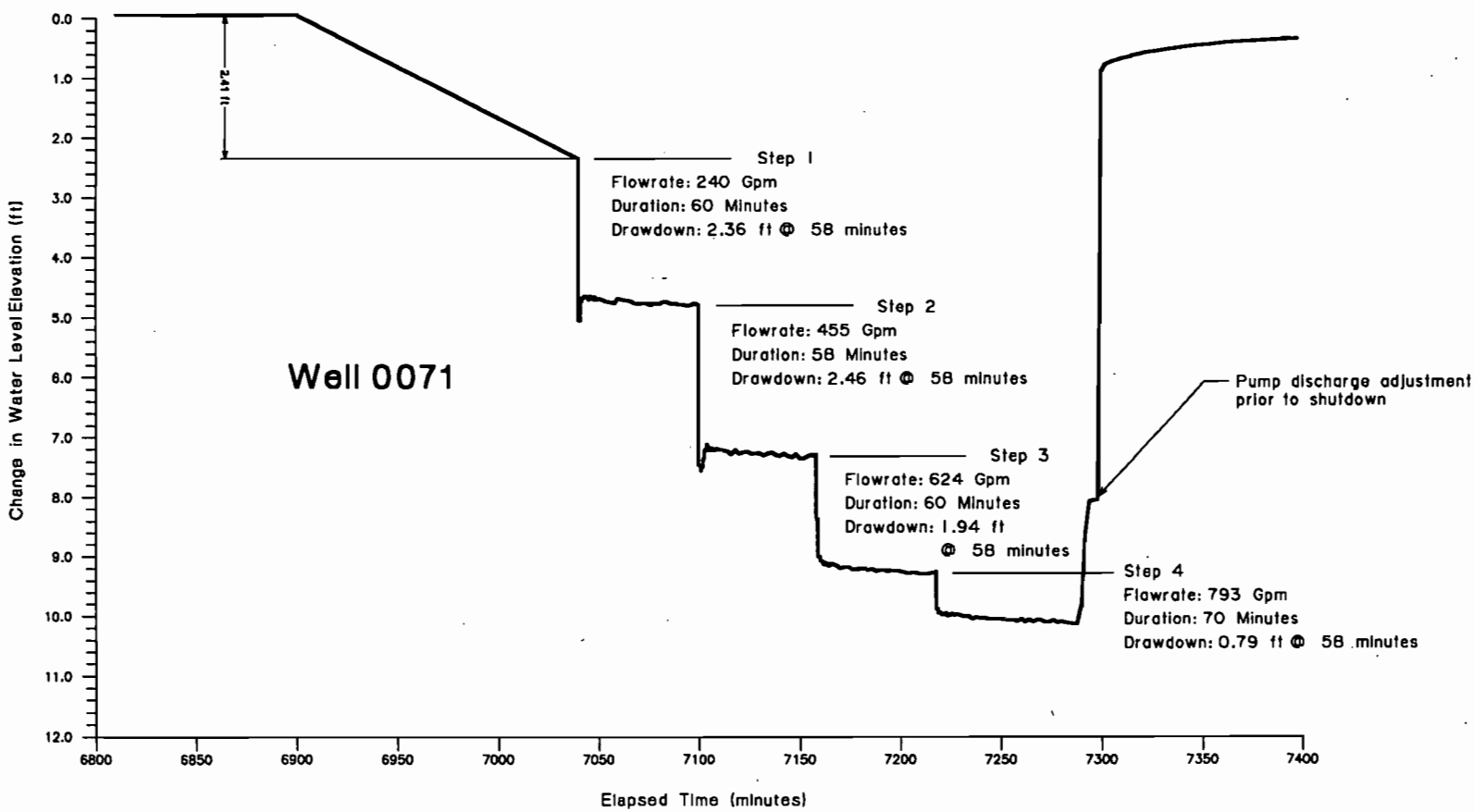


Figure 4.14. Change in water level elevations during Step Drawdown Test, 7 May 1993.

interval were 240 gpm (2.36 ft), 455 gpm (2.46 ft), 624 gpm (1.94 ft), and 793 gpm (0.79 ft). The information from the Step-Drawdown Test was used (by inspection) to determine a pumping rate at well 0071 of approximately 670 gpm. The rate was conservative to avoid dewatering the aquifer or damaging the 30-year-old pumping well.

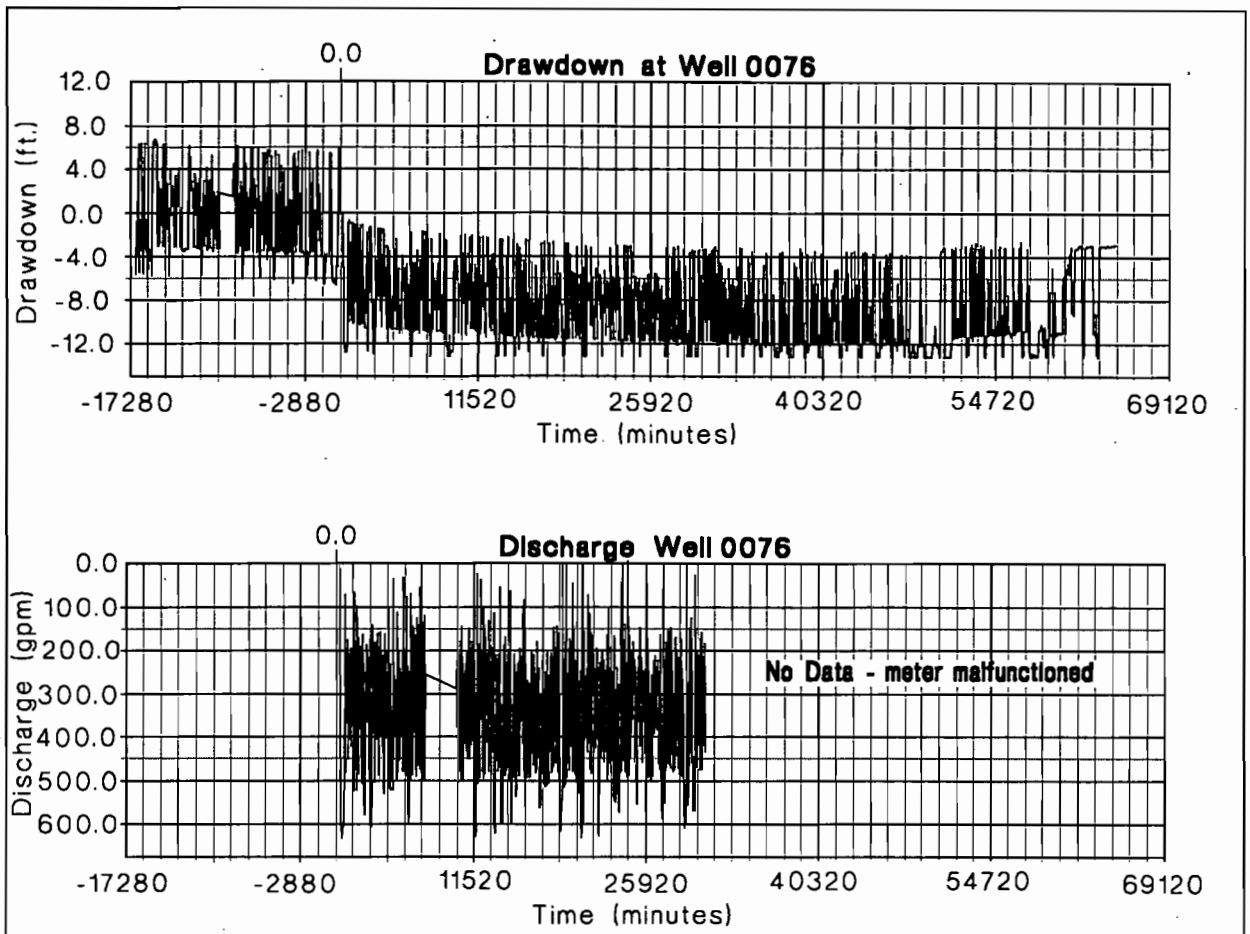
Conduct of the Test: The aquifer test began at 12:15 pm on 14 May 1993 and continued for 35 days through 18 June 1993. The pumping rate averaged 669 gpm over the duration of the pumping phase of the test. Variations in the pumping rate were less than 2 percent. Well 0076 cycled on and off during the aquifer test at approximate 360,000-gallon intervals, due to filter backwash and recharge at the water conditioning plant and pumping for the plant water supply (Figure 4.15). Pumping at 0076 caused a cyclic fluctuation of water levels in wells nearest to 0076, P032, and P033. Other wells did not show the water level fluctuation from the cycling on and off at 0076. Pumping at 0076 did contribute to the regional decline rate observed in wells in this area. In addition, Miamisburg well 0913 was pumping on 19 May 1993 and for a period after 2 June 1993. This well was used to fill the municipal swimming pool on an as-needed basis. Pumping rates and durations are not available, but there appears to be no effect from this well on the monitored wells. The recovery portion of the test began on 18 June 1993 at 9:30 am and continued for 10 days until 28 June 1993.

Initial Data Evaluation: The first step in the aquifer test analysis was to generate an arithmetic plot of the drawdown data with time for each well (Appendix G, Figures G1a-G1r). These plots were done to the same scale so that the graphs could be compared. The changes in barometric pressure, river stage, precipitation, and in the pumping rate at 0076 were also plotted to the same time scale (Appendix G, Figure G2). The drawdown data from each well were then compared to the barometric pressure, river stage, precipitation, and 0076 pumping plots to identify the effect of each variable on each well (Table IV.3).

- Precipitation had no direct effect on water levels during the duration of the aquifer test.

- Diurnal fluctuation is observed in those wells completed in or beneath fine-grained material, such as till or wells completed in the bedrock. Water levels within those wells are interpreted to be affected by the changes in barometric pressure because they show a cyclic change over a 24-hour period that is similar to the diurnal change in barometric pressure. However, the general trend of drawdown is apparently not affected by the barometric pressure.

- The pumping at Well 0076 appears to affect only piezometers P031 and P033. The drawdown in these two wells fluctuates as well 0076 turns on and off but, like the barometric pressure, there appears to be no long-term effect on the drawdowns in the wells.



Note:

0.0 is the start of the pumping portion of the aquifer test.
Each interval is one day.

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Figure 4.15. Drawdown and discharge at well 0076.

Table IV.3. Factors Affecting Measured Drawdown in Monitoring Wells

Well Number	Formation of Completion	Filter Pack Interval (FPI)	Saturated Thickness (ft)	Aquifer Unit	Measurement Method	Fine Grained Unit above FPI	Partially Penetrating	Barometric Pressure	River Stage	0076 Pumping	0071 Pumping	Corrected Drawdown at 14,400 minutes (ft)
0071	GP/GC/GW/GC	2.0-53.5	27(e)	UBVA	*IN SITU*	Y	N		Y		Y	7.9
0076	TS/GP/GM/CL/GW/SP	2.0-64.0	86(e)	UNK	*IN SITU*	Y	N		U	Y	U	6.5(b)
0118	SM-SP	27.5-41.5	92	UBVA	Hand	Y	Y	h	h	h	h	NR
0129	SM-SP	28.5-41.5	31(e)	UBVA	Hand	N	Y	h	h	h	h	0.8
0130	SP	22.5-35.5	148(e)	UBVA	Telog	N	Y	Y	Y		Y	0.3
0152	SP/CL/GP/GC/SH	22.0-47.0	18	UBVA	Hand	Y	N	h	h	h	h	0.9
0155	GM/SP/SW	19.0-32.7	32(e)	UBVA	*IN SITU*	N	Y	Y	Y		Y	1.4
0156	SM-SP/ML-GM/SP	23.0-36.5	149(e)	UBVA	Telog	N	Y		Y		Y	0.7
0157	GP/SP/GP	48.3-61.8	149(e)	UBVA	Telog	N	Y		Y		Y	0.7
0159	SP/GP	17.0-32.0	43(e)	UBVA	Telog	N	N		Y		Y	0.2
0276	UNK	UNK	UNK	UNK	*IN SITU*	U	U		U		U	0.5
0302	GC-GM/SP	105.0-120.6	118(e)	LBVA	Telog	Y	N		Y		Y	0.2
0304	CL/SP-GP-GM	87.5-103.9	150(e)	LBVA	Telog	Y	Y		Y		Y	0.5
0306	GC/GC-GP/GC-SH	30.5-41.0	18	UBVA	*IN SITU*	N	N	Y	Y		Y	1.1
0309	SH	43.5-53.0	Bedrock	Bedrock	*IN SITU*	Y	N	Y	Y		Y	1.0
0313	CL/GW	30.5-41.5	13(e)	UBVA	Hand	Y	N	h	h	h	h	0.9
0317	SP\SM\SC-SM	47.5-63.5	40	UBVA	*IN SITU*	N	N	Y	Y		Y	1.1
0320	CL/SW/SP-SW	27.0-43.5	160(e)	UBVA	Hand	Y	Y	h	h	h	h	0.3
0333	GP/SP-GP	63.0-75.0	143	LBVA	Telog	Y	Y	Y	Y		N	NR
0334	GP	16.0-29.0	143(e)	UBVA	Telog	N	Y	Y	Y		N	NR
0342	SP-GP	145.0-160.0	150	LBVA	Telog	Y	N		Y		Y	0.3
0343	ML/SM/SP	80.0-90.0	80	LBVA	Telog	Y	N		Y		Y	0.2
0344	GP	162.0-175.5	156	LBVA	Hand	N	N	h	h	h	h	0.1
0353	TI/SH-LS	10.0-18.0	16	Bedrock	Telog	Y	N	Y	Y		Y	0.1
0354	CL/ST-LS	11.0-23.0	Bedrock	Bedrock	Hand	Y	N	h	h	h	h	0.1
0377	SP/SM-SP/GP	11.0-25.0	63(e)	UBVA	Telog	N	N		Y		Y	1.0
0380	SH-LS	48.0-61.0	Bedrock	Bedrock	Telog	Y	N	Y	Y		Y	0.6

Table IV.3. (page 2 of 3)

Well Number	Formation of Completion	Filter Pack Interval (FPI)	Saturated Thickness (ft)	Aquifer Unit	Measurement Method	Fine Grained Unit above FPI	Partially Penetrating	Barometric Pressure	River Stage	0076 Pumping	0071 Pumping	Corrected Drawdown at 14,400 minutes (ft)
0382	ST-LS/ST-SH/ST-LS	26.0-37.0	Bedrock	Bedrock	Telog	N	N				N	NR
0382	SH/LS/SH	22.0-35.0	Bedrock	Bedrock	Telog	Y	N	Y			N	NR
0393	ST-LS	42.0-50.0	Bedrock	Bedrock	*IN SITU*	N	N	Y	Y		Y	0.8
0394	LS/GP/ST-LS	52.5-60.0	Bedrock	Bedrock	*IN SITU*	N	N	Y	Y		Y	1.6
0912	UNK	UNK	UNK	UNK	Telog	U	U		Y		Y	0.4
P001	GP	33.0-45.0	11	UBVA	*IN SITU*	N	N	Y	Y		Y	1.2
P003	TI/SP-GP/ST	21.6-39.0	12	LBVA	*IN SITU*	Y	N	Y	Y		Y	1.1
P004	LS/ST-SH/SH/SH-LS/SH	51.0-62.3	Bedrock	Bedrock	*IN SITU*	N	N	Y			N	NR
P005	FL/GM-GP	49.5-63.0	6	UBVA	*IN SITU*	N	N	Y	Y		Y	1.2
P006	GP/SM-SP	19.5-31.8	9	UBVA	*IN SITU*	N	N		Y		Y	1.4
P007	SP/SM/SC/GP/SH/TI	17.5-30.5	16	UBVA	*IN SITU*	N	N	Y	Y		Y	0.2
P008	GP	13.0-25.0	40	UBVA	Telog	N	Y		Y		Y	0.9
P009	SP-GP	53.5-57.0	61	UBVA	Telog	N	N		Y		Y	0.9
P013	GP	12.0-24.0	94	UBVA	Telog	N	Y		Y		Y	1.1
P014	TI/GP	27.5-40.5	7	LBVA	Telog	Y	N		Y		Y	0.7
P015	GM-GP/SP/GM-GP	42.0-55.0	8	UBVA	Telog	N	N		U		Y	1.5
P017	GP/SP/GP	17.0-25.0	152(e)	UBVA	Telog	N	Y	U	U		U	-0.1
P018	ML/GM/GP/SP	11.5-24.0	145	UBVA	Telog	N	Y	Y	Y		Y	0.6
P024	TI/LS	33.0-44.0	25	Bedrock	Telog	Y	N	Y			N	NR
P025	GP	17.0-24.5	40(e)	UBVA	*IN SITU*	N	N		U		Y	T
P027	SP/ML/SP	27.0-35.0	40(e)	UBVA	*IN SITU*	N	N	Y	Y		Y	1.7
P028	CL/SW	21.0-28.0	51(e)	LBVA	*IN SITU*	Y	Y		U		U	D
P029	SM/GP	20.0-28.0	154(e)	UBVA	Telog	N	Y		Y		Y	0.8
P030	SP-GP/SP	80.0-89.0	154	LBVA	Telog	N	Y		Y		Y	0.8
P031	SM/GP	22.0-30.0	74(e)	LBVA	*IN SITU*	M	Y	Y	Y	Y	Y	1.2
P032	TI/GP	27.0-34.0	123(e)	LBVA	*IN SITU*	Y	Y		Y		Y	0.7

Table IV.3. (page 3 of 3)

Well Number	Formation of Completion	Filter Pack Interval (FPI)	Saturated Thickness (ft)	Aquifer Unit	Measurement Method	Fine Grained Unit above FPI	Partially Penetrating	Barometric Pressure	River Stage	0076 Pumping	0071 Pumping	Corrected Drawdown at 14,400 minutes (ft)
P033	GP/SP/GP/SP	17.0-25.0	83(e)	UBVA	*IN SITU*	N	Y		Y	Y	Y	0.7
P035	GP	18.0-25.0	93	UBVA	Telog	N	Y	Y	Y		N	0.1
P036	GP	46.0-55.0	93	UBVA	Telog	N	Y	Y	Y		N	-0.1
P037	GP/SP/GP	78.0-85.0	93	LBVA	Telog	N	Y	Y	Y		N	0.0
P038	GP/SP/TI	90.0-98.0	93	LBVA	Telog	N	Y	Y	Y		N	0.1
P039	GP	13.0-20.0	45	UBVA	Telog	N	Y	Y	Y		Y	0.3
P040	GP/SP	35.0-42.0	45	UBVA	Telog	N	Y	Y	Y		Y	0.4
P041	GP/SP	45.0-52.0	45	LBVA	Telog	N	Y	Y	Y		Y	0.3
P042	ST	59.0-68.5	Bedrock	Bedrock	Telog	N	N	Y	Y		N	3(a)

(a) - Possible problem with well construction
(b) - Drawdown at 0076 fluctuated widely. At 14,470 minutes the corrected drawdown was 11.4 ft. At 14,410 minutes the corrected drawdown was 15.4 ft.
(e) - Estimated
CL - Lean clays, sandy or silty clays, or gravelly clays
D - Transducer dry
FL - Fill material
GC - Clayey gravel or clayey sandy gravel soils
GM - Silty gravel or silty soils
GP - Gravel or sandy gravel, poorly graded
h - Hand measured, not analyzed
LBVA - Lower Buried Valley aquifer
LS - Limestone
ML - Silts, sands or, clayey fine sands
N - No
NR - No response
SH - Shale
SM - Silty sand or sand-silt mixtures
SP - Sand or gravelly sand, poorly graded
ST - Siltstone
SW - Sand or gravelly sand, well-graded
T - Problem with Transducer
TI - Till
TS - Topsoil, undifferentiated
U - Unknown
UBVA - Upper Buried Valley aquifer
Y - Yes
UNK - Unknown

- Pre-test monitoring showed there was a regional decline in water levels that appears to be directly affected by the river stage. Wells closest to the Great Miami River respond to a rise in river stage within 24 hours. This response is seen in piezometer cluster P035-P042, as well as indicated wells listed in Table IV.3. Well 0159, located approximately 2500 ft south of pumped Well 0071, shows that the regional water level decline is also affected by the river stage. A well-defined decline rate, 0.083 ft/day, is seen from 2 May 1993 through 31 May 1993.

  The river stage increases from 0.5 to 1.5 ft over the last 14 days of the test. This rise in the river stage resulted in a decrease in the regional decline rate from 0.08 ft/day to 0.022 ft/day. In addition, several wells, including wells P006, 0309, and P032, show water level recoveries of less than 0.1 ft during the same time period.

  The regional decline rate is caused by a net deficit in the water budget in this area of the Buried Valley aquifer. Inflows to the area include recharge from the Great Miami River and the bedrock and from inflow of water from upgradient areas. Outflow occurs from pumping, evapotranspiration, and flow to downgradient areas. Outflow greater than inflow during a given time period will result in a decline in water levels.

Data Correction: Based upon the comparison of drawdown and the other variables affecting the drawdown, the data were corrected for the regional decline rate by subtracting the regional decline from the drawdown (Appendix G, Figures G3a-G3d). Approximate extent of drawdown maps for 14,400 minutes, 60 minutes, 600 minutes, and 1,400 minutes are shown in Figures 4.16 to 4.19, respectively. The extent of drawdown stabilized by 14,400 minutes. The capture zones for both 0071 and 0076 are delineated by the 1.0 ft drawdown contour. This provides a conservative estimate of the area in which water movement is toward the two pumping wells.

Drawdown Data Analysis: Although 62 wells were monitored during the test, the data from 13 wells were selected for analysis (Table IV.4). These wells were selected on the basis of distance from pumped well, screened interval and formation of completion, and the data quality (primarily the amount of noise in the record). The goal was to select wells that provided good areal coverage in the Mound Plant area and that were completed in the upper and lower Buried Valley aquifer and in the bedrock. Those wells with recorded data that were particularly noisy or showed random fluctuations or malfunctioning transducers were eliminated. As shown in Figure 4.20 and in the comparison of the time drawdown data in Appendix G, there were several groups of wells that responded to the pumping in a similar fashion. Wells with similar responses, that is, drawdown curves that were the same shape and drawdown magnitudes that were similar, were combined into a group and one well from that group was analyzed. After correction for the regional decline, nine wells (0302, P017, P035-P038, 0159, 0333 and 0334) showed little or no effect from pumping at well 0071.

Analysis of the aquifer test data was performed using "AQUIX-4S" produced by EnviroTools, LTD (EnviroTools, LTD. 1993), and by the use of distance-drawdown graphs (IGWMC 1992). AQUIX-4S offers four methods for analyzing aquifer test data:

Table IV.4. Monitoring Wells Used for Aquifer Parameter Analysis

Well Number	Depth	Thickness	Partially Penetrating	Fine Grained Unit	Bedrock	Responds to Change in Barometric Pressure	Responds to Change in River Stage
0156	37	149	Y	N			Y
0304	104	150	Y	Y			Y
0309	53	41	N	Y	Y	Y	Y
0393	50	39	N	N	Y		Y
0394	60	50	N	N	Y	Y	Y
0912	U	U	U				
P005	63	6	N	N	Y	Y	Y
P006	32	9	N	N	Y		Y
P009	57	61	N	N			
P013	24	94	Y	N			Y
P018	24	145	Y	N			
P027	35	40	Y	N		Y	Y
P029	28	154	Y	N			
P032	34	123	Y	Y			Y

N - no
U - unknown
Y - yes

- The Theis (1935) model assumes the aquifer is homogeneous, isotropic, non-leaky, semi-infinite areal extent and that the well is screened over the entire aquifer thickness. Water discharge to the well is released from storage. The Theis method is generally used for a confined aquifer but can be used for an unconfined aquifer if drawdown is small compared to the aquifer thickness.

- The Hantush (1960) model assumes the aquifer is homogeneous, isotropic, confined with a leaky aquitard, semi-infinite areal extent and that the well is screened over the entire aquifer thickness. Water discharged to the well is released from storage. The leaky aquitard assumption can also be used to simulate a recharge boundary.

- The Hantush (1964) model assumes the aquifer is homogeneous, anisotropic, confined with a leaky aquitard, semi-infinite areal extent and that the well can be screened over part of the aquifer thickness. Water discharged to the well comes from aquifer storage.

- The Neuman (1975) model assumes that the aquifer is unconfined, homogeneous, anisotropic, semi-infinite in areal extent and that the well can be screened over part of the aquifer thickness. Water discharged to the well is released initially from storage by way of pressure release and later from gravity drainage.

The Theis (1935), Hantush (1964), and Neuman (1975) models were used to analyze the aquifer test data. The method that best fit the aquifer conditions at each well was used to calculate transmissivity and storativity. For example, some of the well screens are located below a fine-grained unit, such as till. These wells fit either the Theis (1935) model or the Hantush (1964) model. On the other hand, since no leakage or confining layers are involved, wells completed strictly in alluvium are better analyzed by Neuman (1975).

A summary of transmissivity and storativity values for all of the monitoring wells is shown in Table IV.5. The geographical distribution of the values that characterize the aquifer is shown on Figure 4.21.

Transmissivity values were also calculated for the 1993 aquifer test using the distance-drawdown program developed by the International Groundwater Modeling Center (IGWMC 1992). The distance-drawdown analysis used the log-linear relationship of the distances between the pumping well and monitoring wells and the drawdown in monitoring wells. Transmissivity values were calculated by evaluating the slope of the time-drawdown or distance-drawdown curve over a selected time or distance interval (Appendix G , Figure G4a-G4n). Storativity values were calculated by evaluating the intersection of the drawdown curve with the time or distance axis.

Three distance-drawdown analyses were run using the drawdown measured at 17,280 minutes to determine whether transmissivity varied with direction from the pumped well. The wells used in the distance-drawdown analyses were selected based on the distance from the pumped well, the saturated

Table IV.5. Comparison of Aquifer Parameters Calculated from May 1993 Aquifer Test

Well Number	Saturated Thickness (ft)	Complete Test						20,000 Minutes into the Test			
		Theis		Neuman		Hantush		Neuman			
		Transmissivity (ft^2/day)	S	Transmissivity (ft^2/day)	Sy	Transmissivity (ft^2/day)	Sy	Transmissivity (ft^2/day)	Conductivity (ft/day[a])	S	Sy
0156	149(e)	46,400	0.15	50,500	0.13			52,200	870	0.001	0.14
0304	150(e)					17,900	0.06	54,100	900	0.14	0.27
0309	Bedrock					30,500	0.33	30,800	500	0.28	0.34
0393	Bedrock	29,800	0.27	27,700	0.21	14,700	0.17	32,600	550	0.1	0.14
0394	Bedrock	58,400	0.01	39,600	0.04			38,700	650	0.01	0.04
0912	U	35,800	0.23	36,000	0.23	18,500	0.15	27,500	460	0.11	0.12
P005	6			39,100	0.05			36,400	600	0.01	0.05
P006	9			35,500	0.06			34,300	600	0.02	0.06
P009	61	54,300	0.11	49,100	0.13			47,500	800	0.004	0.13
P013	94	58,300	0.13	47,900	0.1			30,200	500	0.03	0.1
P018	145	45,700	0.13	45,700	0.14			49,100	820	0.06	0.07
P027	40(e)			33,900	0.11			32,300	550	0.1	0.17
P029	154(e)	55,800	0.09	57,800	0.08			50,900	850	0.009	0.10
P032	123(e)			53,300	0.09	44,900	0.09	55,200	900	0.001	0.07

[a]Transmissivity divided by Well 0071 thickness (60 ft) values are rounded.
U - Unknown
(e) - estimate

thickness of the aquifer, and the depth of well completion. Every attempt was made to use wells that were oriented in a specific direction and completed in similar material. The first analysis, on a line running north from the pumped well in the Buried Valley aquifer (wells P013, P009, P008, 0129, and 0912), had a transmissivity of 45,000 ft^2/day and a storativity of 0.12 (Appendix G, Figure G6a). The second analysis, on a line to the northeast from the pumped well (wells 0394, 0393, P003, 0313, P001, and P014) had a transmissivity of 39,600 ft^2/day and a storativity of 0.09 (Appendix G, Figure G6b). The third analysis was on a line south from the pumped well (wells P029, P030, P032, P013, and 0157). The transmissivity and storativity were 47,500 ft^2/day and 0.11, respectively (Appendix G, Figure G6c). As with the aquifer test analysis, the distance-drawdown analyses show a decrease in transmissivity to the north and east of the pumped well, where saturated thicknesses are less. The storativites calculated in the distance-drawdown analyses are equal to the median storativity calculated in the aquifer test.

The recovery portion of the aquifer test was not subjected to extensive analysis because of the river stage rise 17 days into the aquifer test. There were five periods of higher river stage, occurring from 17 days through the middle of the recovery portion of the test. However, it is possible to utilize data from the first day of recovery to calculate reasonable aquifer performance parameters. This analysis, together with additional considerations provided by EG&G Mound, is provided in Appendix K.

Discussion of Results: Transmissivity and storativity values calculated from data collected during the 1993 aquifer test demonstrate that aquifer characteristics varied by screened lithology and location of the monitoring wells. This may be seen by examining the data in Tables IV.3 and IV.5 and in Figure 4.21.

Although the thinning of the Buried Valley aquifer to the east of well 0071 may increase the drawdown measured in wells to the east, this boundary effect is muted by the larger volume of saturated sediments to the south and west of the pumped well. It is further masked by the apparent recharge from the river stage fluctuations and by the regional water table decline. An increase in drawdown was observed from 10 to 12 hours after the test began so that the data deviated from the typical Theis type curve. However, the period of increase was followed by a period of decreased drawdown where the data fell back onto the Theis curve. This change in drawdown can be interpreted in three ways: as a boundary effect, as the result of delayed drainage, or as a result of the onset of pumping of well 0076. The data can be matched using Neumann's delayed yield curves for a transmissivity ranging from 27,500 ft^2/day to 55,200 ft^2/day. However, if the change in drawdown is assumed to be caused by a barrier, and if the data before the change in drawdown are analyzed, the transmissivity is doubled (54,000 ft^2/day to 108,203 ft^2/day). Based upon previous aquifer tests in the area, it is unlikely that the higher transmissivities (calculated assuming a barrier is present) are reasonable. A third explanation

the higher transmissivities (calculated assuming a barrier is present) are reasonable. A third explanation is the onset of pumping at well 0076. Well 0076 began pumping approximately 3 hours after the aquifer test began. The increase in drawdown could be a result of the increased withdrawal, and the subsequent decrease in drawdown could be a result of the discharge at 0076 stabilizing at a lower rate.

The transmissivity values were calculated from individual well responses for the entire period of pumping for the aquifer test and for the period before 20,000 minutes. The two analyses were run to see what effect the river stage rise, after 20,000 minutes, had on the calculated transmissivity and storativity values. For the analysis of data collected before 20,000 minutes, the transmissivity ranged from 27,500 ft^2/day to 55,200 ft^2/day. For the entire aquifer test, the transmissivities ranged from 33,900 ft^2/day to 57,800 ft^2/day. Transmissivities changed less than 10 percent between the two analyses. Storativites for the entire test and the early time ranged from 0.04 (well 0394, completed in bedrock) to 0.23 (well 0912, completed in the Buried Valley aquifer) and 0.04 (well 0394) to 0.34 (well 0309, completed in bedrock), respectively. In general, the data from the earlier part of the test yielded lower storativities.

Although it would be expected that the transmissivities calculated for wells completed in the bedrock and the Buried Valley aquifer would be greatly different, this is not true for the Mound aquifer test. The interconnection between the bedrock and the Buried Valley aquifer allows pressure changes to be readily transmitted to the bedrock wells. This is shown by the lack of vertical gradients at well clusters. The bedrock wells respond in a fashion similar to the Buried Valley aquifer wells, because their water levels are controlled by pressure in the overlying Buried Valley aquifer.

Previous Test Results: Results from previous aquifer tests of Mound Plant production wells and of a former Miamisburg production well located near Mound Plant are listed in Appendix G, Figures G5a-G5b.

An earlier aquifer test at Mound Plant Production well 0071 was conducted from 18 to 22 April 1990 to determine aquifer characteristics in and around Area B. Fifteen wells in Area B were monitored for drawdown. The pumping rate averaged 546 gpm over the duration of the pumping phase of the test, but variations in the pumping rate of plus or minus 150 gpm occurred at approximate 360,000-gallon intervals, due to filter backwash and recharge at the water conditioning plant. Analysis of the pump test data was performed using the "Well Hydraulics Interpretation Program" (WHIP) produced by Hydro Geo Chem, Inc. (Hydro Geo Chem 1988). WHIP uses the Theis equation for confined aquifers of infinite areal extent to calculate the transmissivity and storativity.

Transmissivity values calculated from individual well responses in the 1990 test ranged from 37,000 ft^2/day to 83,000 ft/day. The transmissivity values calculated from the 1993 test ranged from 27,500 ft^2/day to 55,200 ft^2/day. The highest values from both tests were in the southern wells, where the aquifer-saturated thickness is greatest and where the aquifer material is largely glacial outwash. Transmissivity values are lower to the north and east because of the smaller saturated thickness and the greater percentage of till. The storativity values ranged from 0.04 to 0.24 for the 1990 test and from 0.01 to 0.34 for the 1993 test.

Supporting Test Results: Slug tests were performed by WESTON personnel at the Mound Plant in January 1988 and June 1990. On 20 and 21 January 1988, slug test data were acquired for Area B wells 0119, 0154, and 0155. From 12 to 14 June 1990, slug test data were acquired for Area B wells 0305, 0309, 0317, 0306, 0310, 0307, 0313, 0314, and 0315. Injection and withdrawal tests analyses were performed on all wells except wells 0154 (withdrawal only) and 0314 (injection only).

The slug tests were analyzed to determine saturated hydraulic conductivity (K) values of the unconsolidated sediments and bedrock. The Bouwer and Rice (1976) method of analysis was used on all wells because it accommodates both partially and fully penetrating wells under unconfined conditions (Table IV.6). Table IV.6 summarizes the hydraulic conductivity values.

As discussed in Section 3, Bowser and Morner also performed three field permeability tests to measure the water loss to the formation at specific depths. Three hollow-stem auger borings (A, B, and C) were drilled to depths of 10 ft, 10 ft, and 20 ft, respectively. Open-ended casing was installed from the top to the bottom of each borehole to isolate the zone of the formation being tested. Water was then added to each hole, and the water lost to the formation was measured over a 20-minute period. The precise locations of these boreholes are not known, but it was confirmed that they were completed in the general area of the overflow pond in the northeast section of Area B. The tests performed in auger borings A and B (each 10 ft deep) measured permeability characteristics at the base of the clay-bearing glacial till unit.

The results of the field permeability tests are shown in Table C.3 in Appendix C and were based on the assumption that the units tested were at their ambient moisture content, the clay bearing till was essentially impermeable, and the underlying glacial till was slightly permeable during the 20-minute test period (Bowser and Morner 1975).

Laboratory-derived hydraulic conductivity values were collected from various monitoring wells, soil borings, and soil type localities (soil conservation survey) at various depths throughout the different field stages of the RI. The sample locations are shown in Figure C10 in Appendix C. The corresponding permeability test results are summarized in Table IV.7.

Table IV.6. Hydraulic Conductivity Values Calculated from the January 1988 and June 1990 Slug Test Data, Area B

Well ID	Formation of Completion		Date	Test Type	Method	K(ft/day)
0119	ML-GM:	Sandy, gravelly silt	1-20-88	I	Bouwer-Rice	19.3
	SP:	Gravelly sand	1-21-88	W	Bouwer-Rice	10.2
0154	GP:	Sandy gravel, medium-grained	1-21-88	W	Bouwer-Rice	146.0[a]
0155	SP:	Sand, medium-grained				
	SW:	Gravelly sand, coarse-grained	1-22-88	W	Bouwer-Rice	2.7
0305	GC-GM:	Gravel with clay	6-90	I	Bouwer-Rice	135.9[a]
	CL:	Clay regolith	6-90	W	Bouwer-Rice	1,046.8[a]
0306	GC:	Sandy, clayey gravel	6-90	I	Bouwer-Rice	354.8
			6-90	W	Bouwer-Rice	273.6
0307	GW:	Sandy gravel	6-90	I	Bouwer-Rice	15.9
	SH:	Shale	6-90	W	Bouwer-Rice	16.1
0309	SH:	Shale	6-90	I	Bouwer-Rice	0.6
			6-90	W	Bouwer-Rice	3.8
0310	LS:	Limestone	6-90	I	Bouwer-Rice	1.3
			6-90	W	Bouwer-Rice	1.3
0313	GW:	Sandy gravel				
			6-90	W	Bouwer-Rice	118.1
0315	ML-GM:	Sandy, gravelly silt	6-90	I	Bouwer-Rice	218.9[a]
	GP:	Sandy gravel, coarse-grained	6-90	W	Bouwer-Rice	277.8[a]
0317	GM:	Sand and silty sand, coarse-grained	6-90	I	Bouwer-Rice	25.4
	SC-SM-SP:	Clayey, silty sand, fine-grained	6-90	W	Bouwer-Rice	26.1

I = Injection of slug volume
W = Withdrawal of slug volume
[a]Data show influence of filter pack, K values suspect.

Table IV.7. Laboratory Derived Hydraulic Conductivity Values

Sample Collected By	Location or Soil Type	Depth	USCS Classification	k (ft/day)	Vertical k (ft/day)
Dames and Moore (1973)	BP-1	4-5'	CL-ML	1.13E-6 2.22E-4	
	BP-3	19-20'	CL-ML	5.20E-7	
	DM-5	21-22' 32-33' 39-40'	CL-ML CL-ML GW		1.06E-5 1.45E-6 3.49
	DM-6	7.5-8.5' 15-16' 36-37'	CL-ML CL-ML GW		1.57E-4 9.45E-7 3.45E-7
SCS (1976)	Fairmont	0-7" 7-19"	ML, CL ML-CL, CH	2.08E-2 to 6.61E-2 6.61E-3 to 2.08E-2	
	Made Land	----	ML-CL	1.51E-2 to 4.67E-1	
	Miamian	0-7" 7-24" 24-60"	ML, ML-CL CL CL, ML-CL	2.08E-2 to 6.61E-2 6.61E-3 to 2.08E-2 6.61E-3 to 2.08E-2	
	Ross	0-22" 22-34"	ML, ML-CL SM, ML	2.08E-2 to 6.61E-2 2.08E-2 to 6.61E-2	
WESTON (1993)	0370	20.6-20.9	ND	2.88E-7	
	0372	46.3-46.6	CL-ML	4.72E-7	
	0373	0.5-0.8 30.4-30.7 50.5-50.8	SC SC-SM SC-SM	3.02E-6 5.20E-6 3.64E-5	
	0374	9.3-9.6 13.5-13.9	SC GM	4.30E-4 5.20E-3	
	0379	9-11'	CL-ML	5.67E-7	
	0393	approx. 48'	NA	5.67E-8	
	0397	3.5-3.8 9.3-9.7 14.6-14.8	CH SM CL-ML	2.69E-7 2.08E-2 9.45E-7	
	P008	approx. 57'	CL	9.92E-6	
	P009	approx. 63'	CL	7.09E-7	

(a)- remolded sample
NA - not applicable
ND - not determined
USCS - unified soil classification system

Recently collected soil samples were submitted for geotechnical analysis. As part of these analyses, undisturbed samples were subjected to a falling head permeability test to measure the hydraulic conductivity of various soil types found within and adjacent to Area B. Each test was performed in accordance with procedures ASTM D5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter." The corresponding permeability test results are summarized in Table IV.7. The hydraulic conductivity of the silts and clays (CL-ML and CL) range from 2.0E-8 centimeters per second (cm/sec) to 2.1E-7 cm/sec. The Soil Conservation Survey (1976) found hydraulic conductivity values to be greater in the silts and clays from soil type localities that vary from 4.4E-4 cm/sec to 1.4E-3 cm/sec. Dames and Moore (1973) had similar results. Silty sands-clayey sands (SM-SC) have hydraulic conductivities values from 7.7E-7 cm/sec to 4.4E-4 cm/sec. It is recognized that hydraulic conductivities of less than about 1E-6 cm/sec are unrealistically low and should merely be interpreted as "very small."

Comparison of the two classes of data: Slug tests results and aquifer (pump) test results are measures of the hydraulic properties of an aquifer system. However, the slug test results are most appropriate for determining relative hydraulic conductivities, as opposed to aquifer tests, which generally give a more accurate representation of overall aquifer properties since they measure a larger portion of the aquifer. For example, using the Bouwer and Rice method, the radius of influence of the slug test at well 0154 was calculated to be approximately 4 ft around the wellbore. While slug tests attempt to measure the hydraulic conductivity of the unconsolidated sediments and bedrock, skin effects caused by formation damage while drilling and by development techniques may have a large effect on the calculations. The shale, with low permeability and minimal fracturing, has the lowest hydraulic conductivity (as low as 0.1 ft/day at well 0309). Limestone, with some fracturing that could allow for water flow, has slightly higher hydraulic conductivity values (approximately 1 ft/day at well 0310). No well was tested in a completely isolated section of till, but the tests in some of the siltier wells (0119 and 0317) averaged hydraulic conductivities of around 25 ft/day. The outwash, being the most permeable, had hydraulic conductivities averaging nearly 200 ft/day. Well 0306 is a good example of high hydraulic conductivities in a section of outwash. Wells completed in both alluvium and bedrock show effects of both media. Well 0307, completed in outwash and shale, showed a combined hydraulic conductivity measurement of approximately 13 ft/day. These results show that, while the calculated hydraulic conductivity values from slug tests should not be taken as absolute numbers, they can be used to determine the relative potential for groundwater flow in the consolidated and unconsolidated sediments at Mound Plant. The calculated aquifer test results are appropriate for evaluating the properties of the aquifer as a whole.

4.2.4. Man-Made Influences

Active Pumping Locations

Daily 1992 pumping rates for the Mound Plant are presented in Table G8 (Appendix G). The volumes of water shown in Table G7 are not measured at the Mound Plant production wells (the production wells are not metered) but are volumes of water softened for the plant.

Well 0912 (Miamisburg Production Well #2) is pumped as needed to control tritium levels in the Buried Valley aquifer. Over the last 5 years, well 0912 has been pumped a total of 18 days. No pumping occurred in 1992 and 1993. No long-term pumping effects have been observed.

Several water wells at the Miamisburg municipal well field, which are completed in the Buried Valley aquifer, pumped 691.57 million gallons in 1992 (Table G6a in Appendix G). Wells at the Dayton Power and Light Hutching Power Station pumped 208 million gallons in 1992 (Figure 4.2, Table G7b in Appendix G). The Miamisburg municipal wells are located approximately 0.5 miles upstream of Mound Plant on the opposite side of the Great Miami River, while the wells at the Hutching Power Station are 1.5 miles downstream of Mound Plant, also on the other side of the Great Miami River.

Hydraulic Structures

Surface drainage on the Mound site is collected by the plant drainage ditch, an interconnecting series of retention basins, and the overflow pond in Area B (Figure 4.22). Runoff from the Main Hill is transported down the plant drainage ditch into the retention basins and/or the overflow pond. Runoff from the northeastern portion of the SM/PP Hill is first collected in an asphalt-lined pond and is then transported in the plant drainage ditch to the retention basins. Runoff from the western portion of the SM/PP Hill is either delivered to the overflow pond in Area B or flows along the ditch on the south side of the site sanitary landfill, where it is diverted to a south-trending ditch located on the western margin of the spoils area (Figure 4.22).

Water is ponded in the retention basins to allow suspended sediments to settle and to be removed before discharge. During periods of high flow when the retention basins are filled to capacity, excess water flows into the overflow pond in Area B via the spillway at the northeast corner of the overflow pond. Water that is released from a standpipe in the northwest corner of the overflow pond, and from the retention basins, passes through a NPDES outfall and is released to an abandoned section of the Miami Erie Canal. Water then flows from the canal in an open ditch to the Great Miami River. The overflow pond and retention basins are lined to prevent percolation into the groundwater system; the plant drainage ditch and the Miami-Erie Canal are not lined.

The site sanitary landfill, located to the south of the overflow pond, has two sets of subsurface drains that may, at times, transport water. Perforated plastic drains at the base of the encapsulated trash within the landfill are designed to drain leachate into the overflow pond (Figure 4.23). Except for approximately 6 months after the installation of the landfill, these drains have reportedly been dry (DOE 1986). A series of five parallel, east-to-west-trending french drains installed beneath the landfill is designed to transport infiltrating moisture away from the site (Figure 4.23) (Mound 1977). The drains were located during the additional field work effort and were found to be dry.

4.2.5. Analysis of Time-Series Sampling

A time-series sampling study was conducted as part of the aquifer test described previously. Such a test monitors a migrating plume through time at various strategic geographic locations, either under natural or induced flow conditions. The tracer in a times-series sampling study is usually chemical contaminants from an identified or suspected source area. The objective of a time-series study is to acquire information about the contaminant(s) plume migration and source area characteristics to determine remediation methodology. Time-series analysis requires that groundwater samples be collected at specific times during the induced flow period. Collection times are usually logarithmic, generally corresponding to the logarithmic development of a pumped well cone of influence. Groundwater samples are analyzed for the contaminants whose movement will be analyzed. The analytical results are tabulated and graphical analysis is conducted to determine characteristics, such as maximum concentration relationships between wells, chemical relationship between wells, and long-term or steady-state concentrations.

The purpose of the chemical time-series sampling near and at well 0071 was to determine contaminant concentrations under dynamic conditions as a function of the total volume of water displaced during the aquifer test. The 35-day aquifer test in Area B provided the opportunity to collect information on the identified VOCs in groundwater and possible migration characteristics under an induced flow field. Locations that either bound or are down-gradient of the suspected VOC source area were used for the time-series sampling study. The pumping phase of the aquifer test lasted 35 days. During this time, groundwater in the vicinity of these wells was drawn to the pumped well. This extracted water was replaced with upgradient groundwater thought to contain contaminants. Increases in contaminant concentrations measured in these wells during the aquifer test allowed inferences to the contaminant source location.

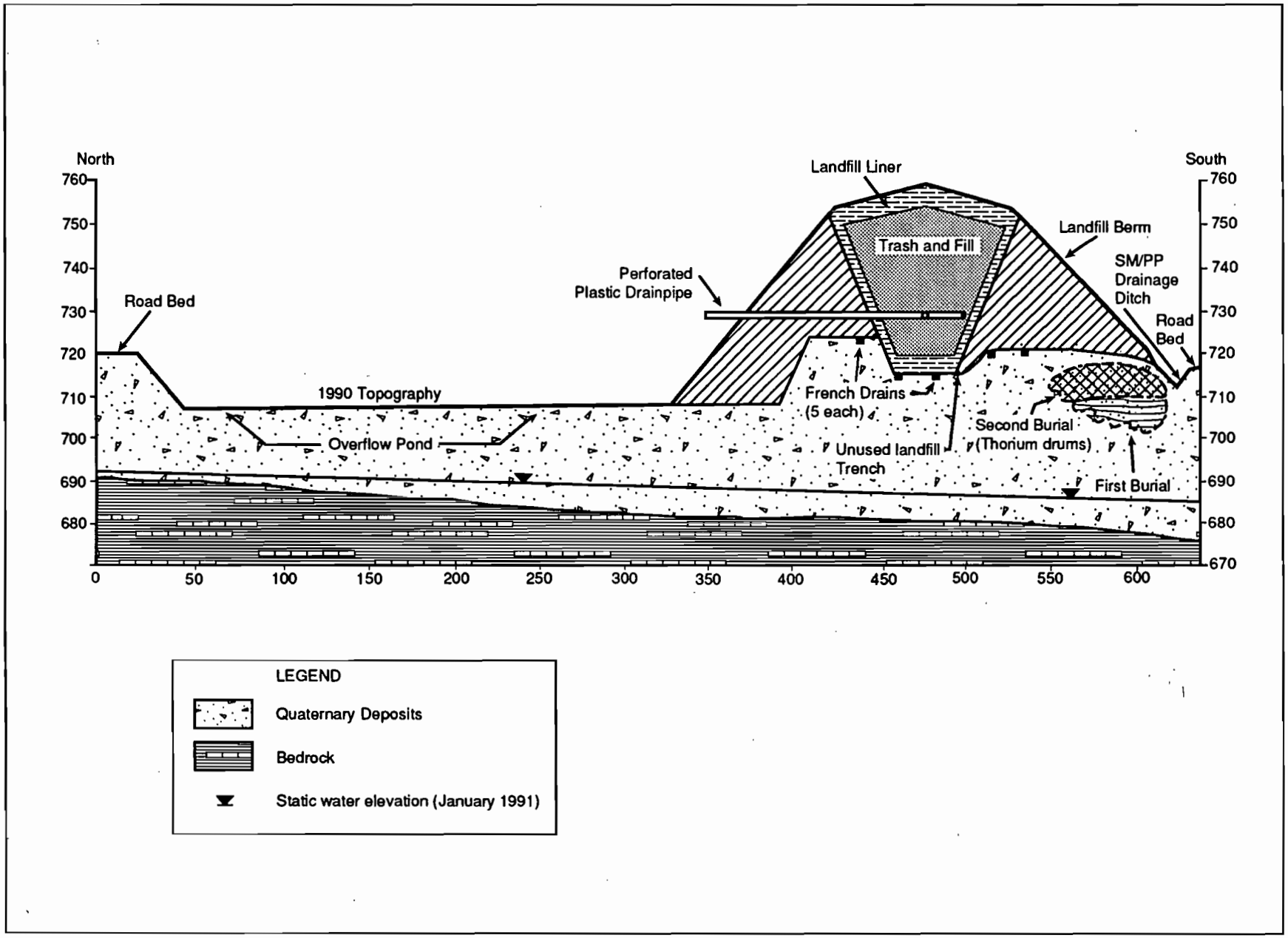

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Figure 4.23. Schematic north to south cross section across Area B.

Time-Series Sampling Methodology

Time-series sampling monitoring locations were based on four criteria. First, the time-series sampling locations had to be completed in the Buried Valley aquifer, but could not be used as continuously monitored locations for the aquifer test because water level monitoring equipment could not be disturbed for sampling. Secondly, monitoring wells had to bound the historic landfill, which is the suspected contaminant source area (monitoring wells 0374 and 0063, Figure 4.24). Thirdly, monitoring wells were chosen downgradient of the suspected contaminant source and in the anticipated cone of influence of the aquifer test pumped well 0071 (monitoring well 0305). Finally, wells had to be downgradient of the suspected source under natural flow conditions but where groundwater flow may not be totally captured during normal well field operations (monitoring wells 0153 and 0375).

Time-series samples were collected prior to starting the constant rate aquifer test and during the aquifer test. Groundwater samples were collected from wells 0063, 0071, 0153, 0305, 0374, and 0375 on 7 May 1993 to determine pre-pumping concentrations. Samples were then collected from wells 0063, 0153, 0374, and 0375 four times during the aquifer test on 14, 16, and 21 May and 16 June 1993 (Table IV.8). These samples provide several "snapshots" of the groundwater quality over time in the area affected by the pumped well cone of influence.

Pumped well 0071 was sampled using a logarithmic time schedule during the constant rate aquifer test. As 0071 was pumped, the area of influence or water contribution to the well extended radially in a logarithmic fashion over time, assuming the aquifer was homogenous, isotropic, and no hydraulic boundaries were encountered. Samples were collected, based upon the volume of water removed, to estimate the approximate location of the detected chemicals at any time during the test. Information concerning the concentration of the contaminant as it varies with time was used to characterize the source area. The time-series sampling schedule for well 0071 during the aquifer test is listed in Table IV.9.

Time-series groundwater samples were collected, analyzed, and validated. Each well was purged, using dedicated bladder pumps, of one well volume prior to the sample collection. Normal purging protocol of three well volumes was not used to avoid disturbing the flow field of nearby wells used for aquifer test continuous water level measurements.

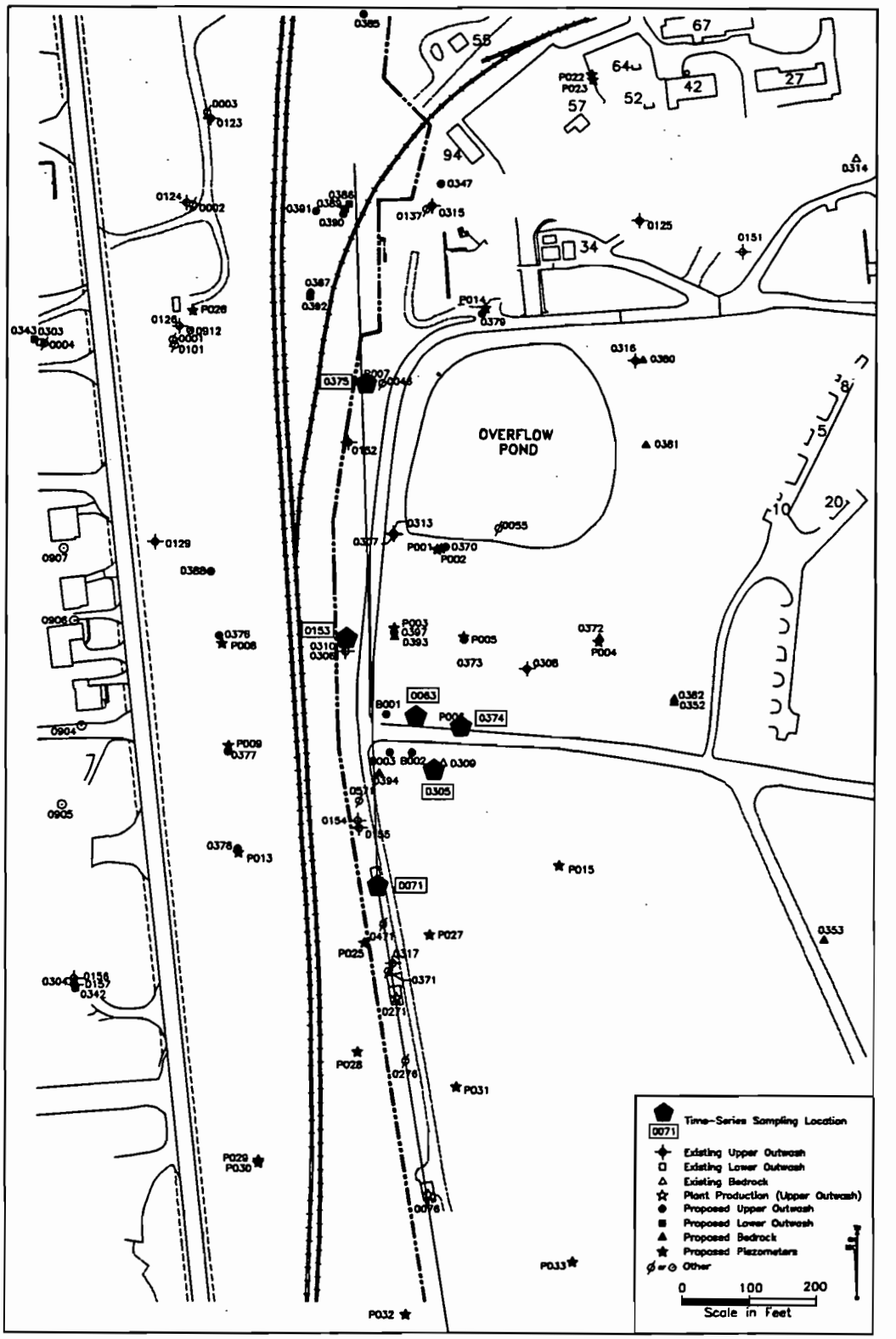


Figure 4.24. Time-series sampling locations, monitoring wells 0063, 0153, 0305, 0374, 0375, and 0071

Table IV.8. Sampling Dates and Times for Monitoring Locations 0063, 0153, 0305, 0374, and 0375

Sampling Date	5-7-93	5-14-93	5-15-93	5-21-93	6-16-93
Well ID	Time	Time	Time	Time	Time
0063	1240	2110	0015	1525	1645
0153	1200	1920	2055	1030	1240
0305	0845	1645	2155	1145	1555
0374	0955	2010	2315	1350	1435
0375	1055	1800	1925	0915	1100

Table IV.9. Time-Series Sampling Schedule for Pumped Well 0071 and Amount of Water Captured Using an Average Discharge of 669 Gallons Per Minute

Sample Number	Sample Date	Sample Time	Time From Start of Constant Rate Test (minutes)	Amount of Water Pumped (Gallons)
MND01-0071-0001	5/7	1630	-9825	0
MND01-0071-0002	5/14	1217	2	1,339
MND01-0071-0003	5/14	1220	5	3,347
MND01-0071-0004	5/14	1225	10	6,694
MND01-0071-0005	5/14	1235	20	13,388
MND01-0071-0006	5/14	1305	50	33,470
MND01-0071-0007	5/14	1355	100	66,939
MND01-0071-0008	5/14	1535	200	133,878
MND01-0071-0009	5/14	2045	510	341,389
MND01-0071-0010	5/15	0455	1000	669,390
MND01-0071-0011	5/15	2135	2000	1,338,780
MND01-0071-0012	5/18	1215	5760	3,855,686
MND01-0071-0013	5/21	1445	10230	6,847,860
MND01-0071-0014	6/1	0700	25605	17,139,731
MND01-0071-0015	6/16	1818	47883	32,052,401

Volatile Organic Compounds Identified During Time-Series Sampling

All analytical results from the time series sampling were reviewed to determine VOCs above detection limits, common VOCs among the wells sampled, and the time of peak VOC concentrations at each well.

The VOCs identified during the time series sampling were vinyl chloride, dichloromethane, trichlorofluoromethane, 1,2-*trans*-DCE, trichloromethane, 1,1,1-trichloroethane (TCA), tetrachloromethane, TCE, PCE, 1,2-*cis*-DCE, xylene, and freon-113. The distribution of identified VOCs by well is shown in Tables IV.10 through IV.15.

TCE Observations: The only VOC parameter detected during the time series sampling at all wells was TCE. The concentrations of TCE through time for each monitoring well are shown in Figure 4.25. Several wells had maximum concentrations of TCE prior to the aquifer test; well 0063 had 38 μg/L during background and declined to 15 μg/L, while well 0153 had a concentration of 16 μg/L and declined gradually to 4.1 μg/L. Monitoring well 0375 had a TCE concentration that remained at 4 μg/L until the test end, when it declined to 3.4 μg/L. Monitoring wells 0305 and 0374 were the only wells that showed an increasing concentration of TCE during the test. It can be seen in Figure 4.25 that well 0374 peaked at 500 minutes into the test and well 0305 peaked at 10,000 minutes. The peak concentration in well 0305 was 50 percent greater than 0374.

The maximum change in concentration of TCE was at well 0305. This well had a variation of 28 μg/L between maximum and minimum concentrations. Well 0063 had a change of 24 μg/L, while well 0374 reported a similar 23 μg/L change. Well 0153 had a maximum change of 12 μg/L. Wells 0375 and 0071 had TCE concentration changes of 1.1 and 2.7 μg/L, respectively.

PCE Observations: PCE was also a commonly detected parameter in some of the wells. The maximum concentration for each well occurred at the same time as the TCE maximum concentration except for well 0153, where the maximum PCE concentration occurred at 47,790 minutes. The greatest concentration change occurred in wells 0374 (24 μg/L) and 0063 (19 μg/L).

Graphical analyses of each monitoring location were completed to discern any trends and determine when and if a plume of maximum concentration migrated through a well. All detected VOCs were plotted on semi-log graphs with a linear x-axis expressing elapsed time from the background sample to the end of the aquifer test. The logarithmic y-axis is the VOC concentration in μg/L. An analysis of each location and the accompanying graphs follow the attached figures. Maximum concentrations of TCA, TCE, PCE, DCE, and vinyl chloride (chloroethene) were compared with maximum

Table IV.10. Time-Series Monitoring Location, Well 0305 Results

Well 0305	Sample Date and Time				
	5/7 0845	5/14 1645	5/15 2155	5/21 1145	6/16 1555
Volatile Organic Compounds	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Tetrachloroethane	3.1J	2.9	1U	2.8J	2.7J
Trichloromethane	6.6J	7.2	8.3	10J	4.8J
1,2-*cis*-dichloroethene	13	23	40	94J	11J
1,2-*trans*-dichloroethene	1U	2.6	2.6	3.1J	1U
Freon-113	1U	3	3.3	1.4	2.2
Methylene chloride	4.7UJ	4U	4U	4U	4U
Tetrachloroethene (PCE)	20J	19	20	22	23J
Trichloroethene (TCE)	38	40	42	56	28J
1,1,1-trichloroethane (TCA)	0.3UJ	0.31	0.3	0.3U	0.3U
Trichlorofluoromethane	2UJ	2.3	2U	2UJ	2UJ
Chloroethene	1.8UJ	1.8U	6	11J	1.8U

Table IV.11. Time-Series Monitoring Location, Well 0374 Results

Well 0374	Sample Date and Time				
	5/7 0955	5/14 2010	5/15 2315	5/21 1350	6/16 1435
Volatile Organic Compounds	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Tetrachloroethane	1UJ	1U	1U	1U	1.7J
Trichloromethane	2.8J	3.5	2.5	2.8J	4.2J
1,2-*cis*-dichloroethene	55J	56	70	54J	44J
Freon-113	1U	3.2	3.2	1.4	4
Tetrachloroethene (PCE)	29	40	26	16	32J
Trichloroethene (TCE)	30	38	22	15	25J
1,1,1-trichloroethane (TCA)	0.3UJ	0.4	0.3U	0.3U	0.3U
Trichlorofluoromethane	3.1J	3.6	3.6	2UJ	2UJ
Chloroethene	4J	1.8U	4.7	3.1J	1.8U

Table IV.12. Time-Series Monitoring Location, Well 0375 Results

Well 0375	Sample Date and Time				
	5/7 1055	5/14 1800	5/15 1925	5/21 0915	6/16 1100
Volatile Organic Compounds	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Tetrachloroethane	1UJ	1U	1.1	1.2UJ	1.6J
Tetrachloroethene (PCE)	5.4J	5.3	5.8	6.5	7.3
Trichloroethene (TCE)	4.2	4.1	4.3	4.5	3.4J

Table IV.13. Time-Series Monitoring Location, Well 0063 Results

Well 0063	Sample Date and Time				
	5/7 1240	5/14 2110	5/16 0015	5/21 1525	6/16 1645
Volatile Organic Compounds	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Tetrachloroethane	3J	2.7	3	1UJ	3.1J
Trichloromethane	5.9J	5.9	6.3	4.1J	3.2
1,2-*cis*-dichloroethene	5.6J	6.4	5.3	7.6J	2
Freon-113	1U	1U	1U	1U	3.5
Tetrachloroethene (PCE)	21J	18	21	6	25
Trichloroethene (TCE)	38	32	35	14	15J

Table IV.14. Time-Series Monitoring Location, Well 0153 Results

Well 0153	Sample Date and Time				
	5/7 1200	5/14 1920	5/15 2055	5/21 1030	6/16 1240
Volatile Organic Compounds	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Tetrachloroethene (PCE)	8.9	6.9	7.2	6.2	4
Trichloroethene (TCE)	16	15	15	11	4.1J

U - non-detection UJ - estimated value

Table IV.15. Time-Series Monitoring Location, Well 0071 Results

Well 0071	Sample Date and Time														
	5/7 1630	5/14 1217	5/14 1220	5/14 1225	5/14 1235	5/14 1305	5/14 1355	5/14 1535	5/14 2045	5/15 0455	5/15 2135	5/18 1215	5/21 1445	6/1 070 0	6/16 1818
Volatile Organic Compounds	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Trichloromethane	0.5UJ	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.63	0.57UJ	1.1	0.82J
1,2-*cis*-dichloroethene	9.4J	10	12J	11	8.9	9.2	8.3	8.1	6.5	5.4	5.9	5	4.2	4.2	2.9
Tetrachloroethene (PCE)	0.3UJ	0.53	0.68UJ	0.6	0.56	0.57	0.63	0.62	0.6	0.3U	0.3U	1.9	1.3J	2.4	1.7J
Trichloroethene (TCE)	4.5	4.4	5	4.6	4.1	4.3	4.1	4.1	3.8	3.4	4.3	4.6	4.8	6.1	4J
1,1,1-trichloroethane (TCA)	0.65UJ	0.33	0.46UJ	0.63	0.6	0.76	0.92	0.82	1	0.8	1.8	2.2	2.2	2.8	1.4
Xylene (Total)	2UJ	2.2	2U	2U	2U	2U	2U	2.1	2U	2U	3	2U	2U	2.2	2U

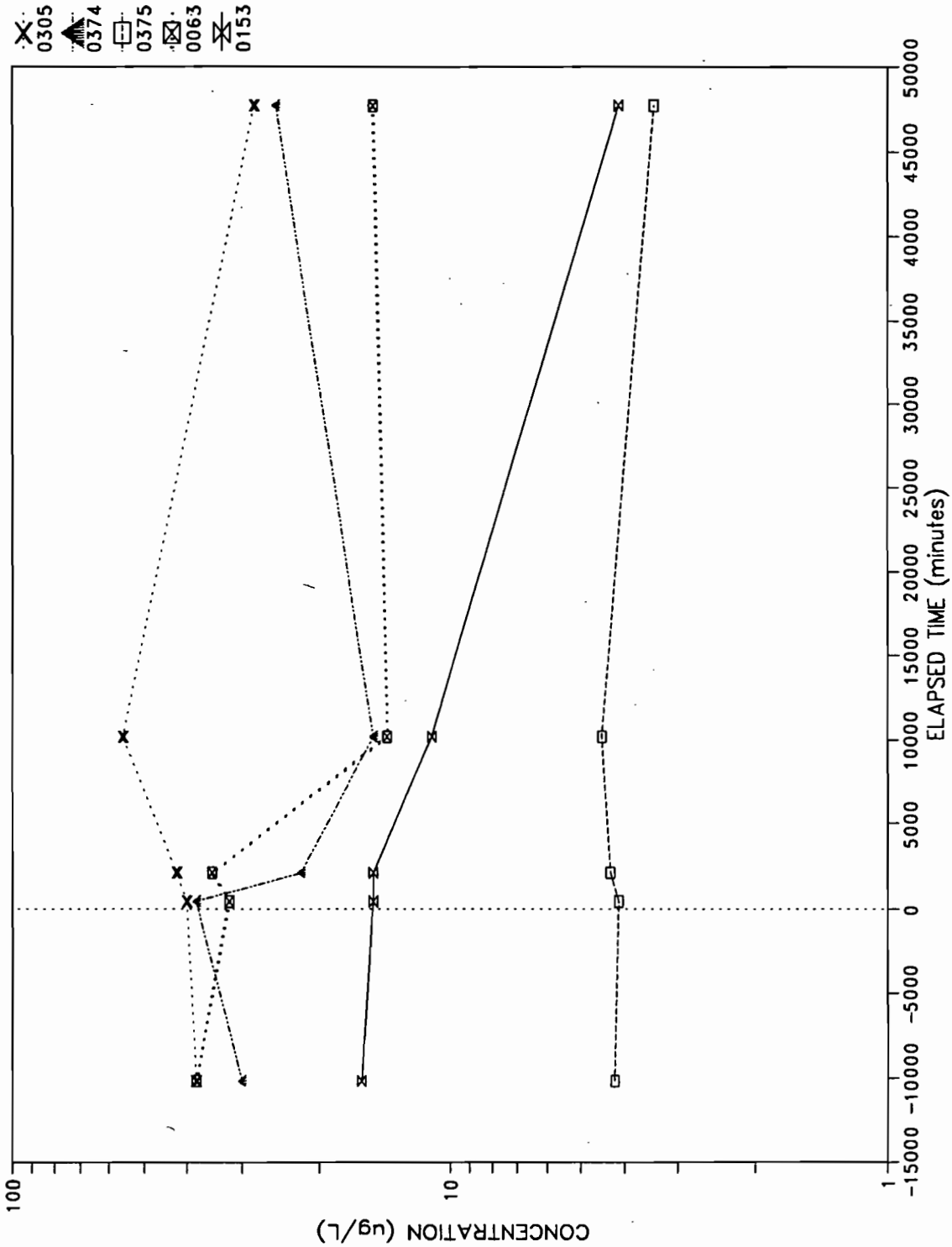


Figure 4.25. Trichloroethene (TCE) concentrations for all wells monitored during the time-series sampling

concentrations identified during quarterly groundwater sampling from October 1990 through September 1992 as summarized in Table 65 of the "Cumulative Groundwater Monitoring Data through Fourth Quarter, FY92" (DOE 1993a).

Monitoring Well 0063: Groundwater samples from monitoring well 0063 reported six VOCs: tetrachloromethane, trichloromethane, 1,2-*cis*-DCE, freon-113, PCE, and TCE (Figure 4.26). Of these six constituents, only two exceeded detection limits: PCE and TCE. The remaining four VOCs were reported near or below the associated detection limit and were estimated values. PCE and TCE had pre-aquifer test concentrations greater or equal to the four time-series samples taken after pumping started. Immediately after pumping started, both PCE and TCE concentrations declined by a few μg/L, followed by a slight increase in concentration. After 10,000 minutes, the concentrations of PCE and TCE decreased 3.5 and 2.7 times respectively from the pre-pumping concentrations. By the end of the test, PCE concentrations had returned to pre-pumping concentrations, while TCE only reached 50 percent of the pre-pumping concentration. The maximum concentrations for TCE are 50 percent of the maximum concentration found in the suspected Area B source area during quarterly groundwater monitoring.

Monitoring Well 0153: Time-series sampling at monitoring well 0153 had reported concentrations of PCE and TCE. Both of these constituents decreased from initial concentrations to the end of the test (Figure 4.27). This decrease was four-fold for TCE and two-fold for PCE. The concentrations found at 0153 were substantially lower than maximum concentrations found for TCE and PCE during previous quarterly monitoring.

Monitoring Well 0305: The greatest number of VOCs was detected at monitoring well 0305. The following VOCs were detected: tetrachloromethane, trichloromethane, 1,2-*cis*-DCE, 1,2-*trans*-DCE, freon-113, dichloromethane, trichlorofluoromethane, 1,1,1-TCA, TCE, PCE, and vinyl chloride. Figure 4.28 indicates that the constituents with the highest concentrations are 1,2-*cis*-DCE, TCE, and PCE, with concentration ranges from 10 to 94 μg/L. Four of the constituents (1,2-*cis*-DCE, TCE, PCE, and vinyl chloride) all increase at the 10,000 minute sample, but return to initial concentrations by the end of the test.

Monitoring Well 0374: The VOCs detected at monitoring well 0374 were the same as well 0305, except 1,2-*trans*-DCE was not detected. The greatest concentrations measured were 1,2-*cis*-DCE, PCE, and TCE. Concentrations for these three constituents are very similar to concentrations found in well 0305. Figure 4.29 shows that well 0374, however, has a different response than well 0305. There is only a slight increase at the 475-minute sample before the three constituents gradually decrease to initial sample concentrations. Concentrations for PCE were at or greater than

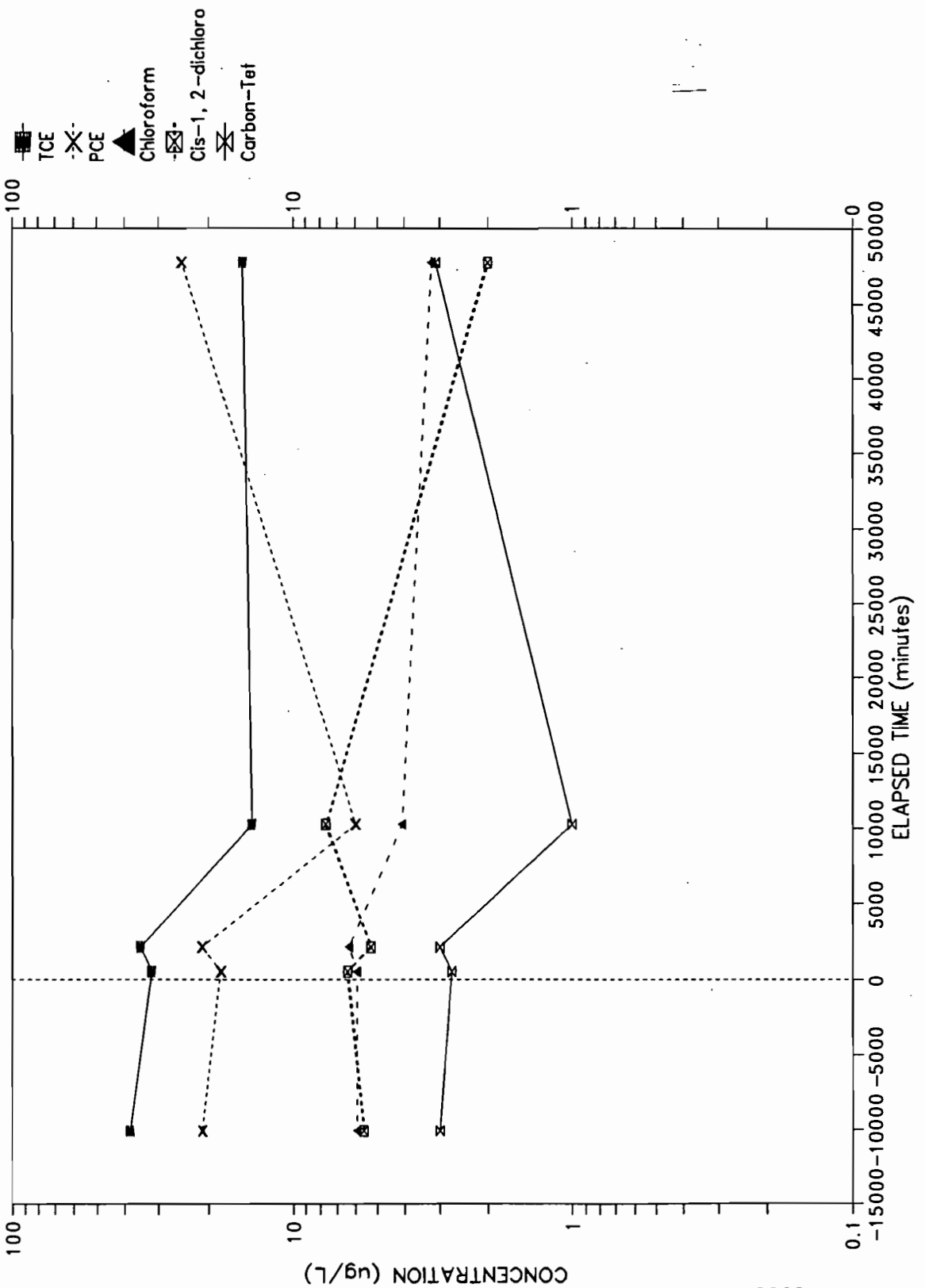


Figure 4.26. VOCs detected during time-series sampling for monitoring well 0063.

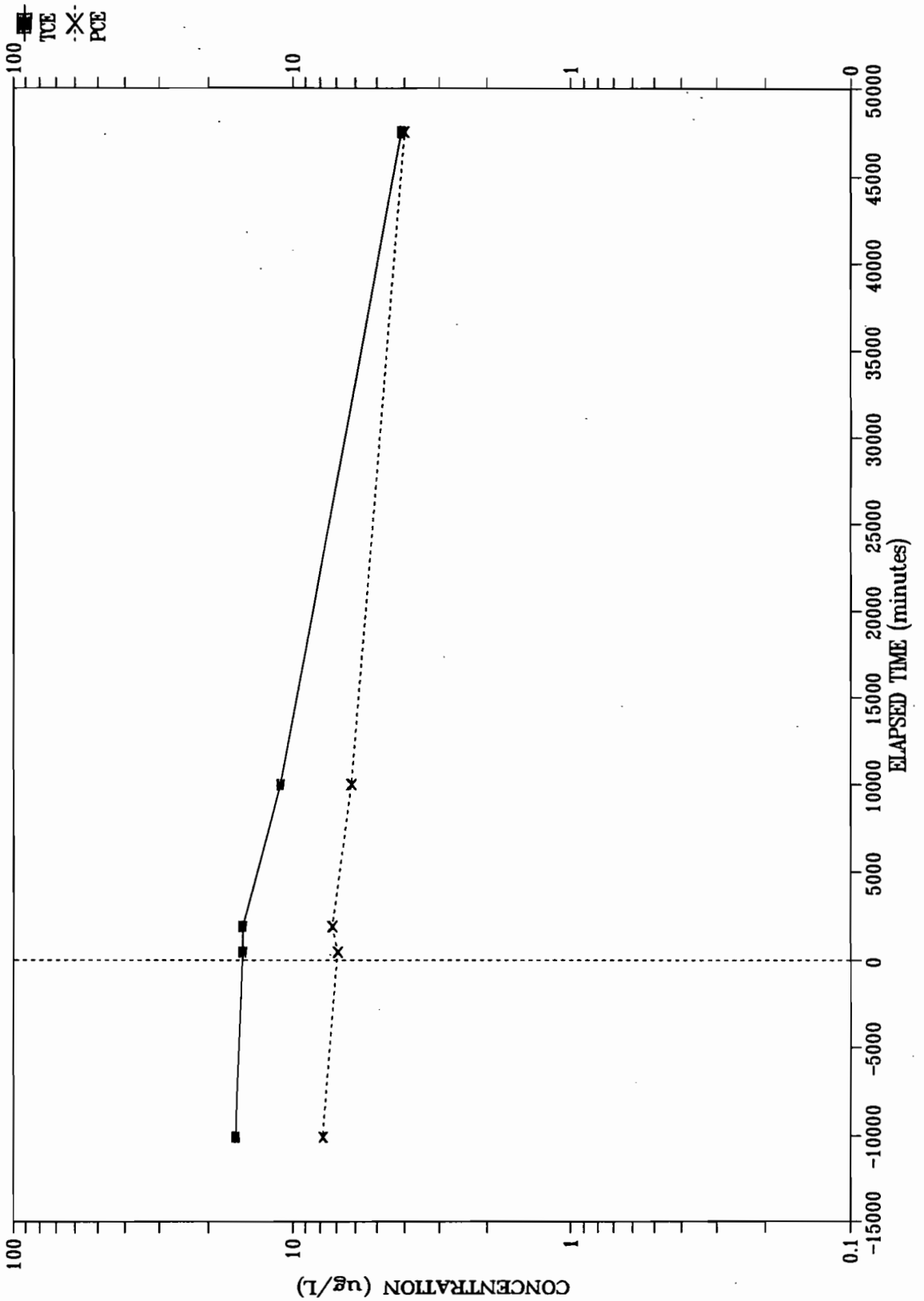


Figure 4.27. VOCs detected during time-series sampling for monitoring well 0153.

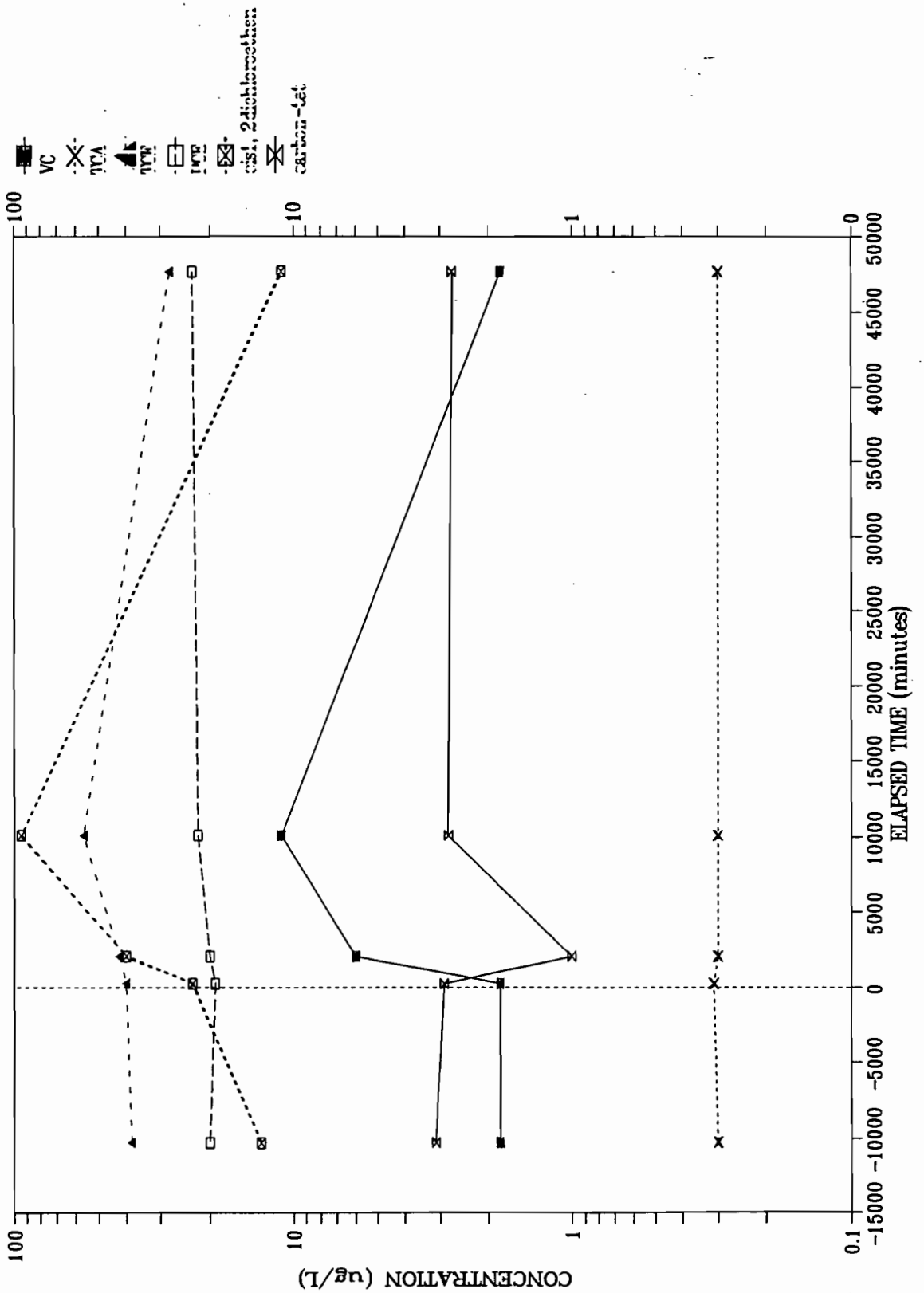


Figure 4.28. VOCs detected during time-series sampling for monitoring well 0305.

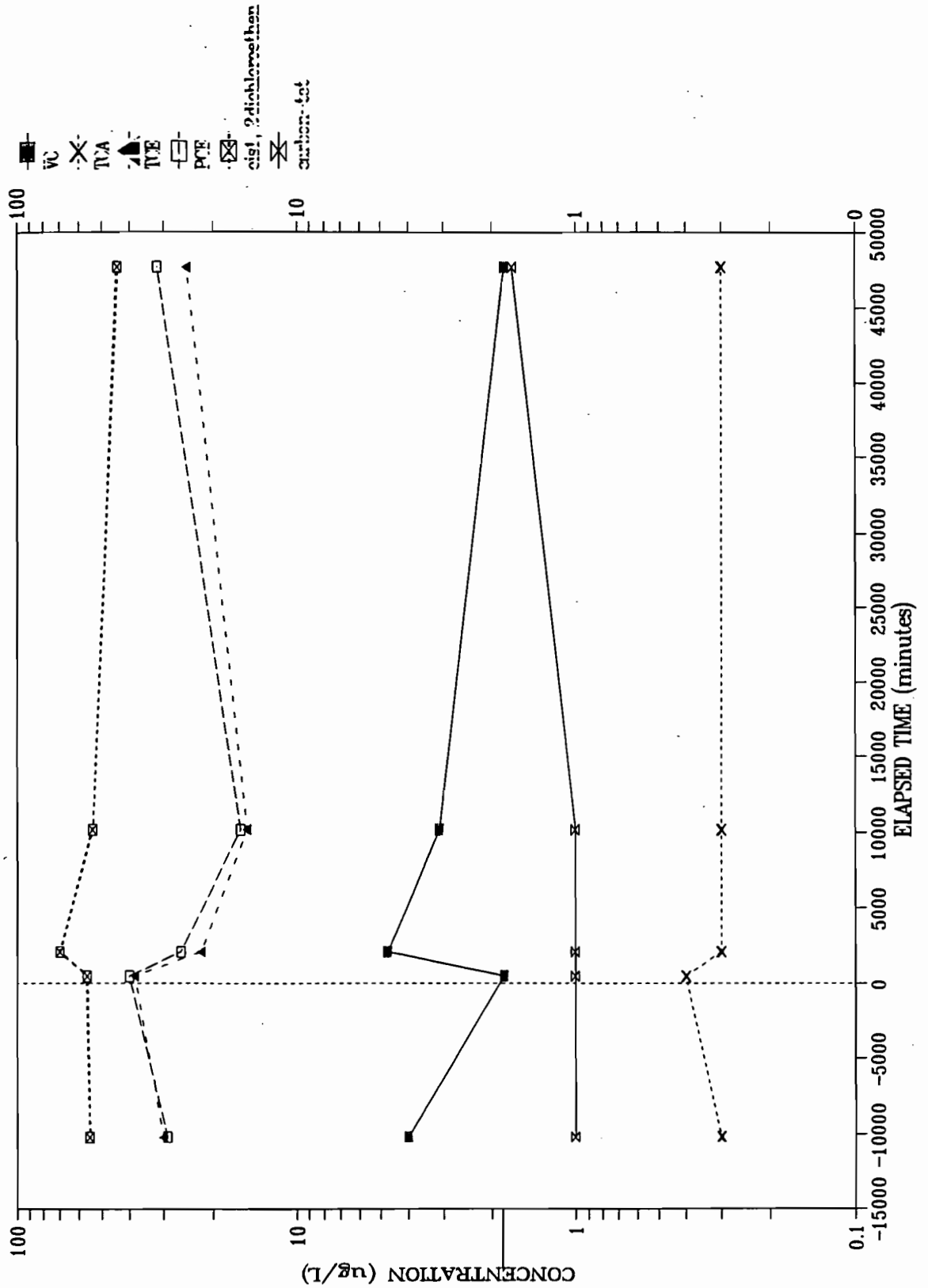


Figure 4.29. VOCs detected during time-series sampling for monitoring well 0374.

concentrations detected during quarterly groundwater sampling. An unvalidated vinyl chloride concentration of 4.7 μg/L was larger than the maximum 2.6 μg/L detected during quarterly monitoring.

Monitoring Well 0375: Monitoring well 0375 time-series samples detected three VOCs: tetrachloroethane, PCE, and TCE. All three of these VOCs had almost identical trends, as seen in Figure 4.30. After pumping started, all three concentrations increased until the 10,000-minute sample. PCE and tetrachloroethane concentrations continued to increase to the end of the test, while TCE concentrations decreased.

Pumped Well 0071: Time-series analysis at the pumped well 0071 detected six VOCs: TCE, PCE, trichloromethane, TCA, 1,2-*cis*-DCE, and total xylene (Figure 4.31). The highest concentration was 1,2-*cis*-DCE at 10 μg/L, which decreased to 2 μg/L by the end of the test. TCE had the second highest concentration with an initial concentration of 3 μg/L, which increased to 4 μg/L and then returned to 3 μg/L by the end of the test. TCA concentration began below 1 μg/L and, by 510 minutes, was greater than 1 μg/L. It reached a peak of 2.8 μg/L at 25,000 minutes, before decreasing to 1.4 μg/L at test end. The general trend at well 0071 was that, after pumping began, samples at 2 and 5 minutes reported a concentration increase before they showed a decreasing trend during the next three sampling times (10, 20, and 50 minutes). Concentrations then started a general increase, which peaked at 25,000 minutes.

The VOCs detected during the time-series sampling are consistent with the groundwater sampling conducted from October 1990 to March 1993. The VOCs detected have high solubilities and, therefore, readily migrate with the groundwater flow. Solubilities, expressed in mg/L, of parameters detected during the time-series sampling include: TCE (1100), PCE (150), 1,1,1-TCA (1500), 1,2-*cis*-DCE (3500), tetrachloromethane (757), trichloromethane (8200), and xylene (total) (175-referenced to o-xylene).

Time-series sampling is used to approximate contaminant source locations by estimating the rate at which a slug of contaminants moved through the monitoring wells. Prior to the start of the aquifer test, the natural flow field and the effects of production well 0076 cycling had reached equilibrium. It is possible that well 0076 does not have much effect on the flow across the landfill. This equilibrium permits a certain level of interaction between the contaminant source and the flowing groundwater. A certain concentration of VOCs is transported at this flow rate. When the aquifer test was started and well 0071 was pumped at an average rate of 669 gallons per minute, the flow field had to adjust to meet this demand. The outcome was a faster flow rate that was highest near the well and decreased in a logarithmic manner away from the well. The contaminant source had less time to interact with the flowing groundwater and, therefore, the groundwater contaminant concentration

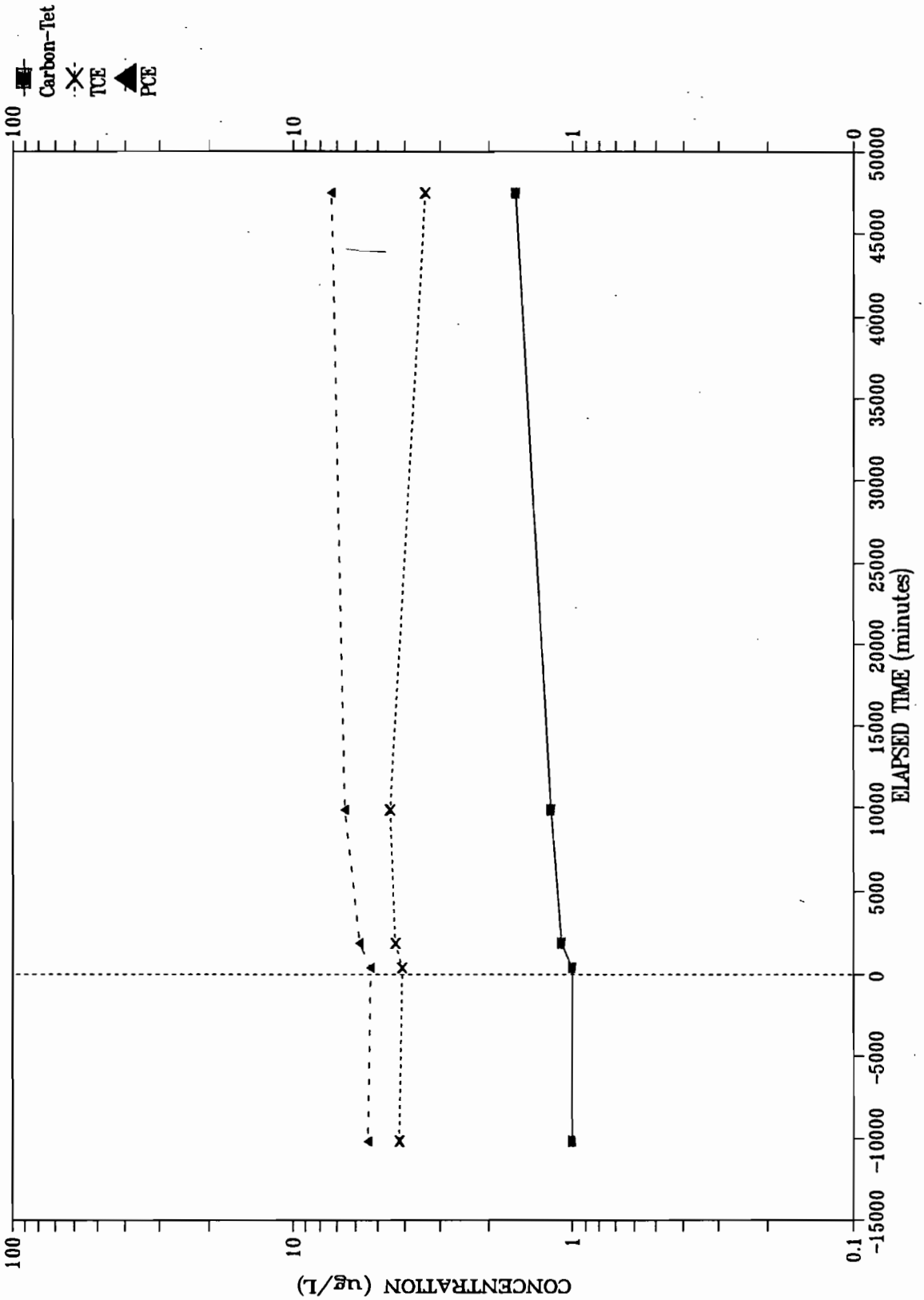


Figure 4.30. VOCs detected during time-series sampling for monitoring well 0375.

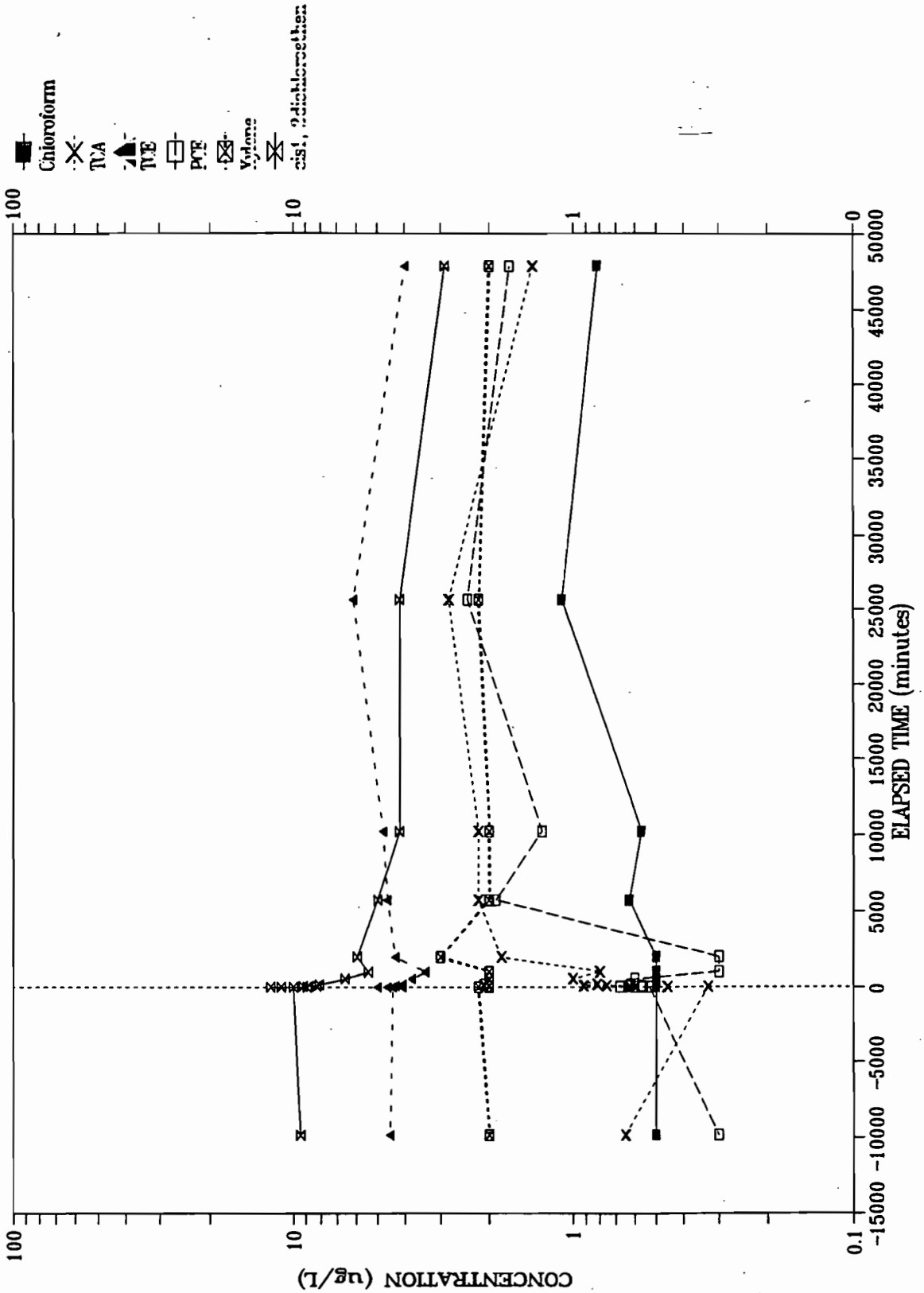


Figure 4.31. VOCs detected during time-series sampling for pumped well 0071.

was less. Observation of changes in contaminant concentration with time allows the distance and direction to possible contaminant sources to be inferred.

A slug of groundwater with VOC concentrations higher than had existed prior to pumping well 0071 moved toward pumped well 0071. After approximately 10,000 minutes, this slug passed well 0305, as identified by the increase in all VOCs. The approximate location of the source may be determined by estimating the average groundwater velocity that occurred between the suspected source and the pumped well for those 10,000 minutes. This is accomplished by the following equation:

$$v = [K[(I_1 + I_2)/2]/n]$$

v - groundwater velocity (L/T)

K - hydraulic conductivity

I_1 - hydraulic gradient between suspected source and pumped well 0071 prior to pumping (L/L)

I_2 - hydraulic gradient between suspected source and pumped well 0071 at 10,000 minutes (L/L)

n - porosity (percent)

and equation:

$$D = t * v$$

D - distance to source (L)

t - time at which slug (maximum concentration) occurred at monitoring well (T)

v - groundwater velocity (L/T)

An average groundwater velocity is used because, as the pumped well's cone of influence grows, the hydraulic gradient changes and continually affects the groundwater velocity. The groundwater velocity, multiplied by the amount of time it took the slug to move past the monitoring well, estimates the distance upgradient to the source. The groundwater gradient between the landfill and well 0071 prior to the aquifer test was calculated using water levels measured on 7 May 1993 for wells P001 and 0071. The same wells were used to calculate the groundwater gradient at 10,000 minutes. Hydraulic conductivity values (calculated during aquifer test analysis) of a minimum 513 ft per day to a maximum of 645 ft per day were used. If the minimum hydraulic conductivity is used, the

distance to the source from well 0305 is 97 ft. If the maximum hydraulic conductivity of 645 ft/day is used, the distance is 122 ft. This places the source at the southernmost edge of the historic landfill.

When the same calculations are conducted for well 0374, which has a peak concentration of VOCs at 475 minutes, the distance to the source is between 4 and 6 ft. A slight peak of VOCs occurred at 25,000 minutes into the test at pumped well 0071. If the same gradients and hydraulic conductivity are used, a distance to source is calculated to be 243 ft. This would put the source in the area of well 0063, adjacent to the historic landfill.

Analysis of monitoring wells 0153 and 0375 time-series results shows no increase in concentration throughout the test. Well 0153 concentrations decline throughout the test, which suggests that the induced flow field is attracting clean groundwater from north of well 0153. Perhaps without the induced flow field, natural flow is toward the west from the landfill. Well 0375 has two VOCs above detection limit, TCE and PCE. TCE concentrations remained constant, while PCE concentrations increased by 2 μg/L by the end of the test. All observations (distance and direction to the projected source) indicate the area within or adjacent to the site of the historical landfill. Thus, the study suggests that the VOC source is the historic landfill, which corroborates findings from previous investigations.

4.2.6. Conceptual Model

This section contains a summary of hydrostratigraphy, groundwater flow, and contaminant distribution and transport information.

The important hydrostratigraphic information is summarized as follows:

- A large portion of the vadose zone underlying Area B is till or other fine grained materials.
- Most of the unconsolidated material below the water table is outwash.
- Area B is situated on a bedrock shelf. The bedrock elevation is lower to the north, west, and south of Area B.

A conceptual model of groundwater flow is presented in Figures 4.32 and 4.33. As shown in Figure 4.33, flow through the vadose zone is primarily vertical. Flow below the water table is primarily to the southwest. Areas where no water level data are available were contoured, using the relationship between water levels and bedrock topography (Figure C.12) in Appendix C. Water level data, as shown in Figure 4.32, indicate that groundwater flow in the northern portion of Area B in the tributary

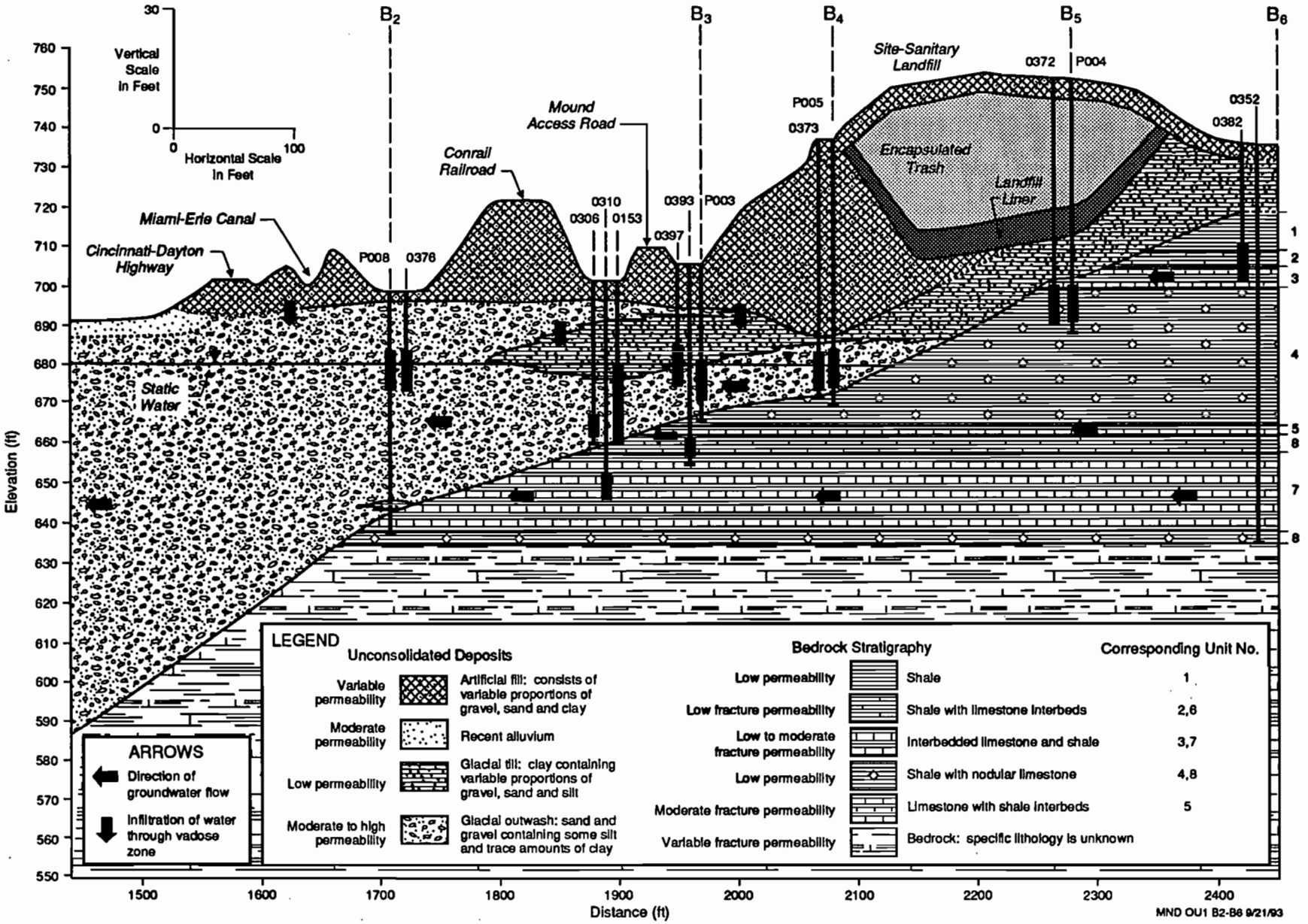


Figure 4.33. Cross-sectional view of groundwater flow in the vicinity of Area B.

valley is to the west. Because of the steep slope of both surface and bedrock topography across the tributary valley, the groundwater surface dips steeply from east to west at gradients of approximately 0.05 ft/ft due west. Water flowing south from the Main Hill and water flowing north/northwest from the SM/PP Hill are incorporated into the westerly flow direction and transported through the tributary valley. In Area B, water flows to the west at natural gradients of approximately .0003 ft/ft. On the western edge of Area B, the volume of water moving southerly in the deeply entrenched Buried Valley aquifer valley deflects the western component of groundwater flow out of the tributary valley.

Because of the high transmissivity and specific yield values of the Buried Valley aquifer, groundwater pumping at the Dayton Power and Light Hutching Power Station and the Miamisburg municipal well field have little or no effect on the groundwater flow patterns at Mound Plant. The effect of pumping at these two locations is also expected to be small because they are across the Great Miami River from Mound. The river is in dynamic equilibrium with the Buried Valley aquifer and would act as a recharge or discharge boundary, as evidenced from the 1993 aquifer test data. Pumpage from the Mound Plant production wells in Area B (wells 0071, 0076, and 0276) may significantly affect hydraulic gradients and contaminant transport.

The primary vehicle for groundwater transport out of Area B is through the outwash (due to its high hydraulic conductivity and large saturated thickness). While till and bedrock provide a means for transport of water out of Area B, the volumes they can transport are insignificant compared to the outwash, because of their significantly lower hydraulic conductivities and volumes. Vertical gradient calculations indicate that outwash is recharging the till and bedrock.

Natural recharge to the Area B groundwater system occurs primarily in three ways: 1) groundwater flux across the northeastern and eastern boundary, 2) through the Buried Valley aquifer in conjunction with river stage increases in the Great Miami River, and 3) through infiltration of precipitation.

The conceptual groundwater flow map suggests that groundwater levels are lowest in a region between Mound Plant and the Great Miami River. Within this region, groundwater flow is southerly and parallel to the river. The higher groundwater levels to the east result from recharge from precipitation, and infiltration and percolation of runoff at the topographically higher area. The higher groundwater levels to the west result from groundwater recharge by the river. A region of reduced recharge from precipitation may exist between the river and the plant site as a result of urban development and surface drainage.

This conceptual model suggests that the river, by elevating groundwater levels in its vicinity, is a barrier to westward groundwater flow from the Plant site. The magnitude of this groundwater mound

changes as a function of river stage, and decreases with distance from the river. The fluctuation in river stage directly impacts the groundwater levels in monitoring wells throughout the Mound Plant by changing the elevation of the groundwater discharge point at the river. During high-river stage, flow is probably from the river to the groundwater. During low-river stage, the reverse may be true. Because water level measurements have been taken on a monthly basis, while the river stage/precipitation data are acquired daily, correlation of precipitation and river stage to water levels cannot be precisely evaluated.

Continuous monitoring was performed before the initiation of the 1993 aquifer test, but the duration of the monitoring was not long enough to make any absolute quantifications of the effect of fluctuating river stages on groundwater elevations. Continuous monitoring is ongoing; analysis of that data is expected to improve the understanding of the effects of varying river stage or groundwater elevations.

4.2.7. Groundwater Composition

Samples collected from the onsite and offsite monitoring wells completed in the upper and lower Buried Valley aquifer and bedrock were analyzed for common field parameters (including pH, electrical conductivity, dissolved oxygen, and alkalinity) to establish general geochemical parameters in the groundwater. Major inorganic constituents were also analyzed in an attempt to distinguish differences in geochemistry between wells completed in different formations.

The effective concentration (activity) of hydrogen ions is most conveniently expressed in logarithmic units, and the abbreviation "pH" represents the negative base-10 log of the hydrogen-ion activity in moles per liter (USGS 1985). The pH of pure water at 25° C is 7.00. Most groundwaters found in the United States have pH values ranging from about 6.0 to 8.5 (USGS 1985). All of the samples collected from the monitoring wells near Area B fit within this range (Appendix H, Table H1) and most values were between 6.75 and 7.25.

Electrical conductance, or conductivity, is the ability of a substance to conduct an electric current. Because conductance is the reciprocal of resistance, the units in which specific conductance is reported are reciprocal ohms, or mhos. Natural waters have specific conductances much less than 1 mho, so data are reported in micromhos. The conductance of groundwaters has a wide range from 50 μmhos/cm to 50,000 μmhos/cm (seawater) (USGS 1985). Specific conductance in the monitoring wells in and surrounding Area B ranges from 20 to 9000 μmhos/cm (Appendix H, Table H1). Most values are in the 800 to 1500 μmhos/cm range. Only eight out of 240 values were over 2000 μmhos/cm (wells 0123 (4), 0126, 0129, 0153, and 0159). All of the wells having values over

2000 μmhos/cm are located offsite in the main portion of the Buried Valley aquifer, except for 0153, which is located due west of the site sanitary landfill.

Oxygen is supplied to groundwater through recharge and by movement of air through unsaturated material above the water table. This oxygen reacts with oxidizable material encountered along the flow path of the water. Water containing measurable amounts of dissolved oxygen may penetrate long distances into the system if little reactive material is available. The principal reacting species are organic materials and reduced inorganic minerals. As time passes, the oxidizable material in the aquifer will be removed or altered for long distances from the point of recharge. Dissolved oxygen concentrations of groundwater cannot be used as an indicator of organic pollution. Dissolved oxygen is also not significant in evaluating the usability of the water for ordinary purposes. Most groundwaters contain little or no dissolved oxygen (USGS 1985). Concentrations of dissolved oxygen at Mound Plant range from .01 to 15.97 mg/L (Appendix H, Table H1).

The alkalinity of a solution is defined as the capacity for solutes within a solution to react with and neutralize acid. In almost all natural waters, the alkalinity is produced by the dissolved carbon dioxide species, bicarbonate and carbonate (USGS 1985). Alkalinity values for wells in or adjacent to Area B ranged from 203.5 to 429.5 mg/L.

Trilinear diagrams were generated by plotting only the major dissolved ionic constituents in milliequivalents per liter. Potassium and sodium were combined, as were fluoride and nitrate with chloride, to describe the composition of natural water in terms of three cationic and three anionic species. Trilinear diagrams for monitoring wells in and adjacent to Area B are presented in Figures H2a-2h in Appendix H. Wells used in the study were completed in the upper and lower portions of the Buried Valley aquifer, in till, and in bedrock. The predominant water type, independent of formation of completion, was calcium bicarbonate. Only wells 0309 and 0123 showed consistent variation from the calcium bicarbonate type water. Each time these wells were sampled, they displayed a sodium-potassium chloride water type. Well 0309 is the only well included in the analyses that is completed in bedrock. This may indicate that the bedrock water at well 0309 is ionically distinct from the Buried Valley aquifer water. Well 0309 may be connected to a bedrock fracture system indicated by the high storage coefficient derived from the aquifer test analyses. No explanation is known for the anomalous water type at well 0123.

4.3. ZONES OF CONTAMINATION

Groundwater and soil have been identified as possible pathways that may have been affected by contamination originating in Area B. Each pathway will be discussed in terms of environmental sampling and contaminant concentrations.

4.3.1. Soils

Soil samples have been collected at Area B during four episodes.. The first samples were collected for geotechnical testing during construction of the overflow pond (Bowser and Morner 1975; Dames and Moore 1976). The second occurred from 1982 to 1985, when Mound Plant performed a survey of radiological contamination of site soils (DOE 1993d). This survey included two sites in Area B: Area 2, which is the former disposal trench for empty thorium drums and for plutonium-238-contaminated sand filters; and Area 18, which is the cover of the site sanitary landfill, portions of which were purportedly made up of sediments excavated from the plant drainage ditch. Plutonium-238 and thorium were detected in the soil samples at levels below the lowest concentration of interest in that study. The third was in 1990, when a shallow soil sampling program was performed to corroborate the VOC contamination detected in a 1987 gas survey (DOE 1992a). The 1990 soil samples showed very low levels of TCE, PCE, and 1,1,2-trichlorofluoroethane were detected west of the site sanitary landfill (DOE 1992a).

Finally, in December 1992, surface soil sampling was conducted to assess the contamination within the drainage ditch sediments that border the western and southern berms of the site sanitary landfill, the soils of the site sanitary landfill cover, and the soils immediately north of the overflow pond. The samples were collected from 13 predetermined locations at depths of 0.5 to 1.5 ft (Figure 4.34) (DOE 1992a).

In addition, during the monitor well and piezometer installation program (December 1992 through April 1993) soil samples were taken (at 1.5 ft intervals) during the well drilling. This sampling program was described in Section 3, above. Both surface and subsurface soil samples were analyzed for VOCs, semivolatile organic compounds, pesticides, polychlorinated biphenyls, metals, and radionuclides. Additionally, subsurface soil samples were analyzed for dioxin/furans. The laboratory results from both surface and subsurface sampling events were subjected to data validation. The parameters discussed in this section were determined to be of significant interest in terms of frequency of detection and background concentration levels. The validated results for all field samples are presented in Appendix A6. The validated data were divided into two subsets, non-qualified and qualified data. Non-qualified results indicated that no qualifiers, such as J (estimated quantity), were associated with the

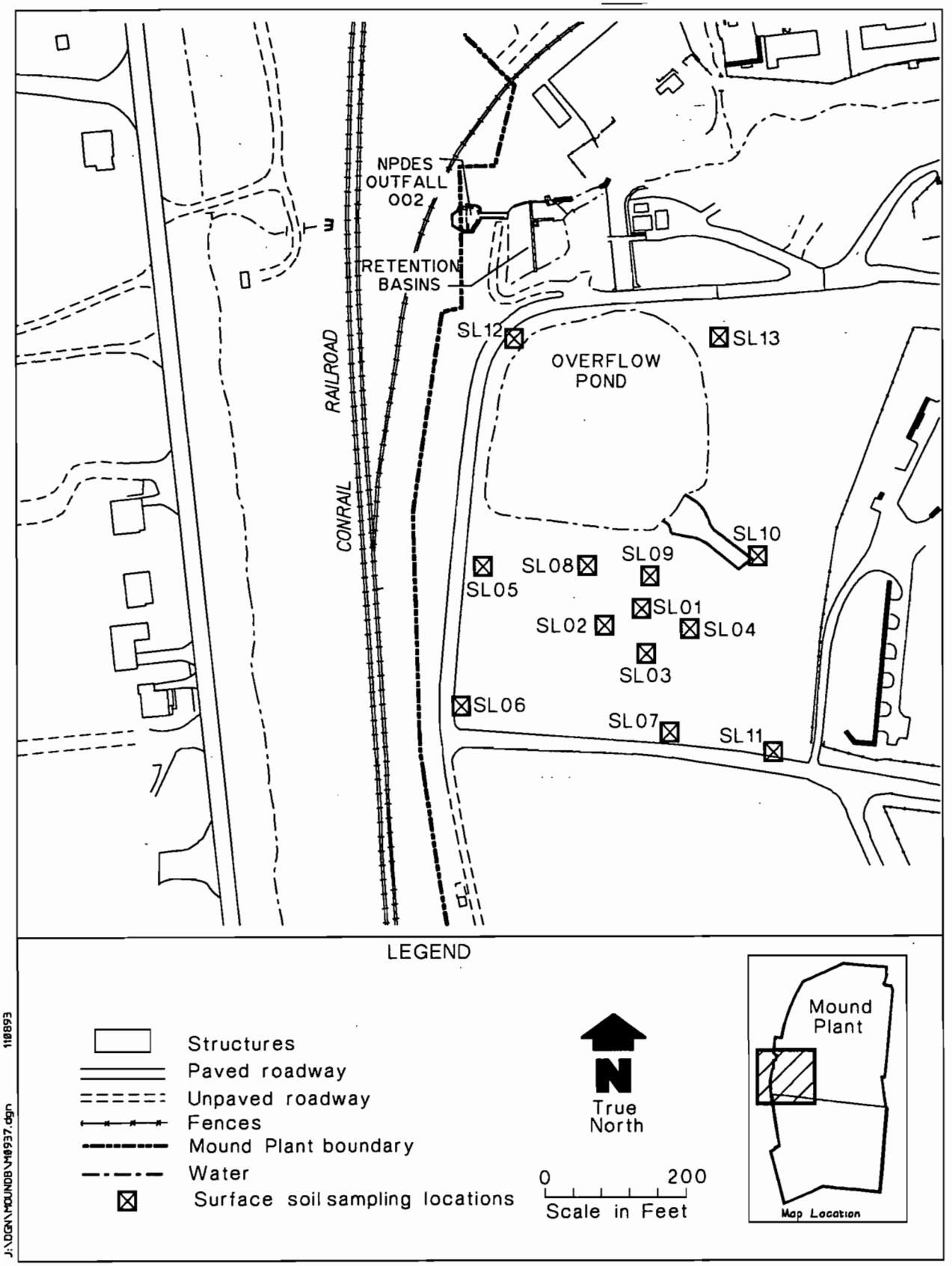


Figure 4.34. Locations for collection of surface soil samples.

result. Qualified results indicate that a J was associated with the analytical result. The quantity of the analyte may be estimated because the analyte was detected in the sample at levels below the CRDL or because the QC checks associated with the analyte value were not within specified criteria. The reasons for qualification and the potential error associated with the results are included in tables in Appendix A8a. If a field duplicate is associated with a field sample location, the higher of the two results is reported.

Volatile Organic Compounds

Figure 4.35 indicates the surface and subsurface soil sample locations with validated detections of VOCs. None of the surface soil samples had any detectable quantities of VOCs. Subsurface soil detections of VOCs are discussed in the following subsections. Table A8a in Appendix A8 presents the validated detections of the analytes discussed. Appendix A6 presents all validated detections for the soil sampling events.

1,2-Dichloroethene

The highest concentration of non-qualified detects for DCE occurred in well 0393 (6600 μg/kg), boring B001 (6700 μg/kg) and piezometer P001 (750 μg/kg) at a depth of 10 to 20 ft. The highest concentration of qualified detects of DCE occurred in P003, 1200J μg/kg at a depth of 10 to 20 ft and P001, 1100J μg/kg at a depth of 20 to 30 ft. These sample locations are all located within the area of the site sanitary landfill. DCE was not detected north of the overflow pond or west of well 0393. The southernmost extent of DCE detected was in piezometer P015 at a depth of 40 to 50 ft, 10 μg/kg.

Ethylbenzene

The highest non-qualified ethylbenzene concentration occurred in P004 at a depth of 0 to 10 ft, 200 μg/kg. The highest qualified detections occurred in P003 at a depth of 0 to 10 ft, 260 μg/kg and P001 at a depth of 20 to 30 ft, 610J μg/kg. These locations are again concentrated in the area of the historic landfill. However, ethylbenzene was detected in samples taken from P007 (northwest of the overflow pond) and in P008 and P009 (located west of the historic landfill). The southernmost qualified detection occurred in 0394 at a depth of 20 to 30 ft.

Tetrachloroethene

Non-qualified detections of PCE followed a similar pattern as the detections of ethylbenzene. The highest non-qualified concentrations were found in 0393 at a depth of 10 to 20 ft (1600 μg/kg), in

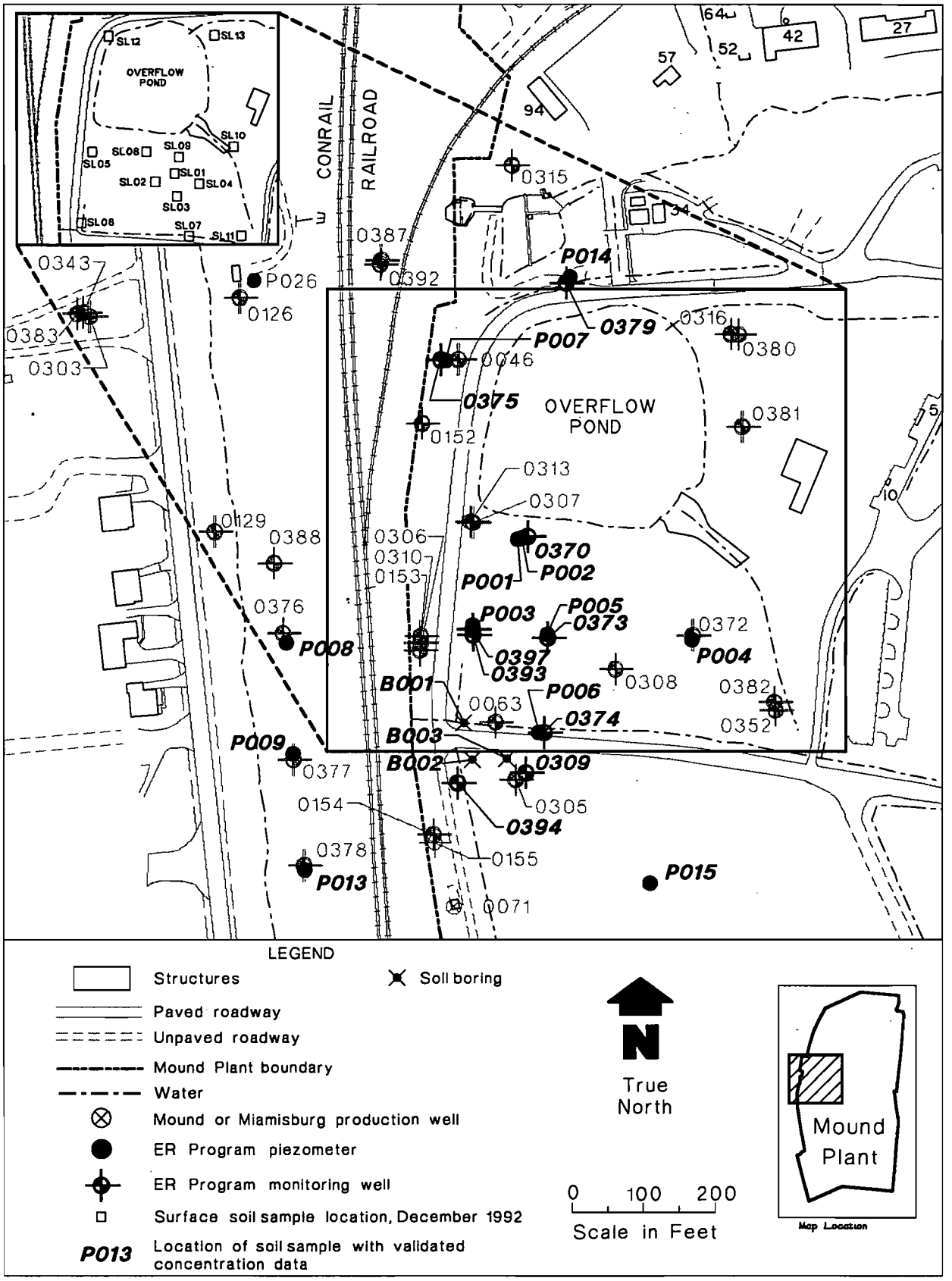


Figure 4.35. Soil sample locations with validated volatile organic compound concentration data, November/December 1992.

P001 at a depth of 26.5 to 28.0 ft (24,000 μg/kg), and in P002 at a depth of 34.5 to 40 ft (5,500 μg/kg). Non-qualified concentrations of PCE were detected in 0375 at a depth of 21 to 30 ft (23 μg/kg), in P007 at depths of 20 to 30 and 30 to 40 ft, 7 μg/kg and 18 μg/kg, and in P014 at a depth of 30 to 40 ft, 13 μg/kg. The southernmost non-qualified detection occurred in P015 at a depth of 50 to 60 ft, 8 μg/kg.

Toluene

Non-qualified detections of toluene were limited to seven samples. The highest non-qualified detection was in a sample taken from 0393 at 10 to 20 ft (7100 μg/kg). The highest qualified concentration occurred in P003 at a depth of 0 to 10 ft, 750 μg/kg. Toluene was detected in 14 other wells and piezometers in qualified concentrations that were less than 8 μg/kg. Toluene was detected in samples taken as far south as P015 and in both P007 and P014 to the north of the overflow pond.

Total Xylenes

Total xylenes were detected in nine of the wells and piezometers sampled. The highest non-qualified concentrations were found in P003 and P004 at a depth of 0 to 10 ft, 6100 μg/kg and 1300 μg/kg, respectively. Qualified detections occurred in P014 to the north, P015 to the south, and P009 to the west. These detections were less than 3 μg/kg.

Trichloroethene

The highest non-qualified detection of TCE occurred in P001 at a depth of 30 to 40 ft, 310 μg/kg, and in P002 and B002 at a depth of 30 to 40 ft, 180 μg/kg and 230 μg/kg, respectively. The highest qualified detection occurred in P001 at a depth of 20 to 30 ft, 970 μg/kg. Non-qualified detections occurred in P007 to the north of the overflow pond and in P015 to the south. Qualified detections of less than 5 μg/kg occurred in samples taken from P014, 0379, and 0375.

Benzene

Two non-qualified detections for benzene were reported in 0393 at a depth of 13.5 to 14.0 ft (160 μg/kg) and 17.5 to 18.0 ft (8 μg/kg). One qualified detection, above CRDL, was reported in P003, at a depth of 15.0 to 17.0 ft (44J μg/kg). The highest qualified detections, but below CRDL, were found in the field duplicate for P003 at 15.0 to 17.0 ft (190J μg/kg) and in P003 at depths of 5.0 to 6.5 ft (150J μg/kg) and 13.5 to 15.0 ft (150J μg/kg).

Vinyl Chloride

The highest non-qualified results for vinyl chloride occurred in 0393 at depths of 13.5 to 14.0 ft (190 μg/kg) and 20.0 to 22.0 ft (26.5A μg/kg). Two other non-qualified detections occurred at P001 (16.5 to 18.0 ft, 18 μg/kg) and P003 (20.0 to 21.5 ft, 21 μg/kg). Three qualified detections were reported at B001 (3.5 to 5.0 ft, 4J μg/kg), P003 (3.5 to 5.0 ft, 2 J μg/kg), and P004 (30.0 to 31.5 ft, 2J μg/kg). These qualified detections are below the CRDL.

Dichloromethane (Methylene chloride)

The only detections reported for dichloromethane occurred at P014, at depths of 1.5 to 3.0 ft (81J μg/kg), 19.2 to 20.0 ft (70 μg/kg), and 24.2 to 25.0 ft (71 μg/kg).

Limited detections were noted for the common laboratory contaminants acetone, 2-butanone, 2-hexanone, and 4-methyl-2-pentanone. Limited detections were also noted for carbon disulfide, 1,1-DCE, trichloromethane, chlorobenzene, 1,1,1-TCA, 1,2-dichloropropane, and tetrachloromethane. Because of the low number of detections and concentrations reported, the results for these analytes were considered to have little impact on defining areas of contamination.

The VOCs detected in the Area B soil samples are, in general, concentrated in the area of well 0393 and piezometer P003, which are both located in the area of the historic landfill. The majority of the detections occurs at a depth of less than 20 ft and is limited in areal extent. A till or fine-grained unit is found in both boreholes at a depth of approximately 20 ft. It is likely that this fine-grained unit has restricted the movement of VOCs within the soil.

Examination of the areal extent of the VOC contamination in the soils shows that it is restricted to the area of past disposal activity in Area B, with no discernible source. Comparison of the areal extent of the VOC contamination in the groundwater shows that the contamination is also largely restricted to the area of past disposal activity in Area B. Only TCE and 1,1,1-TCA show concentrations offsite. These are generally less than 1 μg/l and appear to vary seasonally. There is no consistent trend, over time, in concentrations in area wells. There also appears to be little trend in contamination with depth. Well pair 0155 and 0154 shows a general trend in that the deeper well (0154) is usually higher in concentration than 0155 (the shallower well). One explanation for this pattern is that 0154 is completed in less permeable material than 0155 and that pumping at 0076 may keep concentrations lower at 0155.

Semivolatile Organic Compounds

Figure 4.36 shows the locations and concentration of polyaromatic hydrocarbons, the semivolatile organic contaminants of concern. Tables A8b and A8c, in Appendix A8, list the semivolatile compound detections for surface and subsurface soil samples. The surficial soil sample locations did not show any concentrations above the CRDL for any of the polycyclic aromatic hydrocarbons (PAHs). Soil sample locations SL03, SL12, and SL13 had no detected contamination. The highest qualified concentrations occurred in SL05, 380J µg/kg of benzo(b)fluoranthene.

Only P004, at a depth of 30.0 to 31.5 ft, showed concentrations of PAHs above the CRDL. These include benzo(a)anthracene (1900 µg/kg), benzo(b)fluoranthene (1800 µg/kg), benzo(k)fluoranthene (780 µg/kg), phenanthene (3300 µg/kg), benzo(a)pyrene (1300 µg/kg), benzo(g,h,i)perylene (440 µg/kg), fluoranthene (2600 µg/kg), indeno(1,2,3-cd)pyrene (410 µg/kg), and pyrene (3000 µg/kg) All of the other detections were qualified by being below the CRDL or by exceeding extraction holding times by 39 days.

Pesticides/PCBs

Aroclor-1248 is a polychlorinated biphenyl. The sample locations of detected concentrations of Aroclor-1248 are shown in Figure 4.37. It was detected in both the surficial and subsurface soil samples at 14 different locations within Area B. The validated detections of Aroclor-1248 are presented in Table A8d in Appendix A8. The highest non-qualified detection was in P004 at a depth of 30 to 40 ft, 13,000 µg/kg. However, the highest qualified detections were in P001 and in P004 at a depth of 20 to 30 ft, 220,000J µg/kg and 13,000 µg/kg, respectively, and in P003 at a depth of 0 to 10 ft, 38,000J µg/kg. The deepest occurrence of Aroclor-1248 occurred in P004 and P001 at 30 to 40 ft. The southernmost qualified detection of Aroclor-1248 occurred in 0394. The northernmost qualified detection occurred in SL12.

Tritium

The sample locations of detected concentrations of tritium are shown in Figure 4.38. The concentrations are shown in Table A8e in Appendix A8. The highest non-qualified detection in the surficial soil samples occurred in SL09, 1.17 pCi/g. Non-qualified detections also occurred in all of the surficial soil samples except for SL13 and SL11, which had no detected concentrations, and SL10, which had a qualified detection of 0.402J pCi/g.

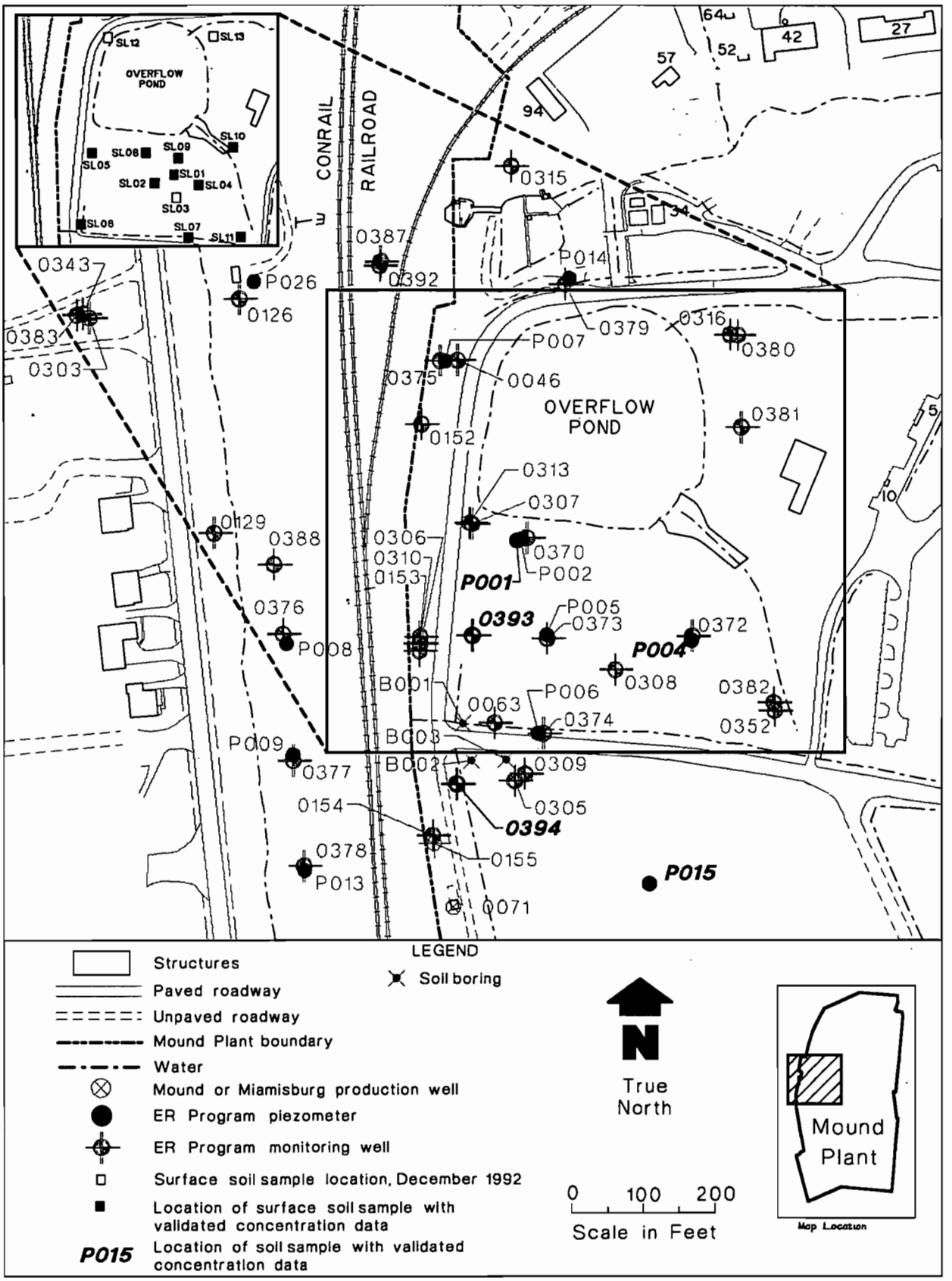


Figure 4.36. Soil sample locations with validated semivolatile organic compound concentrations, November/December 1992.

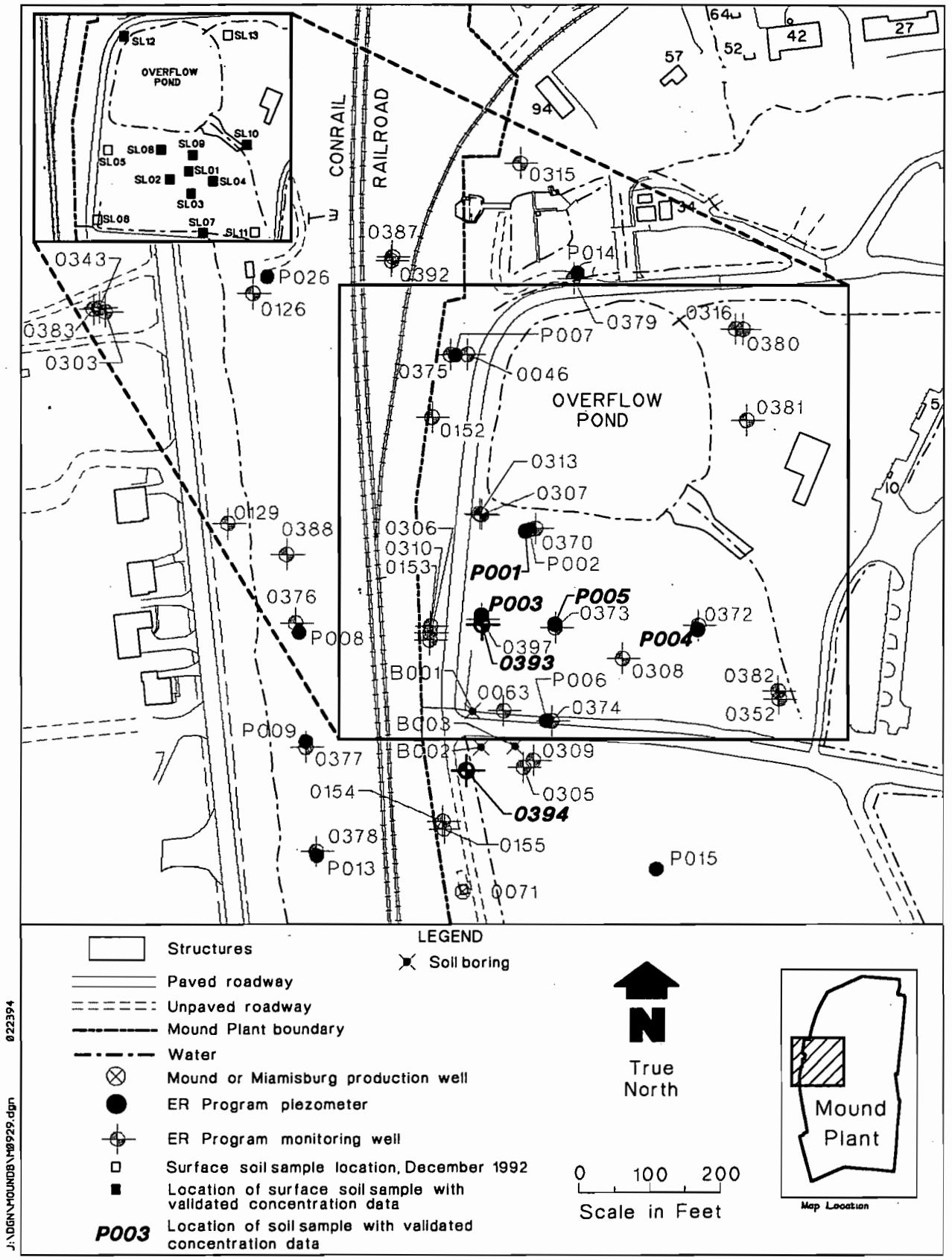


Figure 4.37. Soil sample locations with validated Aroclor-1248 (PCB) concentration data, November/December 1992.

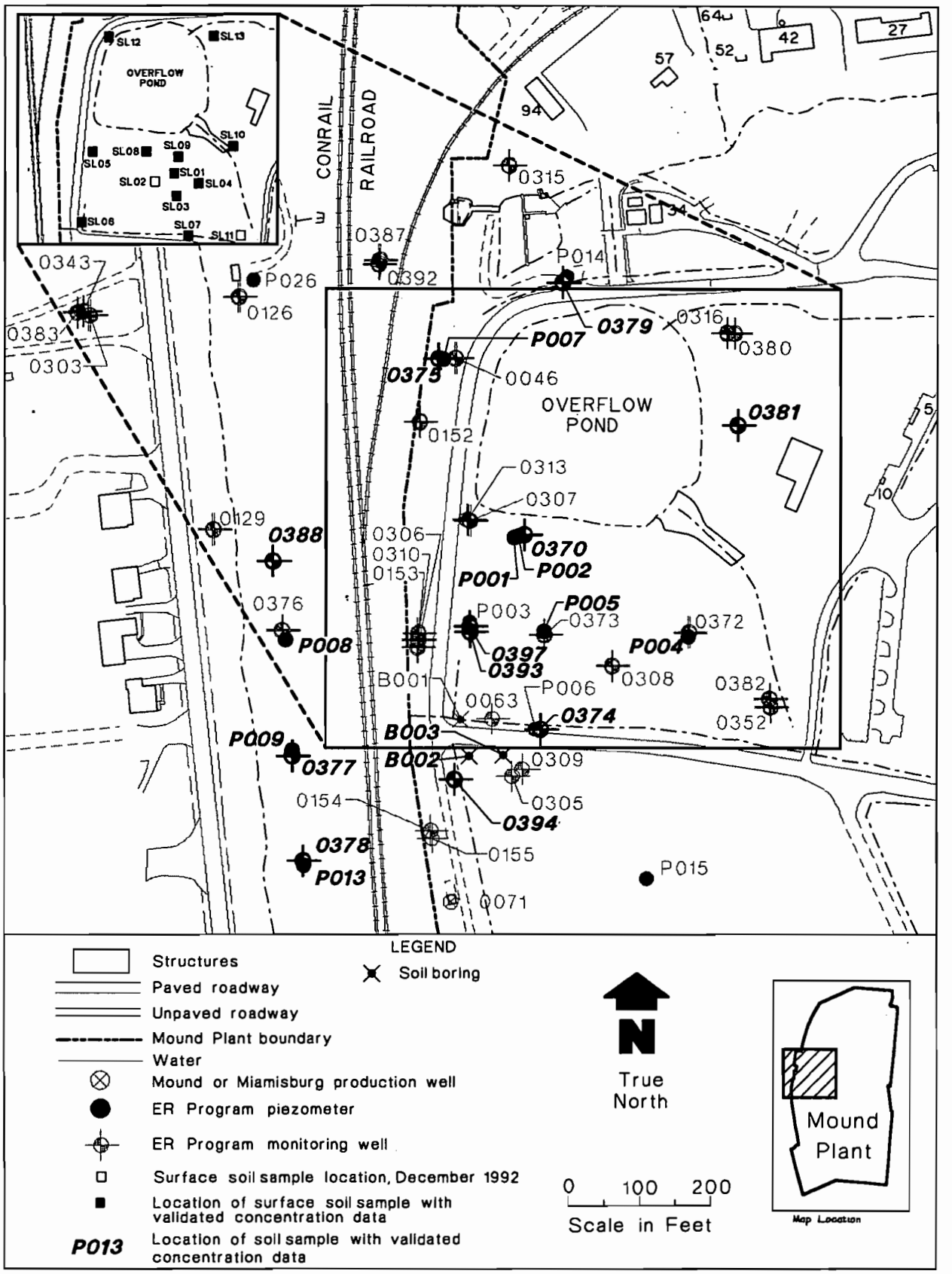


Figure 4.38. Soil sample locations with validated tritium concentration data, November/December 1992.

The highest non-qualified detections in the subsurface soils occurred in P004 at depths of 10 to 20 and 21 to 30 ft, 29.6 pCi/g and 15.8 pCi/g, respectively, and in P001 at 20 to 30 ft, 8.31 pCi/g. Tritium was detected in samples taken as deep as 70 to 80 ft in P009 and in P013. Tritium concentrations are found south of the site sanitary landfill (0378), west of the site sanitary landfill (P009 and P008), and north of the overflow pond (P007 and 0379).

Other Radionuclides

Radionuclides (other than tritium) identified as contaminants of concern by the risk assessment (Section 5) include plutonium-238, plutonium-239/240, and strontium-90. The sample locations and concentrations for these radionuclides are found in Figure 4.39; Table A8f in Appendix A8 presents validated detections for these analytes.

Plutonium-238

Plutonium-238 was detected in all of the surficial soil samples at relatively low levels. The highest non-qualified concentration in surficial soils was detected in SL11, 8.75 pCi/g. The highest non-qualified concentration in the subsurface soils was found in P004 at a depth of 30 to 40 ft, 17.8 pCi/g.

Plutonium-239/240

Plutonium-239/240 was detected in 11 of the boreholes. The highest non-qualified concentration was measured in P004 at a depth of 30 to 40 ft, 1.2 pCi/g. The highest non-qualified concentration in the surficial soil was detected at SL04, 0.120 pCi/g. All of the other detections were less than 0.3 pCi/g in both the surficial and subsurface soil samples. Plutonium-239/240 was detected as far south as P015 and in P014 and P007 to the north.

Strontium-90

Strontium-90 was detected in five of the surficial soil samples and in four of the subsurface soil samples. The highest non-qualified detect was in P006 at a depth of 20 to 30 ft, 5.78 pCi/g. The remainder of the non-qualified detects were less than 1 pCi/g. A qualified detect of 1.08 was detected in P004 at a depth of 20 to 30 ft. There is no pattern to the locations where the strontium-90 was detected, although detections occurred in P004, P005, and P006, near the historic landfill.

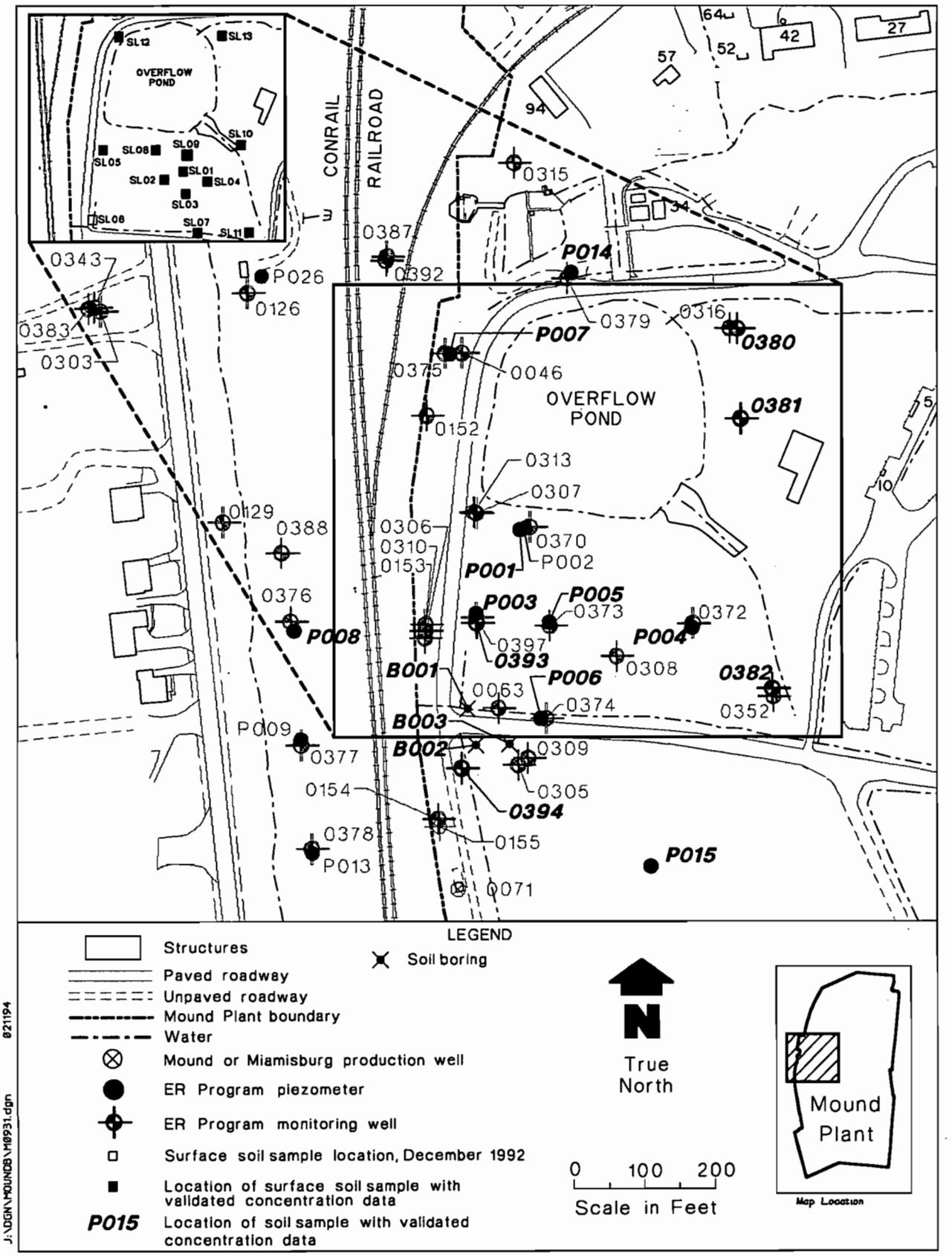


Figure 4.39. Soil sample locations with validated radionuclide concentration data, November/December 1992.

Dioxin/Furans

The locations and concentrations of dioxin and furan compounds are shown in Figure 4.40. Tables A8g, h, and i in Appendix A8 present the validated detections for these compounds. All of the subsurface borehole locations had non-qualified concentrations of dioxin/furan compounds in excess of 0.18 picograms per gram (pg/g). The highest concentration was found for 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin at 246 pg/g at a depth of 10 to 20 ft in P015. All of the samples are located in the area of the historic landfill except for 0394 and P015. Octachlorodibenzodioxin had four non-qualified detections with a maximum of 2110 pg/g at 12 to 14 ft in P015. P006 and 0394 had non-qualified detections at a depth less than 10 ft 371 pg/g and 273 pg/g, respectively.

Of the 210 possible chlorinated dibenzo-p-dioxins (PCDDs) and chlorinated dibenzofurans, the 17 isomers that bear chlorine atoms in the 2,3,7, and 8 positions of their respective structures are the compounds of greatest concern. To aid in the assessment of risks to human health and the environment, the EPA has assigned a factor to each of these 17 isomers that relates the toxicity of that isomer to an equivalent concentration of the most toxic isomer, 2378-TCDD (EPA 1989f). These factors are called toxicity equivalency factors (TEFs). The concentrations of any of the 17 isomers detected in a sample can then be adjusted by the TEF and summed, yielding a concentration of 2378-dioxin (tetrachlorodibenzo-p-dioxin) (TCDD) with an equivalent toxicity.

Table IV.16 presents the TEFs of all samples analyzed for dioxin/furans during the Operable Unit 1 additional work investigation.

Metals

Table IV.17 presents the minimum, maximum, and average concentrations for all surface and subsurface soil samples analyzed, along with the associated sample location and depth. The table also presents the total number of detections (qualified and non-qualified) out of the 67 field samples collected for metals analysis. The extent of metals contamination in soils appears restricted to the areas of past disposal activity. The significance of the metal concentrations reported in Table IV.17 will be discussed in Section 5, Baseline Risk Assessment.

The only discernible pattern for the compounds detected during the surficial and subsurface soil sampling appear to be directly related to activities in and around the historic landfill. There does not appear to be a major source of any of the contaminants detected, but rather a random pattern of dispersed contamination that occurred from reworking and transport of sediments.

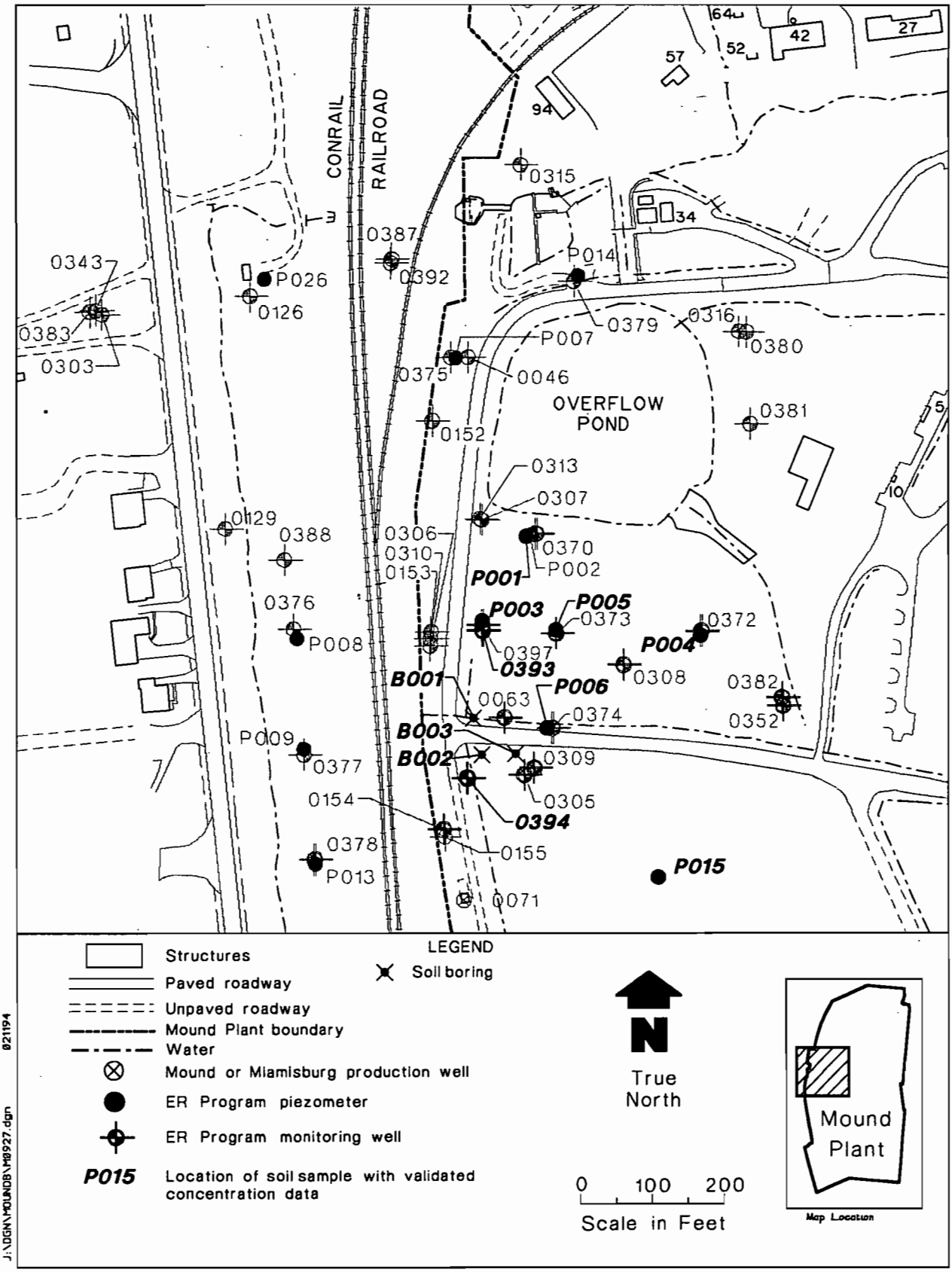


Figure 4.40. Soil sample locations with validated dioxin and furan compound concentrations, November/December 1992.

Table IV.16. Toxicity Equivalency Factors of Soil Samples Analyzed for Dioxin/Furans

Sample Number	TEF Concentration	Units
P006-0010	1.73980	pg/g
P006-0015	0.00196	pg/g
P006-0025	0.00510	pg/g
P015-0014	7.6722	pg/g
P015-0045	0.00681	pg/g
B002-0015	0.04212	pg/g
B003-0026	0.02730	pg/g
B003-1026	0.00210	pg/g
B001-0007	0.07800	pg/g
B001-0015	0.01640	pg/g
P003-0006	46.7669	pg/g
P003-0016	2.57820	pg/g
P003-0026	0.00170	pg/g
P001-0036	0.14853	pg/g
P004-0005	0.00790	pg/g
P004-0025	4.4225	pg/g
P004-0031	165.937	pg/g
P004-0038	4.44470	pg/g
P004-0045	0.00540	pg/g
0393-0005	11.2973	pg/g
0393-0021	0.00650	pg/g
0393-1021	0.00630	pg/g
0394-0003	5.59550	pg/g
0394-0011	1.81168	pg/g
P005-0003	0.01670	pg/g
P005-0009	0.83043	pg/g
P005-0018	0.74390	pg/g
P005-0045	0.01890	pg/g
P005-0056	0.11010	pg/g
P005-1056	0.00692	pg/g

NOTE: Action level may be 1 ppb (1000 pg/g) in soils (DHHS 1987).

Table IV.17. Validated Detections in Soils - Metals

Analyte	Minimum (mg/kg) Location:Depth (ft)	Maximum (mg/kg) Location:Depth (ft)	Average (mg/kg)	Frequency of Detections
Aluminum	1140 0394:10.5-11.0	12400 J P006:9.0-10.0	4457	64 of 67
Antimony		3.8 J P004:23.0-25.0	3.8	1 of 67
Arsenic	2.3 P009:13.5-15.0	13.5 B001:15.0-16.5	5.4	67 of 67
Barium	11.8 P008:10.0-12.0	115 P006:9.0-10.0	37.0	62 of 67
Beryllium	0.12 B001:26.0-28.0	0.68 P003:5.0-6.5	0.3	17 of 67
Bismuth	1.1 P006:13.0-15.0	2.0 P015:12.0-14.0	1.6	4 of 67
Cadmium	0.22 0394:25.0-26.0	0.9 J P004:30.0-31.5	0.39	7 of 67
Calcium	8,050 P003:5.0-6.5	262,000 0393:26.0-27.0	127,600	67 of 67
Chromium	1.7 J B001:25.0-26.5	13.8 P006:9.0-10.0	7.6	34 of 67
Cobalt	2.4 P013:16.0-17.5	14.6 P003:5.0-6.5	5.1	38 of 67
Copper	4.9 0393:26.0-27.0	681 J P004:30.0-31.5	26.5	52 of 67
Iron	4,380 J 0393:26.0-27.0	42,200 P004:30.0-31.5	11,110	67 of 67
Lead	3.9 P009:13.5-15.0	121 J P004:30.0-31.5	12.4	60 of 67
Lithium	7.1 J 0394:25.0-26.2	22.4 P015:12.0-14.0	13.7	27 of 67
Magnesium	4,650 P003:5.0-6.5	75,500 J P008:20.0-21.5	44,230	67 of 67
Manganese	195 J P004:43.5-45.0	1,320 J P005:55.0-59.0	372	64 of 67
Mercury	0.06 J 0393:3.0-5.0	2.7 J P004:23.0-25.0	0.64	10 of 67

Table IV.17. (page 2 of 2)

Analyte	Minimum (mg/kg) Location:Depth (ft)	Maximum (mg/kg) Location:Depth (ft)	Average (mg/kg)	Frequency of Detections
Nickel	7.0 P013:16.0-17.5	28.4 P004:30.0-31.5	13.3	28 of 67
Potassium	195 0394:25.0-26.0	1,950 P015:12.0-14.0	770	63 of 67
Selenium	0.29 J B001:5.0-7.0	0.92 J 0393:20.0-22.0	0.56	3 of 67
Silver	2.0 P008:10.0-12.0	6.3 P006:9.0-10.0	3.3	21 of 67
Sodium	108 SL02:0.5-1.5	504 P006:9.0-10.0	195	47 of 67
Thallium	0.24 J 0394:10.5-11.0	0.77 P005:1.5-3.0	0.43	8 of 67
Vanadium	5.6 B001:26.0-28.0	34.5 P006:9.0-10.0	13.4	52 of 67
Zinc	12.5 P014:35.0-36.0	1,330 P004:30.0-31.5	64.2	48 of 67

4.3.2. Groundwater

This section discusses the analytical results of groundwater samples collected during March 1993. The March 1993 sample set is the most recent analytical data set and, with the addition of the new Operable Unit 1 wells, is the most complete in terms of Area B contamination. In addition, a summary of the data collected over the most recent four quarters (June 1992 through March 1993) is presented to provide a current historical perspective and to coincide with the data collection period used in the development of the risk assessment (Section 5).

The analytes discussed include those identified by the risk assessment as contaminants of concern, as well as additional analytes relevant to the determination of possible contamination. Maps are presented in this section for each organic or inorganic analyte for which at least three validated detections were reported. Only those wells sampled in March 1993 are depicted on these maps; refer to Figure 4.1 for the locations of all wells associated with Area B. To note areas of possible contamination, shading has been added to these maps based on positive results obtained over the last four quarters of groundwater monitoring (June 1992 through March 1993). Maps are also presented in this section for radiological parameters, using data obtained from March 1993 and September 1992. These two quarters represent the most recent radiological data available for both newly installed and previously installed groundwater monitoring wells. The associated maps depict wells sampled in September 1992 and March 1993.

Appendix A7 presents all laboratory and validated data for sample analyses conducted during March 1993 on the newly installed wells. Analytical results for samples collected from previously installed wells in December 1992 and March 1993 were obtained from the Environmental Safety and Health Groundwater Monitoring Reports (EG&G 1993a, b). All groundwater monitoring data collected prior to December 1992 are presented in the Cumulative Groundwater Monitoring Well Data Report (DOE 1993a). Appendix A8 provides tables summarizing the validated detections reported for these organic and inorganic parameters from June 1992 through March 1993.

The discussion of validated analytical results refers to both qualified and non-qualified data. Non-qualified data results indicate that no qualifiers, such as J (estimated quantity), were associated with the result. Qualified results indicate that a J or another qualifier was associated with the analytical result. Data validation of the groundwater samples for March 1993 is discussed in subsection 3.5.4.

Several wells, including well 0313, produced silty water. Preliminary information from the ongoing site-wide sweep groundwater sampling suggests that at least some of the contaminants of concern in well 0313 may be associated with the sediments produced from the well rather than the water.

This is shown by comparing filtered and nonfiltered samples. The inorganic discussion presented in this section is based on all nonfiltered samples. Thus, reported concentrations may not accurately reflect dissolved concentrations in the groundwater.

1,1,1-Trichlorethane

One non-qualified detection of 1,1,1-TCA was reported for March 1993 at well 0129 (3.20 µg/L). Three qualified detections were reported at wells 0376 (1.0J µg/L), 0377 (9.1JA µg/L), and 0378 (18J µg/L). These wells are located offsite, west of Area B. One qualified detection was reported at well 0370 (1.6J µg/L), which is located between the site sanitary landfill and the overflow pond in Area B (Figure 4.41). No evidence of a 1,1,1-TCA source can be determined or described from the March 1993 data. The most recent four quarters of validated detections are summarized in Table A8j of Appendix A8.

This data summary indicates well 0129 consistently reported positive values for 1,1,1-TCA, with the maximum value being 3.2 µg/L. Other wells within Area B reported low levels of 1,1,1-TCA, ranging from 0.36 µg/L to 18J µg/L. Well 0071 reported 18J µg/L in June 1992, but no detection has been reported since that time. The distribution of 1,1,1-TCA suggests that Area B is not a source of this contaminant.

1,2-*cis*-Dichloroethene

Five non-qualified detections of 1,2-*cis*-DCE were reported for March 1993 at wells 0374 (48 µg/L), 0076 (3 µg/L), 0305 (28 µg/L), 0071 (16.50A µg/L), and 0271 (7.20 µg/L) (Figure 4.42). Well 0374 is located along the southern margin of the site sanitary landfill in Area B. Wells 0305, 0071, and 0271 increase in distance respectively along a line south from 0374. Two qualified detections were reported at wells 0370 (640.0J µg/L) and 0373 (17J µg/L) (Figure 4.42). Wells 0370 and 0373 are located in Area B. The highest concentrations were reported in wells in Area B, though an exact source of the 1,2-*cis*-DCE could not be pinpointed. 1,2-*cis*-DCE is a known degradation product of both tetrachloroethene and TCE. However, review of the data does not indicate a discernible pattern of degradation; the presence of 1,2-*cis*-DCE may be an impurity in the tetrachloroethene or TCE used onsite. Validated detections for the past four quarters are summarized in Table A8k of Appendix A8. This data summary indicates that wells 0071, 0271, and 0305 usually reported positive values for 1,2-*cis*-DCE, with the maximum value for these three wells being 28 µg/L. Wells within Area B reported levels of 1,2-*cis*-DCE ranging from 1.8 µg/L (0124, June 1992) to 640J µg/L (0370, March 93).

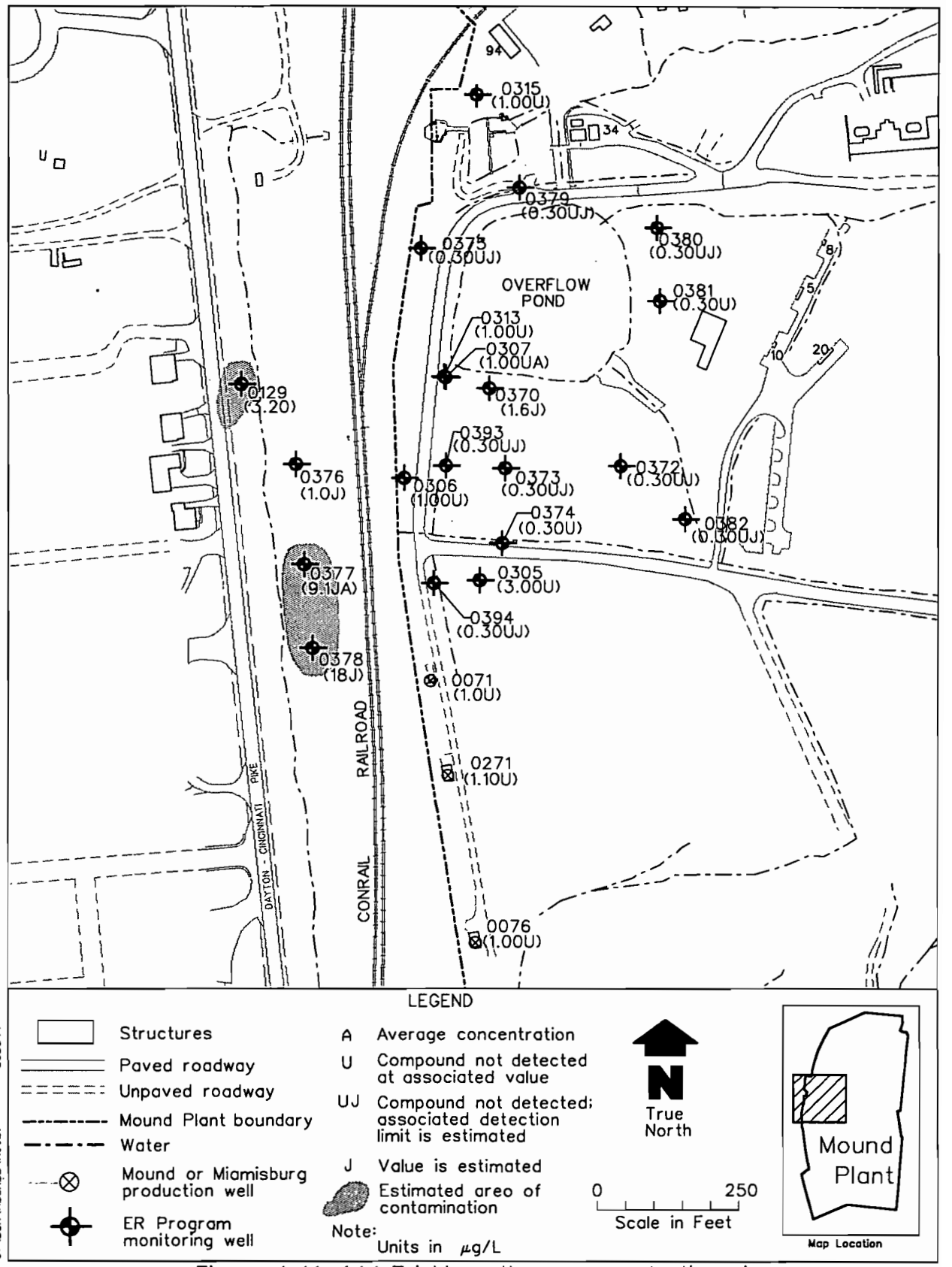


Figure 4.41. 1,1,1-Trichloroethane concentrations in wells in and adjacent to Area B, March 1993.

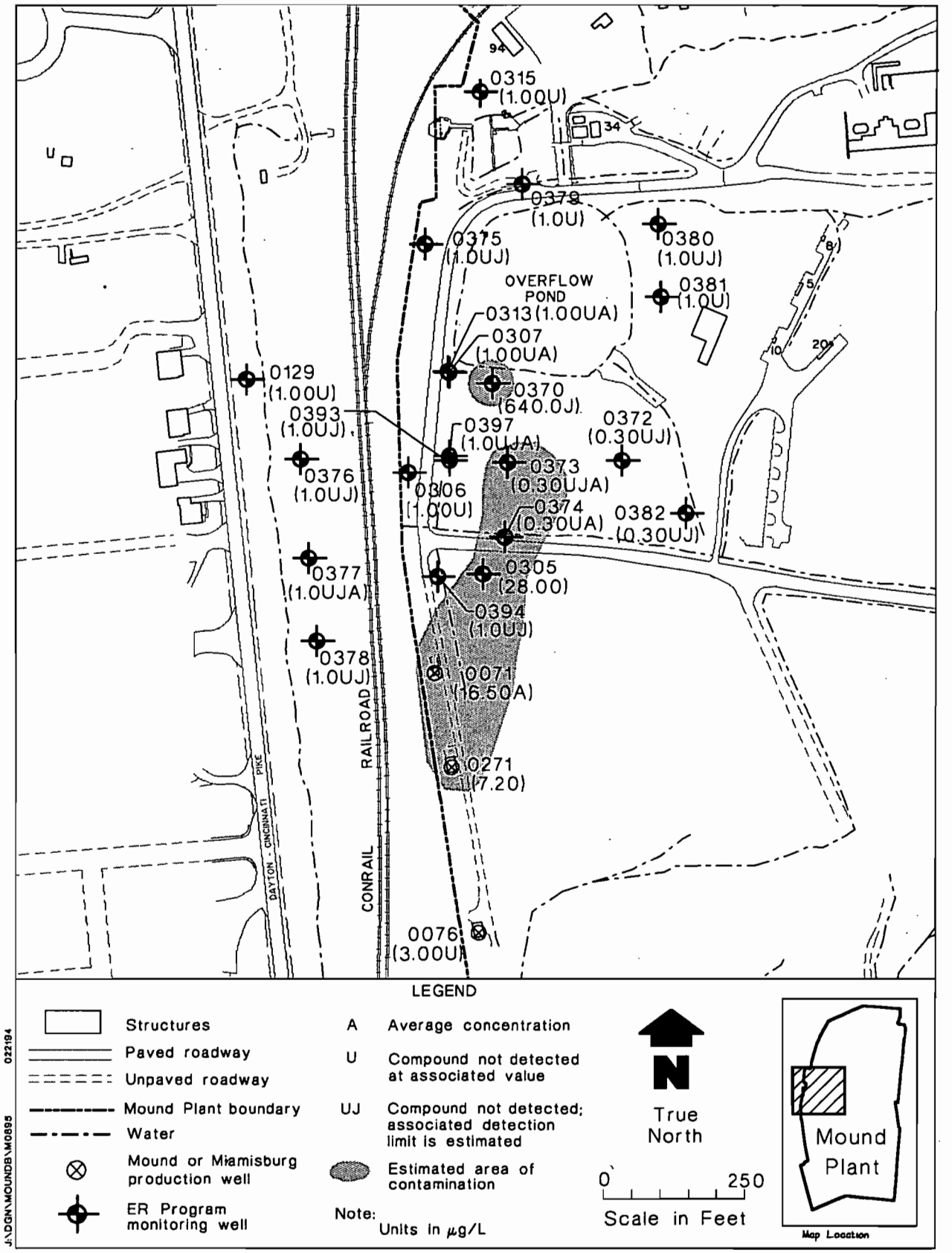


Figure 4.42. 1,2-*cis*-Dichloroethene concentrations for wells in and adjacent to Area B, March 1993.

1,2-*trans*-Dichloroethene

There were no non-qualified detections of 1,2-*trans*-DCE for March 1993. One qualified detection was reported at well 0370 (2.6J µg/L), which is located in Area B between the overflow pond and the site sanitary landfill. While 1,2-*trans*-DCE is a minor degradation product of PCE and TCE, no evidence of a source of 1,2-*trans*-DCE can be determined or described from the March 1993 data. The presence of 1,2-*trans*-DCE may be due to an impurity in the tetrachloroethene and TCE used onsite. No detections, other than that at 0370, have been reported during the previous four quarters.

Tetrachloromethane

Five non-qualified detections of tetrachloromethane were reported for March 1993 at wells 0315 (3.60 µg/L), 0313 (1.50 µg/L), 0307 (2.0A µg/L), 0370 (4.6 µg/L), and 0373 (4.0 µg/L) (Figure 4.43). All wells, except for 0315, are located in Area B. Well 0313 is the shallow well in the cluster with 0307. Well 0315 is located north and upgradient of Area B. Two qualified detections were reported at well 0379 (4.6J µg/L) and well 0397 (2.3JA µg/L) (Figure 4.43). Well 0379 is located 50 ft north of Area B, upgradient of reported activities at Area B. Well 0397 is located within the western portion of Area B. Generally, the highest concentrations were found in the central portion of Area B, near the location of the historic landfill. Validated detections for the most recent four quarters of data are summarized in Table A8l of Appendix A8. This data summary indicates that wells 0305, 0307, 0313, and 0315 usually reported positive values for tetrachloromethane, with the maximum value for these four wells being 5 µg/L. Other wells within Area B reported levels of tetrachloromethane ranging from 0.94J µg/L (0306, June 1992) to 4.7J µg/L (0315, June 1992).

Trichloromethane

No non-qualified detections of trichloromethane were reported for March 1993 (Figure 4.44). Three qualified detections were reported at wells 0373 (13J µg/L), 0397 (0.64JA µg/L), and 0370 (130J µg/L). Wells 0373, 0397, and 0370 are located in Area B. The occurrence of the three detections are in the approximate location of the historic landfill. Validated detections for the past four quarters of data are summarized in Table A8m of Appendix A8. This data summary indicates that other wells within Area B have reported only one positive detection for trichloromethane in the past four quarters, with the exception of well 0305, which reported two detections. The maximum reported value for these wells was 130J µg/L.

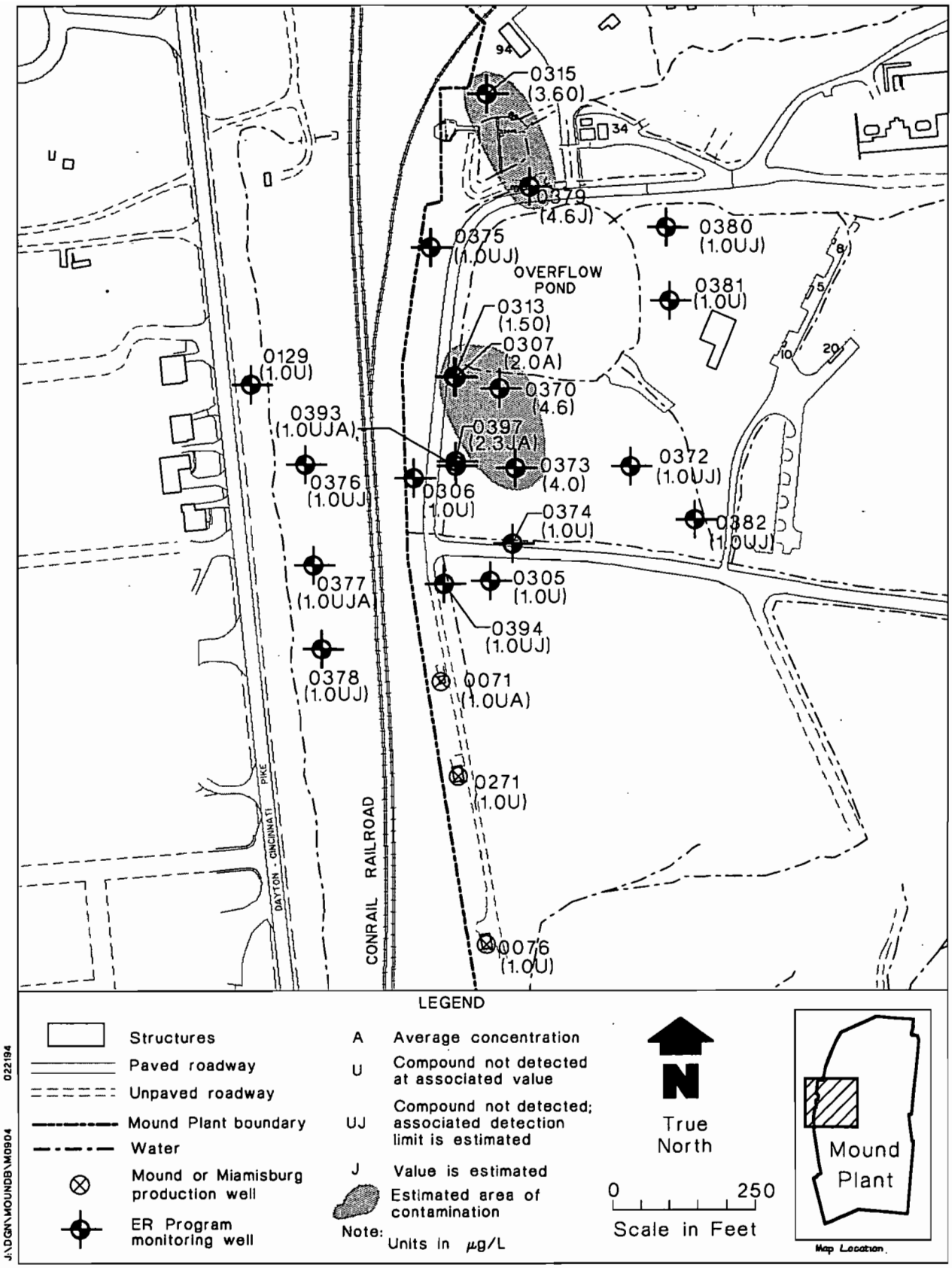


Figure 4.43. Tetrachloromethane concentrations for wells in and adjacent to Area B, March 1993.

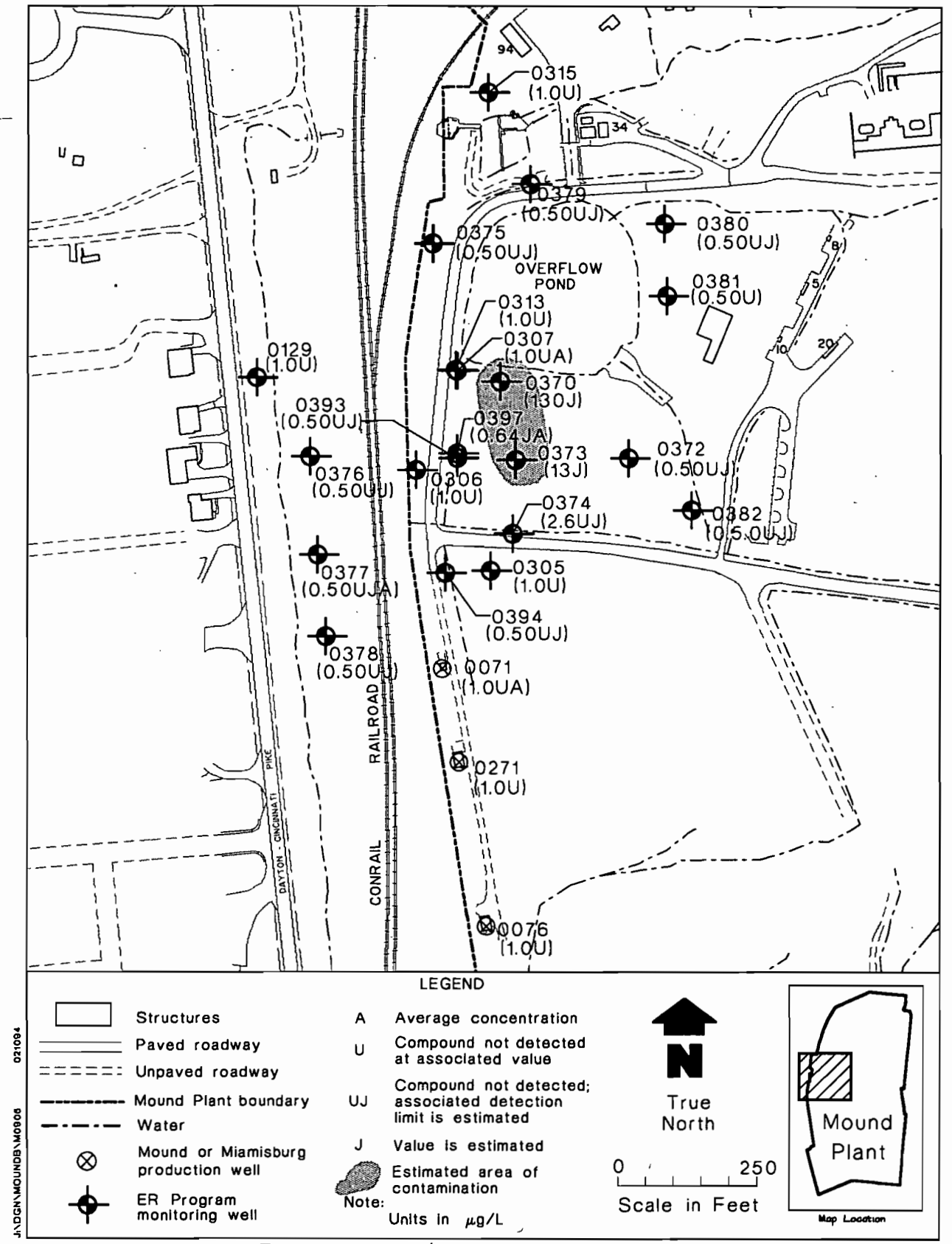


Figure 4.44. Trichloromethane concentrations for wells in and adjacent to Area B, March 1993.

Tetrachloroethene

Five non-qualified detections of PCE were reported for March 1993 at wells 0313 (11.00 µg/L), 0307 (15.50 µg/L), 0306 (5.20 µg/L), 0374 (23 µg/L), 0305 (16.00 µg/L) (Figure 4.45). Wells 0307 and 0313 are a clustered well pair located along the western margin of Area B. Well 0313 is the shallow well in the well cluster. Well 0374 is located along the southern margin of Area B. Well 0305 is located 50 ft south of Area B. Well 0306 is located 50 ft west of Area B. Five qualified detections were reported at wells 0370 (270J µg/L), 0373 (40J µg/L), 0397 (10.6JA µg/L), 0379 (4.8J µg/L), and 0375 (5.3J µg/L) (Figure 4.45). Wells 0370, 0397, and 0373 are located in Area B. Well 0379 is located 50 ft north of Area B, upgradient of reported Area B activities. Well 0375 is located 75 ft west of the northern portion Area B. The highest concentrations of PCE are concentrated in the area of the historic landfill. Validated detections for the past four quarters of data are summarized in Table A8n of Appendix A8. This data summary indicates that wells 0305, 0306, 0307, and 0313 usually reported positive values for tetrachloroethene, with the maximum value for these four wells being 32 µg/L. Other wells within Area B reported levels of tetrachloroethene ranging from 0.33J µg/L (0315, June 1992) to 270J µg/L (0370, March 1993). Since a positive detection in June 1992, wells 0071, 0271, and 0315 have not reported any further positive detections.

Trichlorethene

Nine non-qualified detections of TCE were reported for March 1993 at wells 0315 (7.20 µg/L), 0313 (6.60 µg/L), 0307 (9.5A µg/L), 0306 (16.00 µg/L), 0374 (24 µg/L), 0305 (32.00 µg/L), 0071 (4.15A µg/L), 0271 (1.70 µg/L), and 0076 (2.00 µg/L) (Figure 4.46). Well 0315 is located north and upgradient of Area B. Wells 0313 and 0307 are a clustered well pair located along the western margin of Area B. Well 0313 is the shallow well in the well cluster. Well 0374 is located along the southern margin of Area B. Well 0306 is located 50 ft west of Area B. Well 0305 is located 50 ft south of Area B. The Mound Plant production wells (0071, 0271, and 0076) are located south of Area B. Five qualified detections were reported at wells 0375 (3.9J µg/L), 0397 (7.8JA µg/L), 0370 (210J µg/L), 0379 (2.8J µg/L), and 0373 (31J µg/L) (Figure 4.46). Wells 0370, 0397, and 0373 are located in Area B. Well 0379 is located north and upgradient of Area B. Well 0375 is located 75 ft west of the northern portion of Area B. Generally, the highest concentrations are found in the approximate location of the historic landfill. Table A8o in Appendix A8 summarizes validated detections for the past four quarters of sampling. This data summary indicates that all wells sampled usually reported positive values for TCE, with the values ranging from 1 µg/L to 210J µg/L. Values are fairly consistent within each well.

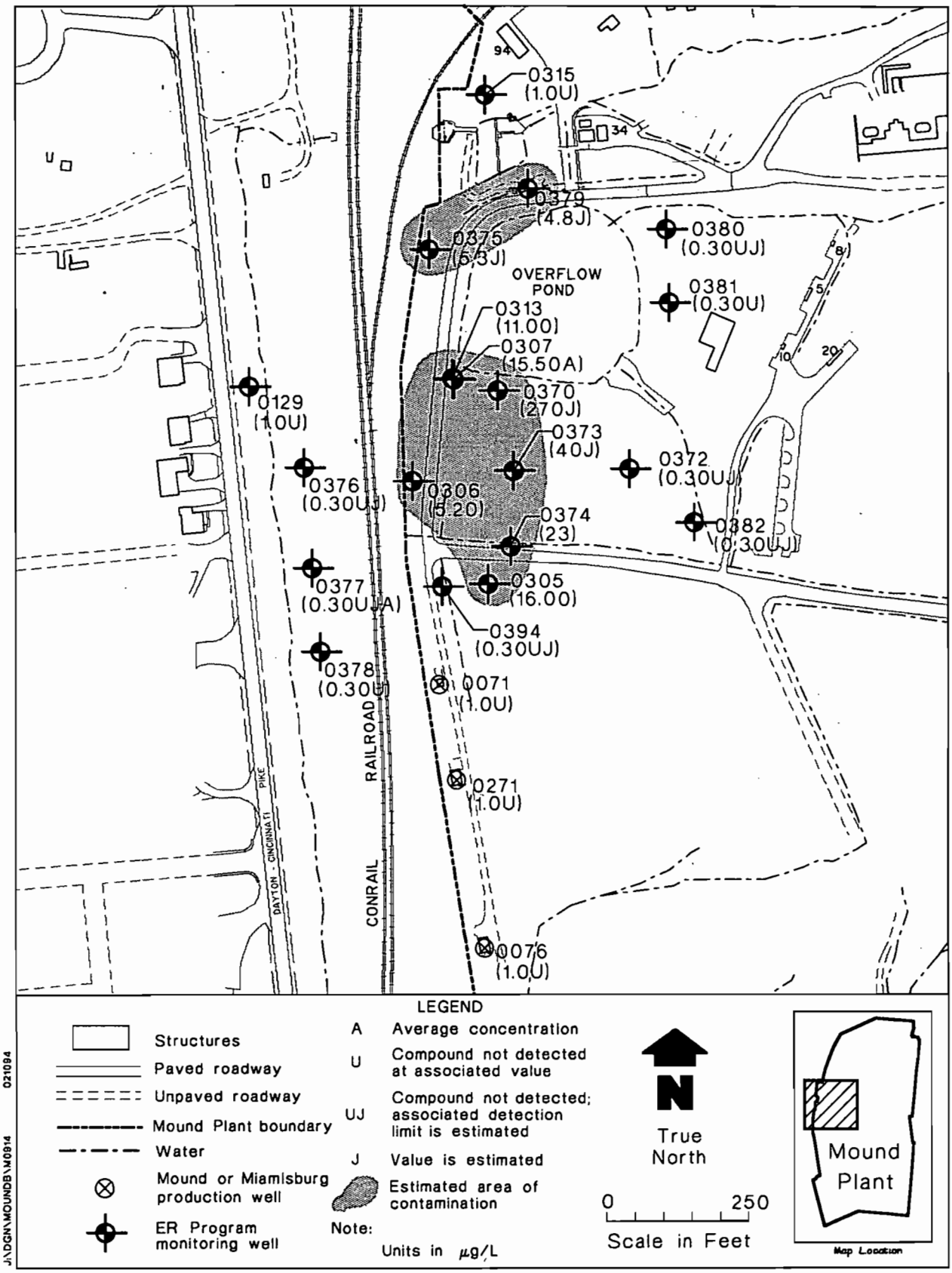


Figure 4.45. Tetrachloroethene concentrations for wells in and adjacent to Area B, March 1993.

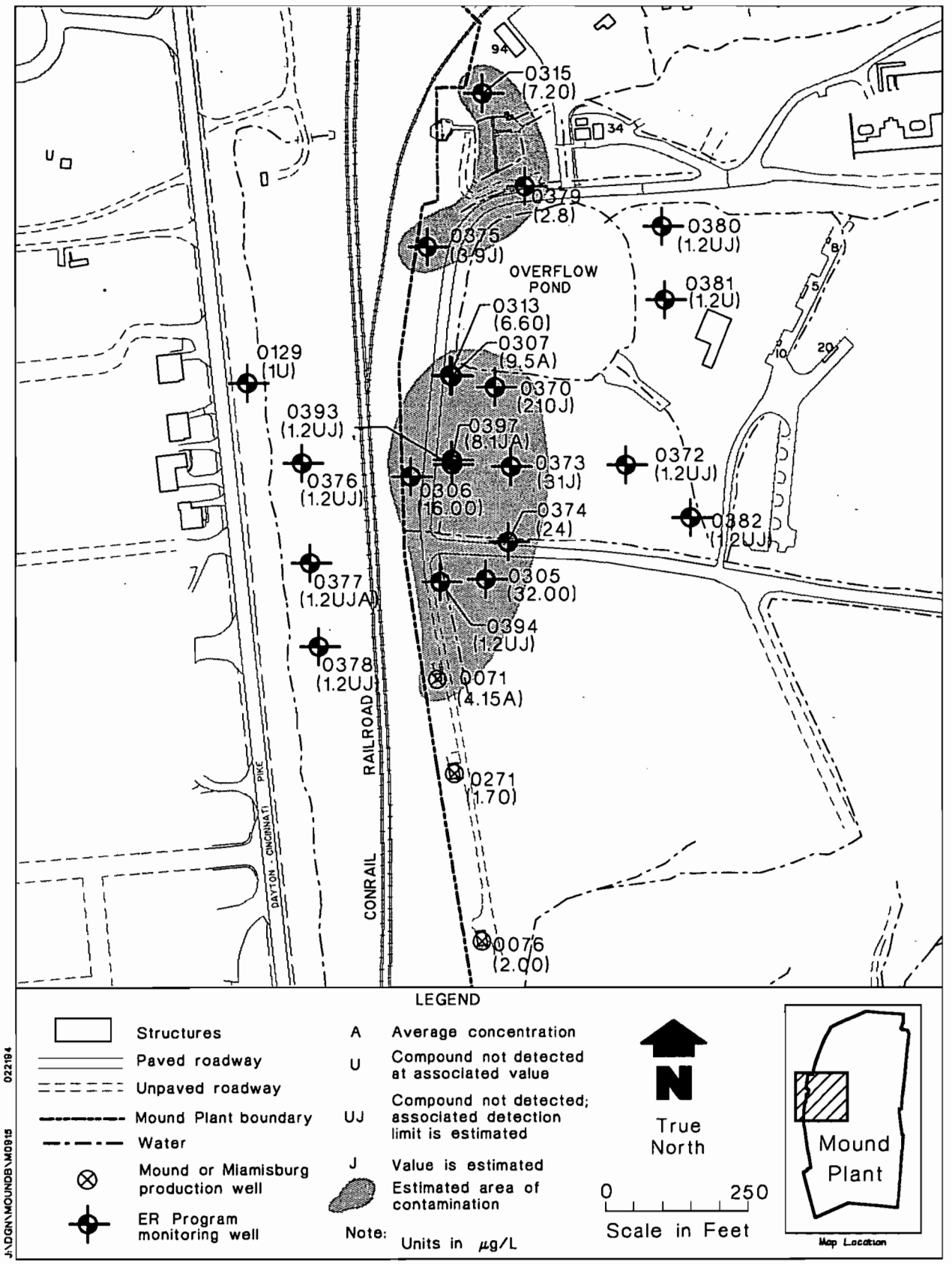


Figure 4.46. Trichloroethene concentrations for wells in and adjacent to Area B, March 1993.

Vinyl Chloride

No non-qualified detections of vinyl chloride were reported for March 1993. One qualified detection was reported at well 0370 (4.5J µg/L). Well 0370 is located in Area B. No evidence of a source can be determined or described from the March 1993 data. Only one other detection was reported during the past four quarters, that of well 0071 (2.0J µg/L).

Trichlorofluoromethane

One non-qualified detection of trichlorofluoromethane was reported during March 1993 at well 0370 (12 µg/L). One qualified result was also reported for March 1993 at well 0373 (3.3J µg/L). Both wells are located within Area B. No detections were reported during the past four quarters.

Bis(2-ethylhexyl)phthalate

Only two detections of *bis*(2-ethylhexyl)phthalate, both qualified, were reported for March 1993. The detections occurred at well 0370 (0.6J µg/L) and well 0379 (23J µg/L). Both wells are located within Area B. No other detections were reported for the past four quarters.

Diethylphthalate

No detections of diethylphthalate were reported for March 1993. Only one detection was reported for the past four quarters for well 0313 (0.9J µg/L, June 1992).

Pyrene

No detections of pyrene were reported for March 1993. Only two detections, both qualified, were reported during the past four quarters. These detections occurred at well 0063 (0.7J µg/L, September 1992) and well 0305 (0.6J µg/L, September 1992).

Alpha Chlordane

Two non-qualified detections of alpha-chlordane were reported for March 1993 at well 0374 (0.070 µg/L) and well 0382 (0.061 µg/L). One qualified detection was reported at well 0394 (0.042J µg/L). Wells 0370 and 0382 are located within Area B. Well 0394 is located south of Area B. No further detections were reported for the past four quarters.

Aluminum

Seven non-qualified detections of aluminum were reported for March 1993 at wells 0379 (24.3 μg/L), 0393 (93.8 μg/L), 0381 (2420 μg/L), 0382 (415 μg/L), 0374 (33.4 μg/L), 0376 (136 μg/L), and 0378 (83.8 μg/L) (Figure 4.47). Wells 0379, 0381, 0393, 0382, and 0374 are located in Area B. Wells 0376 and 0378 are located offsite west of Area B. Six qualified detections were reported at wells 0380 (280J μg/L), 0372 (1440J μg/L), 0370 (36.4J μg/L), 0.397 (31.7JA μg/L), 0313 (1440J μg/L), and 0305 (299J μg/L) (Figure 4.47). Wells 0380, 0372, 0397, 0370, and 0313 are located in Area B. Well 0313 is the shallow well clustered with well 0307. Aluminum was not detected in well 0307. Well 0305 is located 50 ft south of Area B. Detections do not appear to occur in any kind of a pattern; therefore, no evidence of a source can be determined or described from the March 1993 data. Validated detections for the past four quarters are summarized in Table A8p of Appendix A8. This data summary indicates that wells 0305 and 0313 usually reported positive values for aluminum. The values reported during the past four quarters range from 24.3 μg/L (0379, March 1993) to 2330 μg/L (0313, September 1992).

Antimony

No non-qualified or qualified detections of antimony were reported for the March 1993 groundwater sampling. Only two detections have been reported for antimony during the previous four quarters in well 0310 (3.5 μg/L, June 1992) and well 0305 (18.3 μg/L), December 1992).

Arsenic

No qualified or non-qualified detections of arsenic were reported for the March 1993 groundwater sampling. Validated detections for the past four quarters are presented in Table A8q in Appendix A8. This data summary indicates that well 0313 consistently reported positive values for arsenic. Well 0307 reported 2.0J μg/L in June 1992, but no further detections have been reported. The values reported during the past four quarters range from 1.1J μg/L (0305, December 1992) to 2.8 μg/L (0313, September 1992).

Barium

Six qualified detections of barium were reported for March 1993 at wells 0370 (160J μg/L), 0372 (162J μg/L), 0373 (198J μg/L), 0375 (99.7J μg/L), 0380 (62.3 J μg/L), and 0397 (153 JA μg/L) (Figure 4.48). The remaining wells sampled during March 1993 reported non-qualified detections for barium, ranging from 66 μg/L to 282 μg/L (Figure 4.48). No evidence of a source can be determined

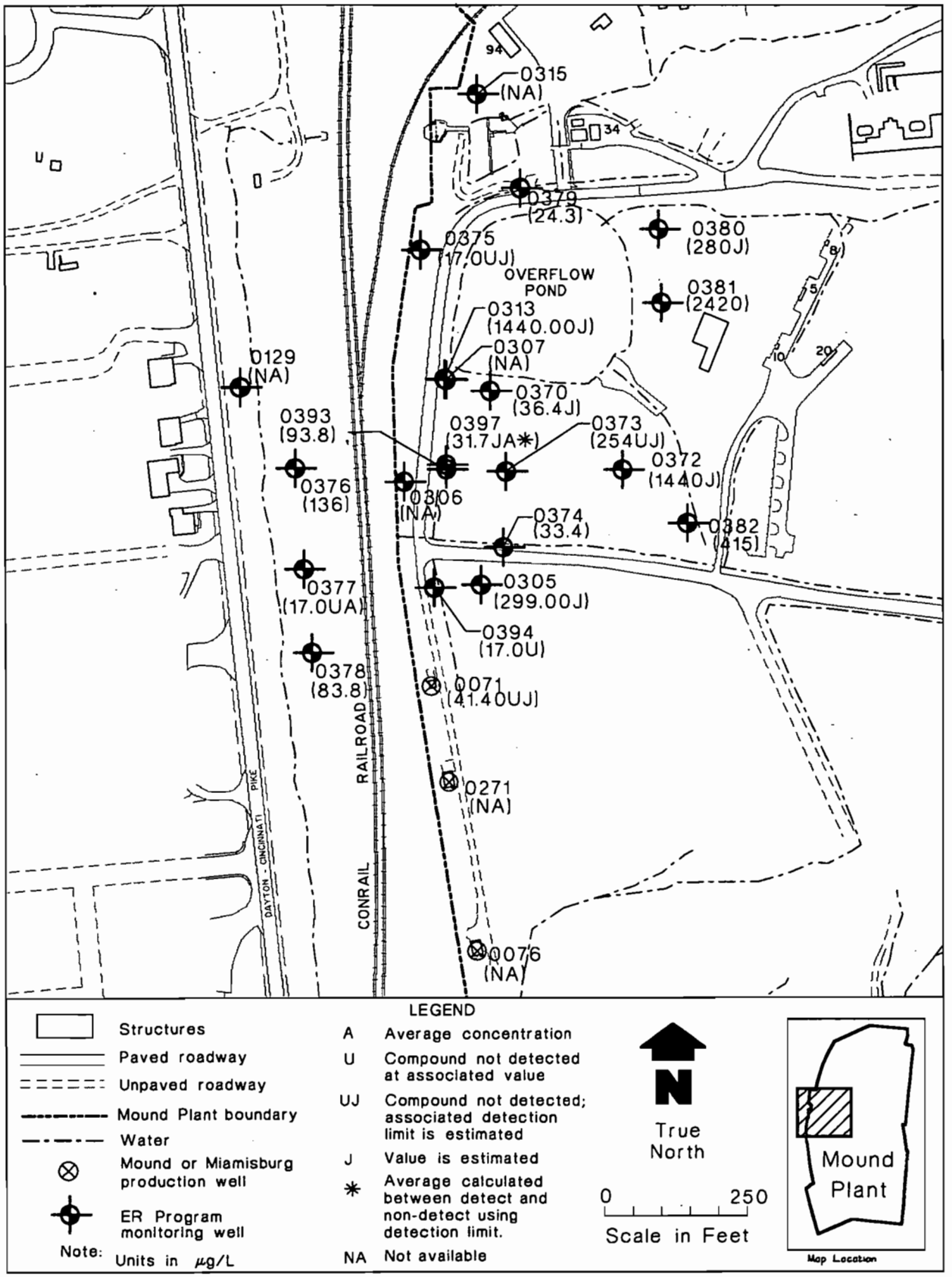


Figure 4.47. Aluminum concentrations for wells in and adjacent to Area B, March 1993.

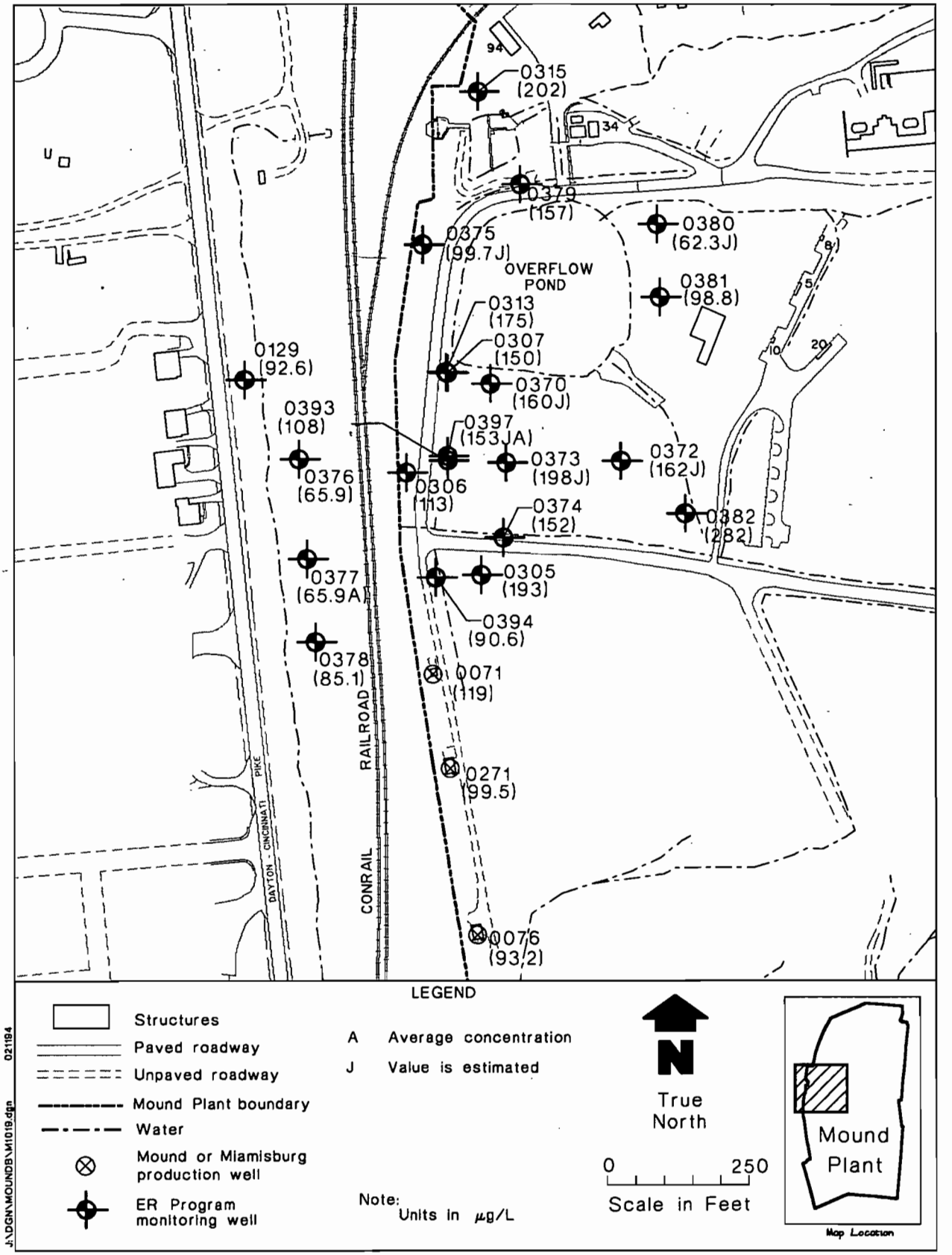


Figure 4.48. Barium concentrations for wells in and adjacent to Area B, March 1993.

from the March 1993 data. Validated detections for the past four quarters are summarized in Table A8r in Appendix A8. This data summary indicates that all wells, when sampled, reported positive values for barium. The values reported during the past four quarters range from 62.3J µg/L (0380, March 1993) to 282 µg/L (0382, March 1993).

Beryllium

No qualified or non-qualified detections of beryllium were reported for the March 1993 groundwater sampling. No validated detections have been reported for beryllium within the past four quarters.

Cadmium

No qualified or non-qualified detections of cadmium were reported for the March 1993 groundwater sampling event. No validated detections of cadmium were noted for the previous four quarters.

Calcium

All wells had non-qualified detections of calcium for March 1993 (Figure 4.49). Concentrations ranged from 34,700 µg/L at well 0380 to 1,136,000 µg/L at well 0071. All concentrations were below 180,000 µg/L, except for the concentration reported at production well 0071. Excluding the 0071 concentration, generally the highest concentrations were reported in Area B, though no pattern indicating a source location was apparent. Validated detection for the past four quarters are summarized in Table A8s of Appendix A8. This data summary indicates that all wells, when sampled, reported positive values for calcium. The values reported during the past four quarters range from 34,700 µg/L (0380, March 1993) to 1,136,000 µg/L (0071, March 1993).

Cobalt

Three non-qualified detections of cobalt were reported for March 1993 at wells 0381 (6.4 µg/L), 0306 (12.30 µg/L), and 0305 (21.00 µg/L) (Figure 4.50). Well 0381 is located along the eastern margin of Area B, upgradient from reported activities in Area B. Well 0306 is located 25 ft west of Area B and 0305 is located 50 ft south of Area B. No evidence of a source can be determined or described from the March 1993 data. Table A8t of Appendix A8 summarizes validated detections for the past four quarters. This data summary indicates that no well consistently reported positive values for cobalt. The values reported during the past four quarters range from 6.4 µg/L (0381, March 1993) to 26.2A µg/L (0305, June 1992).

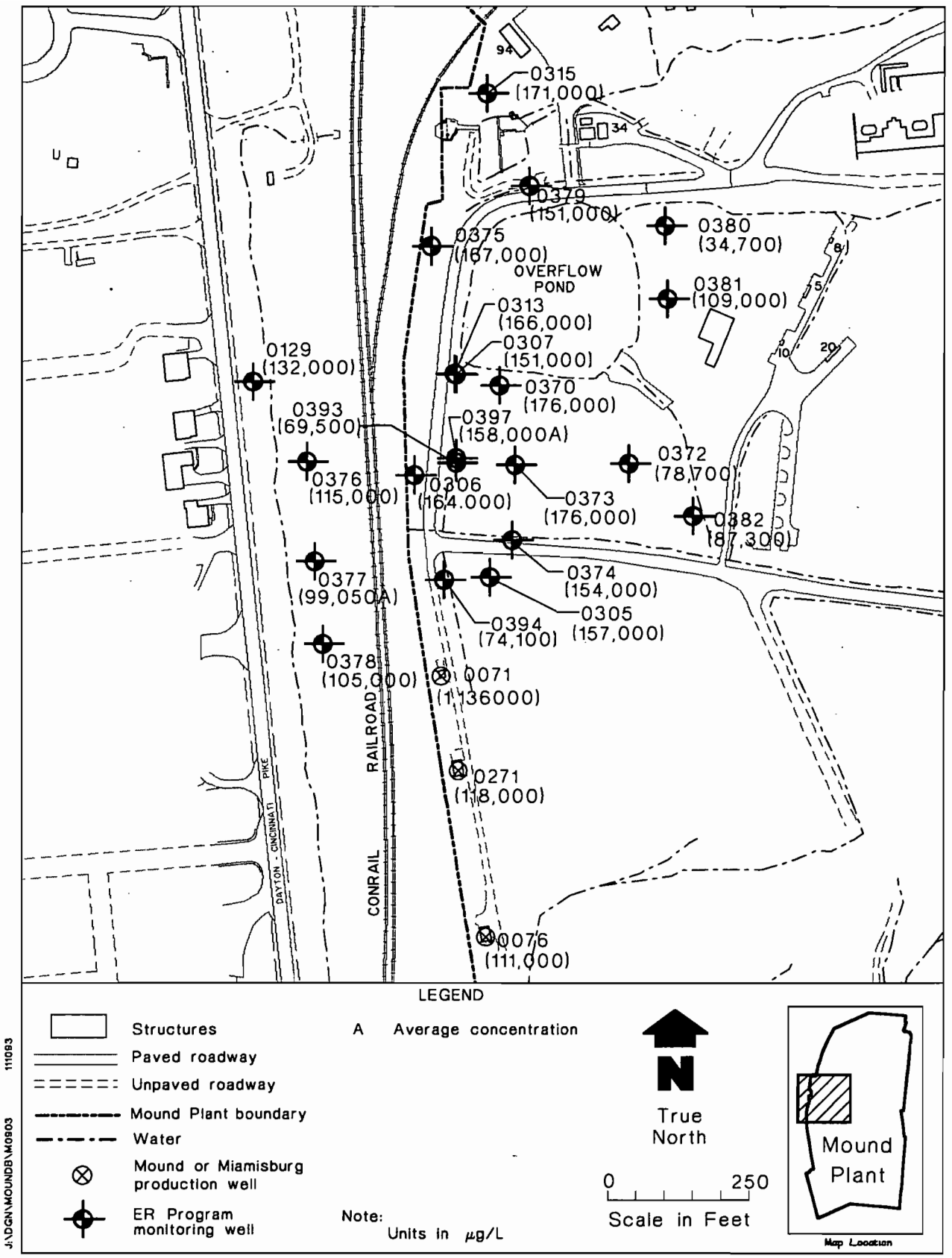


Figure 4.49. Calcium concentrations for wells in and adjacent to Area B, March 1993.

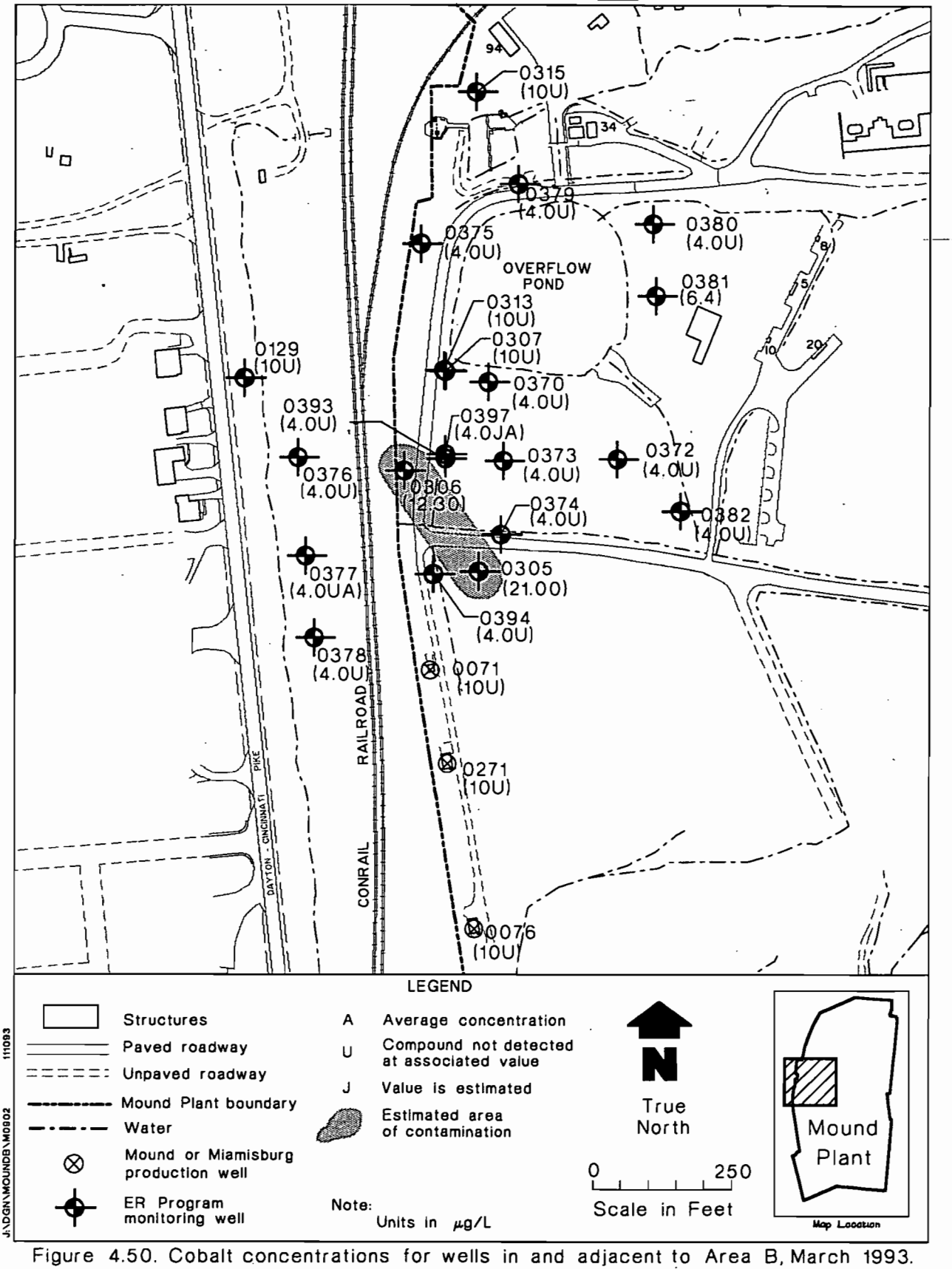


Figure 4.50. Cobalt concentrations for wells in and adjacent to Area B, March 1993.

Chromium

Six non-qualified detections of chromium were reported in March 1993 at wells 0379 (38.4 µg/L), 0313 (315.00 µg/L), 0307 (12.30 µg/L), 0306 (333.00 µg/L), 0305 (2880.00 µg/L), and 0376 (57.0 µg/L) (Figure 4.51). Wells 0307 and 0313 are a clustered well pair located along the western margin of Area B. Well 0313 is the shallow well of the cluster. Well 0306 is located 25 ft west of Area B and 0305 is located 50 ft south of Area B. Well 0376 is located offsite west of Area B. Well 0379 is located 50 ft north of Area B, upgradient of reported Area B activities. Three qualified detections were reported at wells 0380 (4.9J µg/L), 0372 (6.0J µg/L), and 0373 (4.9J µg/L) (Figure 4.51). Well 0380 is located at the northeastern margin of Area B, upgradient of reported activities at Area B. Wells 0373 and 0372 are located in Area B. The highest concentrations were reported along the western margin of Area B and south of Area B. Due to variability in detections and concentrations of chromium, a source for the chromium was not determined. Table A8u of Appendix A8 summarizes validated detections for the past four quarters. This data summary indicates that wells 0305 and 0313 consistently reported positive values for chromium. The values reported during the past four quarters range from 4.9J µg/L (0380 and 0373, March 1993) to 2880 µg/L (0305, March 1993).

Copper

During the March 1993 sampling, three qualified detections were reported for copper at wells 0374 (3.8J µg/L), 0381 (5.7J µg/L), and 0382 (6.3J µg/L). The remaining wells reported non-qualified sample results ranging from nondetect to 89.9 µg/L. Table A8v in Appendix A8 summarizes validated detections of copper for the past four quarters. This data summary indicates that wells 0305 and 0313 consistently reported positive values for copper. The values reported during the past four quarters range from 2.0J µg/L (0129, September 1992) to 95.0A µg/L (0305, June 1992).

Iron

Ten non-qualified detections of iron were reported for March 1993 at wells 0379 (570 µg/L), 0380 (621 µg/L), 0393 (365 µg/L), 0381 (4980 µg/L), 0397 (219 µg/L), 0372 (2900 µg/L), 0382 (1120 µg/L), 0394 (1080 µg/L), 0376 (3800 µg/L), and 0378 (417 µg/L) (Figure 4.52). Well 0379 is located 50 ft north and upgradient of Area B. Wells 0380, 0381, and 0382 are located along the eastern margin of Area B and are upgradient of reported Area B activities. Well 0394 is located 75 ft southwest of Area B. Wells 0376 and 0378 are located offsite to the west and southwest, respectively, of Area B. Wells 0393 and 0397 are located in Area B. Five qualified detections were reported at wells 0315 (824.00J µg/L), 0313 (7240.00J µg/L), 0306 (5850 µg/L), 0305

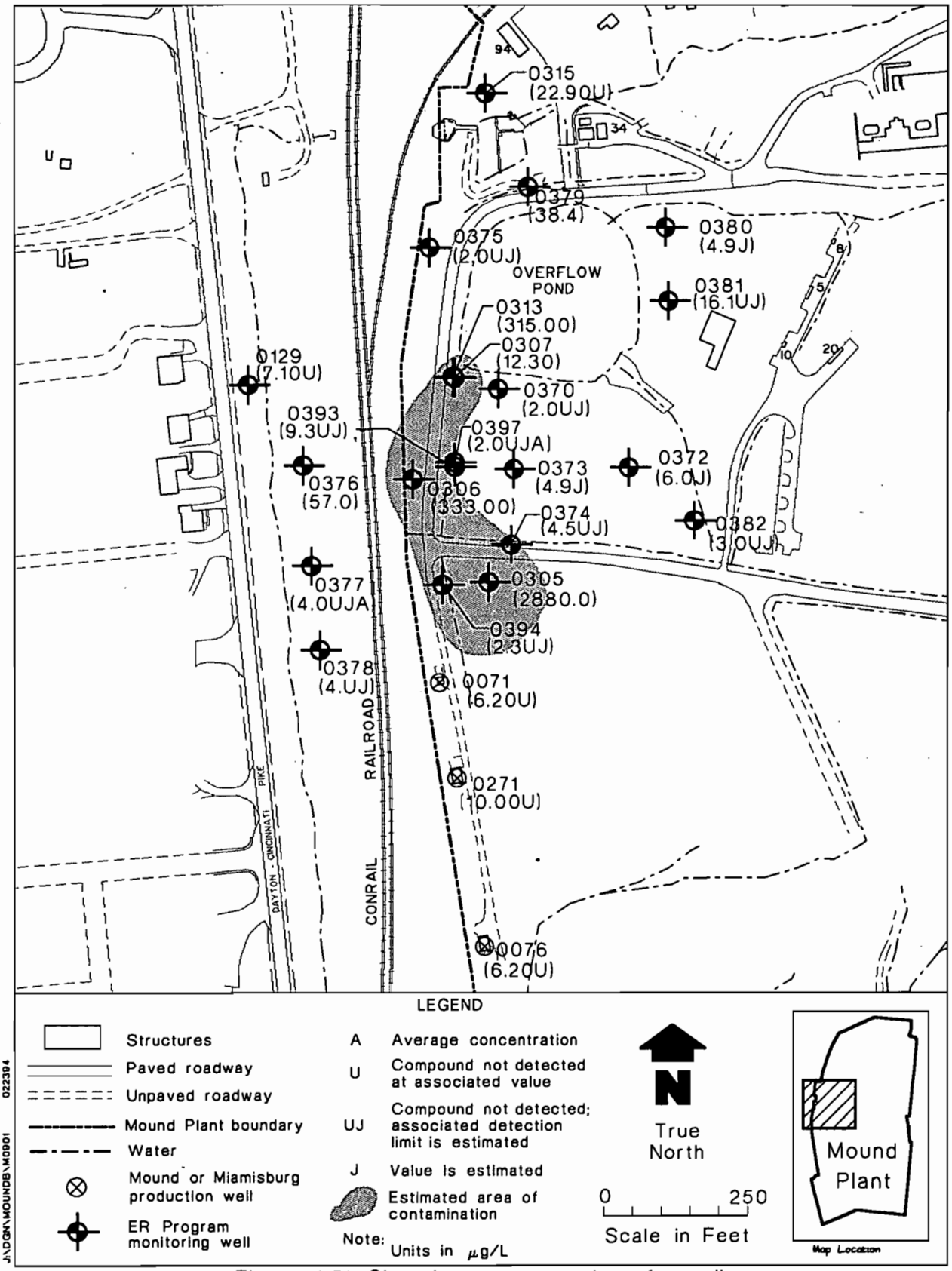


Figure 4.51. Chromium concentrations for wells in and adjacent to Area B, March 1993.

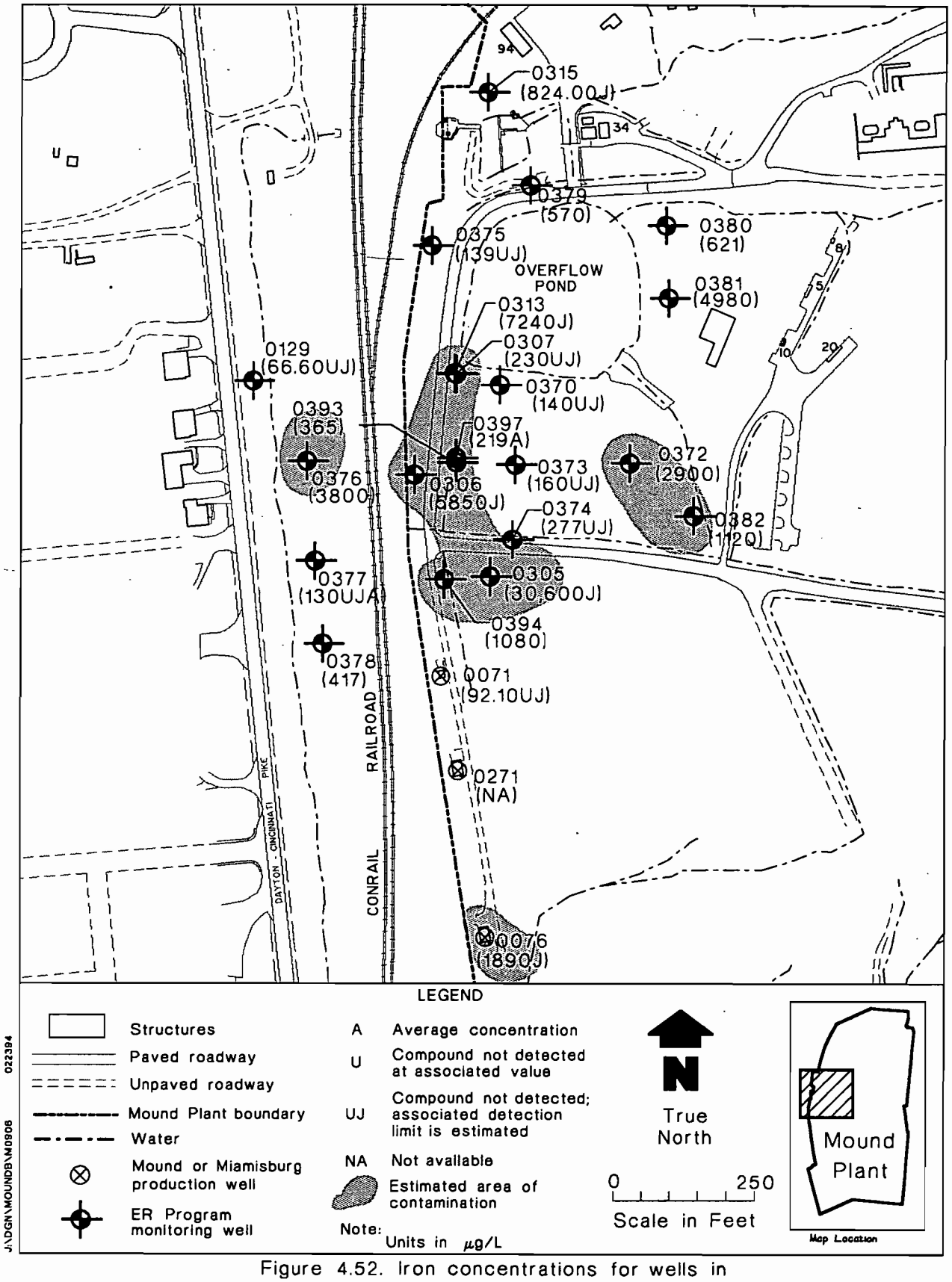


Figure 4.52. Iron concentrations for wells in and adjacent to Area B, March 1993.

(30,600 μg/L), and 0076 (1890 μg/L). Well 0315 is located north and upgradient of Area B. Well 0313 is located along the western margin of Area B. Well 0313 is the shallow well in the cluster with 0307. Well 0307 did not have a detectable concentration of iron. Well 0306 is located 50 ft west of Area B. Well 0305 is located 50 ft south of Area B. Mound production well 0076 is located south of Area B. No evidence of a source can be determined or described from the March 1993 data. Validated detections for the past four quarters are summarized in Table A8w of Appendix A8. This data summary indicates that wells 0305, 0306, 0313, and 0315 consistently reported positive values for iron. The values reported during the past four quarters range from 19.1 μg/L (0126, June 1992) to 31900A μg/L (0305, June 1992).

Lead

Five non-qualified detections of lead were reported for March 1993 at wells 0379 (3.3 μg/L), 0381 (2.5 μg/L), 0313 (1.80 μg/L), 0376 (4.3 μg/L), and 0378 (5.2 μg/L) (Figure 4.53). Well 0379 is located 50 ft north of Area B, upgradient of reported Area B activities. Well 0381 is located along the eastern margin of Area B and is upgradient of reported activities in Area B. Well 0313 is clustered with well 0307 and is located along the western margin of Area B. Wells 0376 and 0378 are located offsite and are west and southwest, respectively, of Area B. One qualified detection was reported at well 0372 (2.0J μg/L), which is located in Area B. No evidence of a lead source can be determined or described from the March 1993 data. Validated detections over the past four quarters are summarized in Table A8x of Appendix A8. This data summary indicates that well 0313 consistently reported positive values for lead, its maximum value being 8.6J μg/L in September 1992. Well 0305 reported 4.7J μg/L in June 1992, but no further detections have been reported. The values reported during the past four quarters range from 1.8 μg/L (0313, March 1993) to 9.6J μg/L (0063, September 1992).

Magnesium

All wells reported detectable concentrations of magnesium for the March 1993 sampling (Figure 4.54). Concentrations ranged from 18,600 to 63,100 μg/L. Generally, the highest concentrations are seen in wells located in Area B, though no consistent pattern was determined to pinpoint a source of magnesium. Table A8y summarizes the previous four quarters of validated detections. This data summary indicates that all wells, when sampled, reported positive values for magnesium. The values reported during the past four quarters range from 18600 μg/L (0380, March 1993) to 63100 μg/L (0370, March 1993).

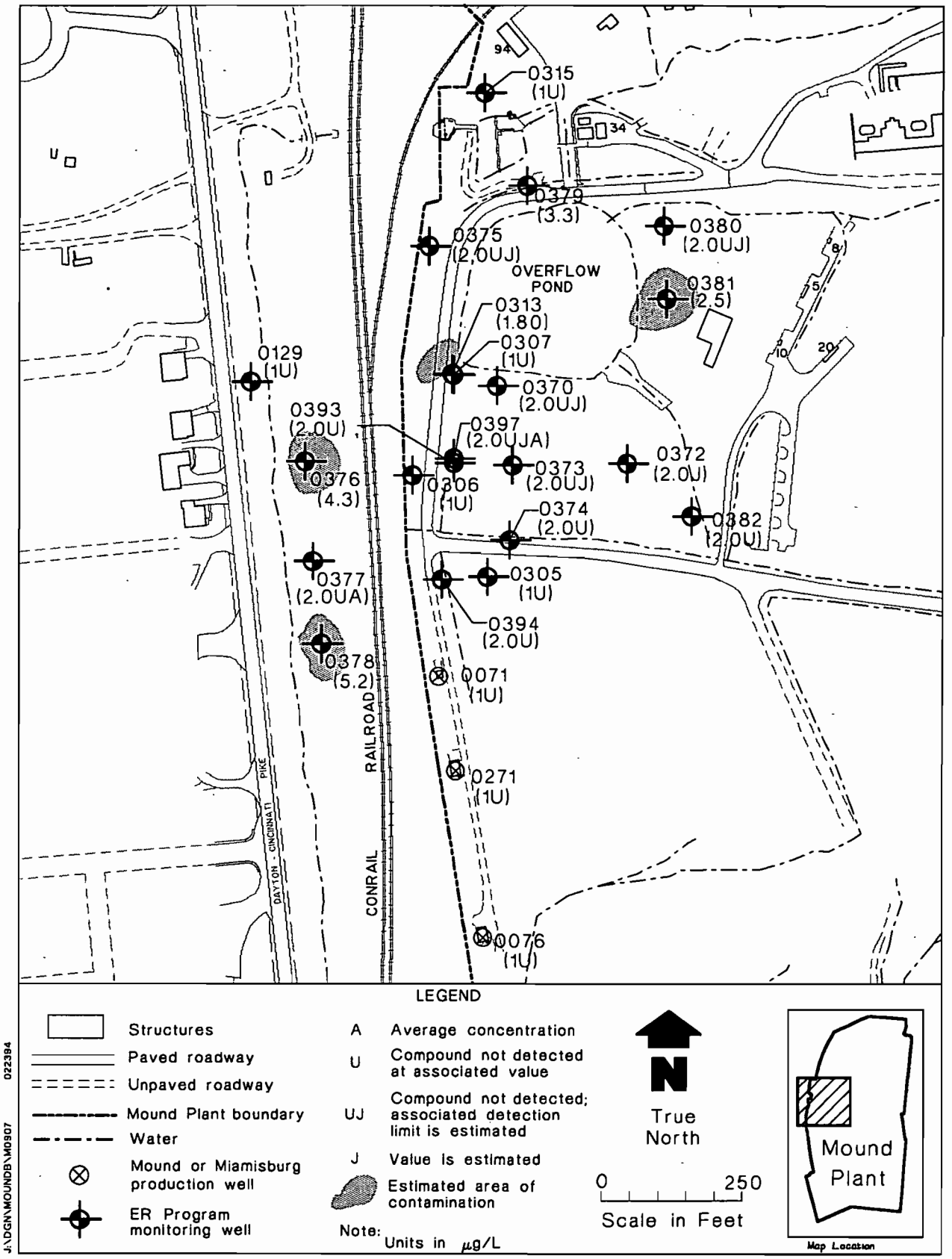


Figure 4.53. Lead concentrations for wells in and adjacent to Area B, March 1993.

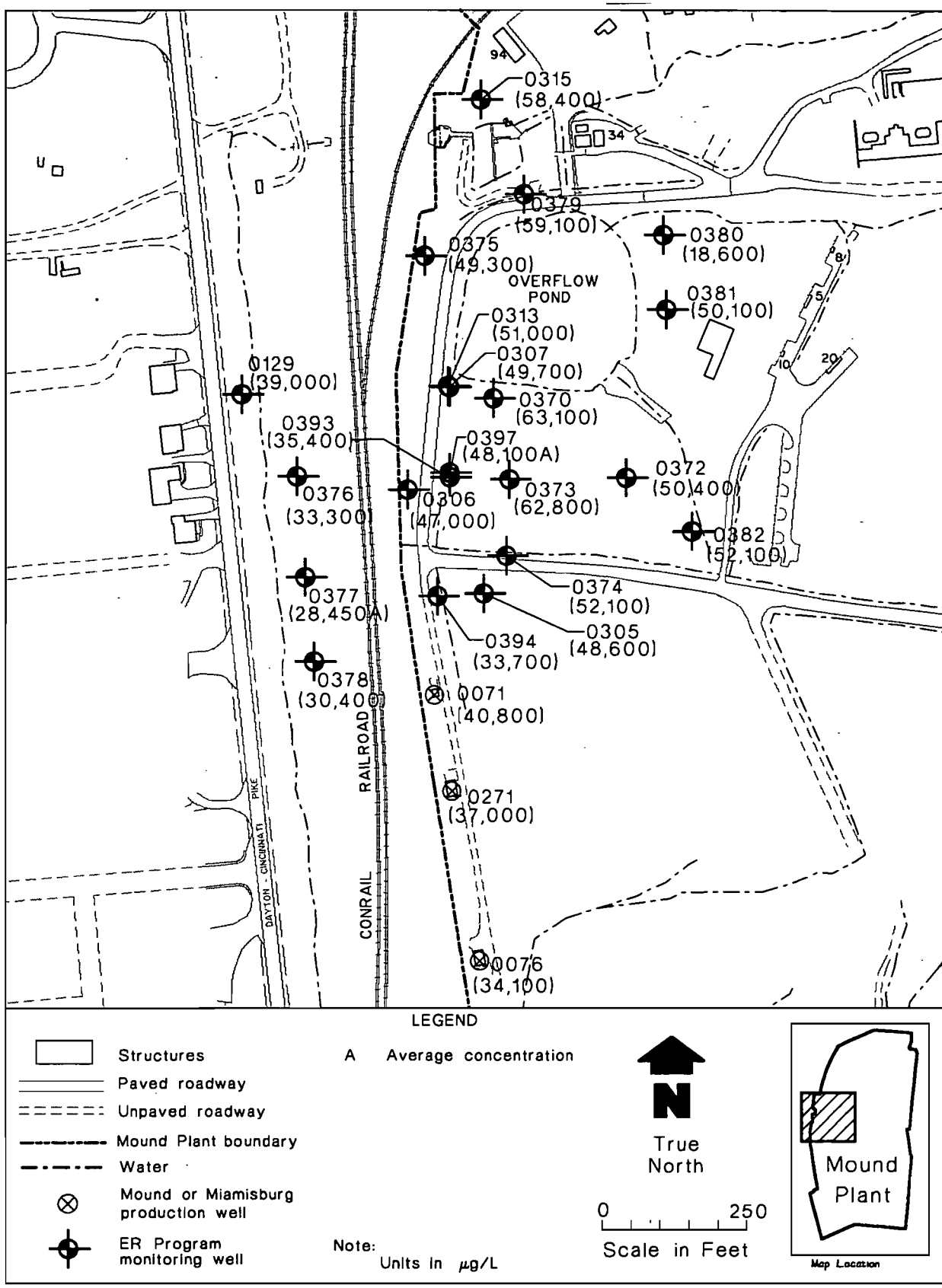


Figure 4.54. Magnesium concentrations for wells in and adjacent to Area B, March 1993.

Manganese

Manganese is not included as a contaminant of concern in the risk assessment. However, it has been the topic of past discussions due to concentrations exceeding the secondary drinking water standards, and is therefore discussed here. Twenty-one of 24 Area B wells had non-qualified detections of manganese in March 1993 (Figure 4.55). Concentrations ranged from 6.69 to 295 µg/L. The highest concentrations were generally seen in wells located in Area B, though no consistent pattern was determined to pinpoint a contaminant source of manganese. Validated detection for the past four quarters are summarized in Table A8z in Appendix A8. This data summary indicates that most wells, when sampled, reported positive values for manganese. The values reported during the past four quarters range from 2.3 µg/L (0154, September 1992) to 3806 µg/L (0123, December 1992).

Mercury

No qualified or non-qualified detections of mercury were reported for the March 1993 groundwater sampling. No validated detections were reported for the past four quarters.

Nickel

Ten non-qualified detections of nickel were reported in March 1993 at wells 0380 (8.3 µg/L), 0381 (204 µg/L), 0397 (61.8A µg/L), 0372 (18.1 µg/L), 0375 (47.7 µg/L), 0313 (425.00 µg/L), 0370 (56.7 µg/L), 0306 (221.00 µg/L), 0373 (20.2 µg/L), and 0305 (663.00 µg/L) (Figure 4.56). Wells 0380 and 0381 are located along the eastern margin of Area B, upgradient of reported activities at Area B. Wells 0370, 0313, 0373, 0374, 0397, and 0372 are located in Area B. Well 0313 is the shallow well in a cluster with 0307. Well 0307 did not have a detectable concentration of nickel. Well 0375 is located 75 ft west of the northern portion of Area B. Well 0306 is located 50 ft west of Area B. Well 0305 is located 50 ft south of Area B. Three qualified detections were reported at wells 0379 (30.8J µg/L), 0393 (11.5J µg/L), and 0376 (46.4J µg/L) (Figure 4.56). Well 0379 is located north and upgradient of Area B. Well 0376 is located offsite, west of Area B. Well 0393 is located in Area B. The detections are spatially inconsistent; therefore, a source area for the nickel could not be determined. Validated detections for the past four quarters are summarized in Table A8aa of Appendix A8. This data summary indicates that most wells, when sampled, reported positive values for nickel. The values reported during the past four quarters range from 8.3 µg/L (0380, March 1993) to 910A µg/L (0305, June 1992).

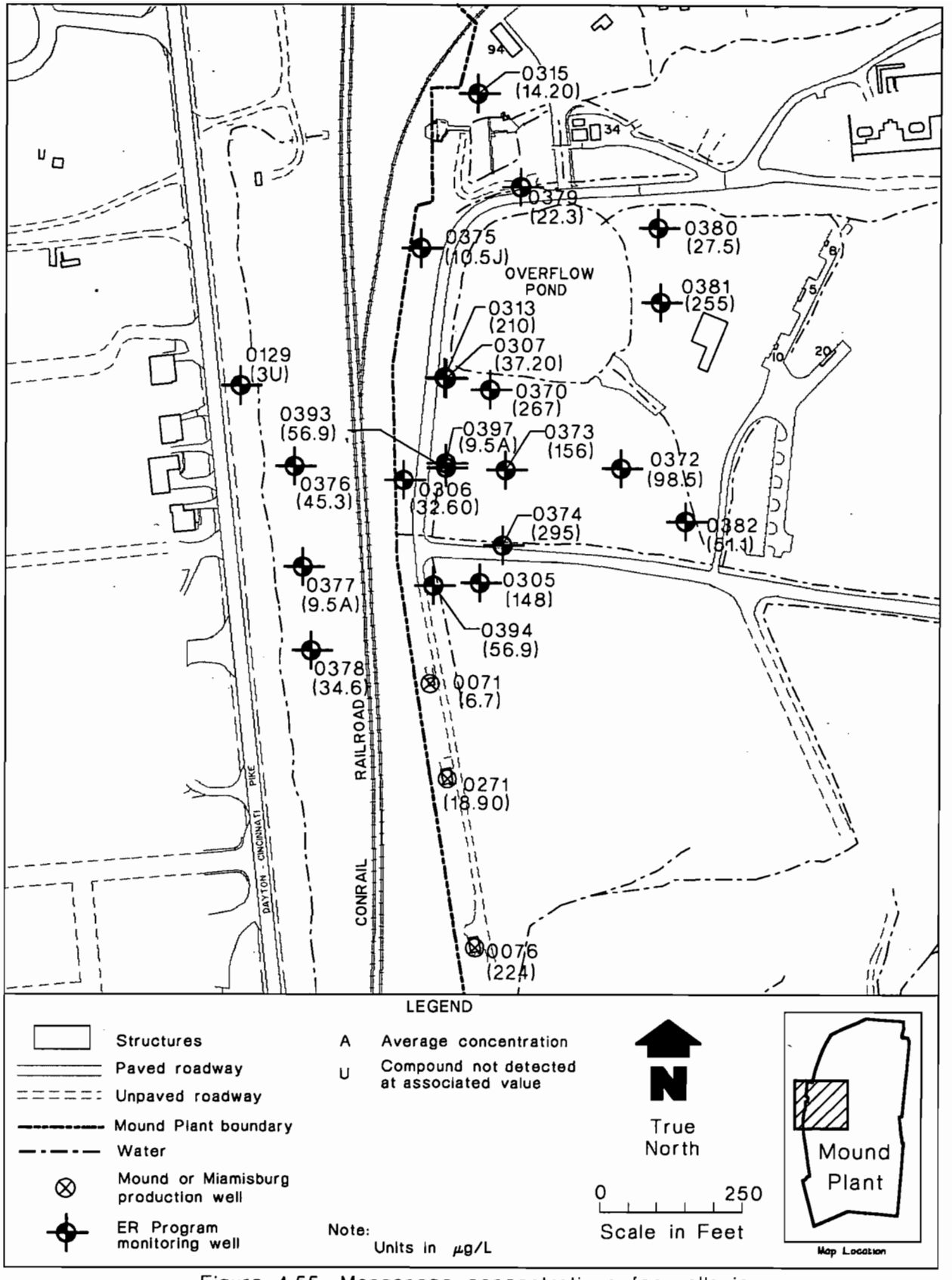


Figure 4.55. Manganese concentrations for wells in and adjacent to Area B, March 1993.

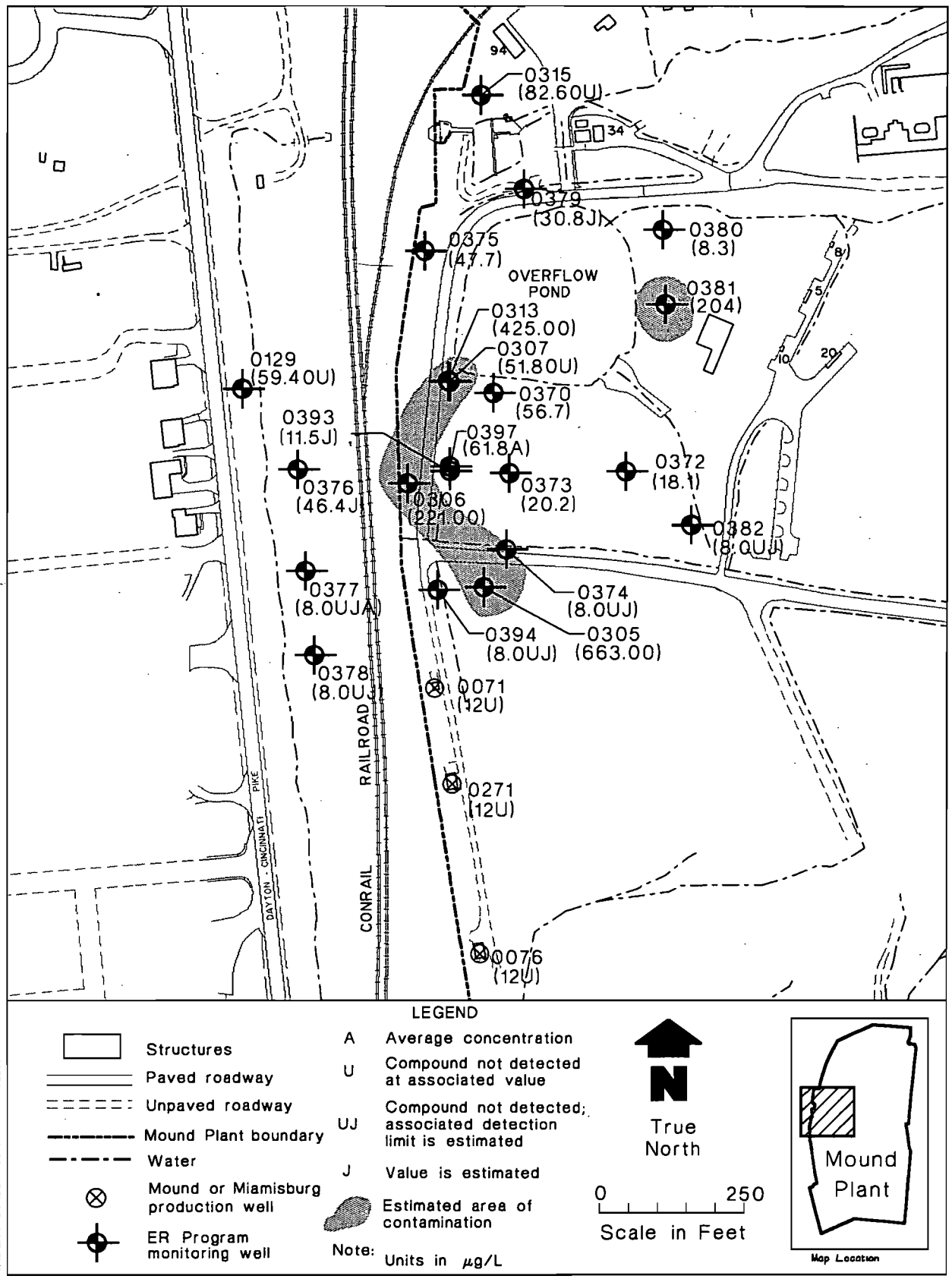


Figure 4.56. Nickel concentrations for wells in and adjacent to Area B, March 1993.

Potassium

Twenty-four non-qualified detections of potassium were reported in March 1993 (Figure 4.57). Concentrations ranged from 2780 to 30700 µg/L. The highest non-qualified concentrations were seen in wells 0380, 0381, and 0372. Wells 0380 and 0381 are located along the eastern margin of Area B, upgradient of reported Area B activities. No evidence of a source can be determined or described from the March 1993 data. Table A8bb in Appendix A8 summarizes validated detections reported during the past four quarters. This data summary indicates that most wells, when sampled, reported positive values for potassium. The values reported during the past four quarters range from 2080 µg/L (0159, June 1992) to 30700 µg/L (0380, March 1993).

Selenium

Four non-qualified detections of selenium were reported during the March 1993 sampling events: wells 0076 (1.5 µg/L), 0129 (2.2 µg/L), 0305 (1.3 µg/L), and 0306 (1.3 µg/L). One qualified detection was reported for well 0370 (2.7J µg/L). No evidence of a selenium source can be determined or described from the March 1993 data. Other than the March 1993 detections, only one other detection was reported during the past four quarters: well 0313 (3.2J µg/L, June 1992). No further detections were reported for this well.

Silver

No detections of silver were reported for the March 1993 groundwater sampling effort. Only two detections were reported for the previous four quarters: well 0126 (3.3J µg/L, September 1992) and well 0305 (9.4J µg/L, September 1992). No further detections were reported for well 0305; well 0126 has not been sampled since September 1992.

Sodium

All wells reported detectable concentrations of sodium for the March 1993 groundwater sampling (Figure 4.58). Concentrations ranged from 51,300 to 2,870,000 µg/L. Validated detections for the past four quarters are summarized in Table A8cc in Appendix A8. This data summary indicates that all wells, when sampled, reported positive values for sodium. The values reported during the past four quarters range from 28300 µg/L (0159, September 1992) to 2,870,000 µg/L (0123, March 1993).

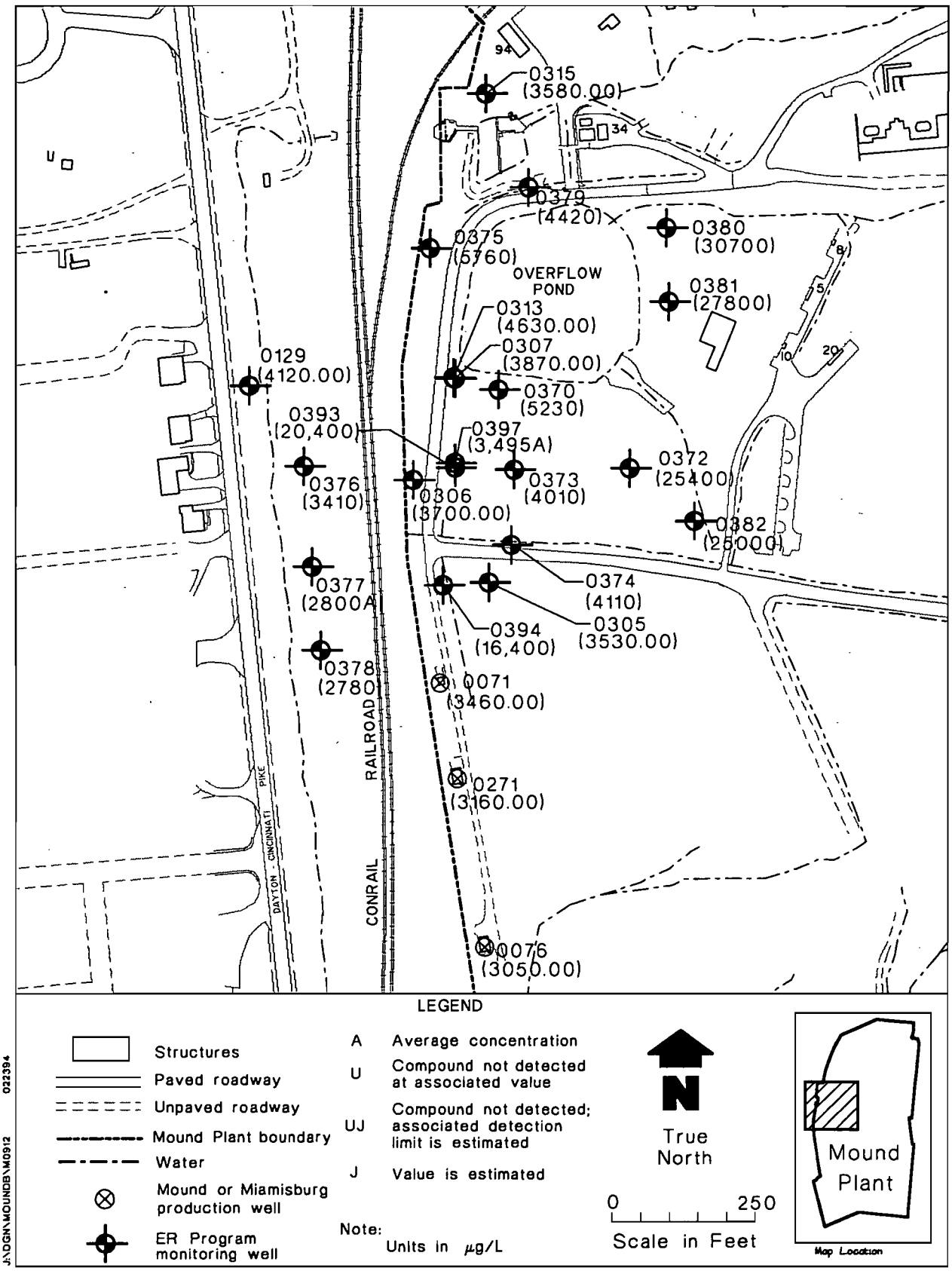


Figure 4.57. Potassium concentrations for wells in and adjacent to Area B, March 1993.

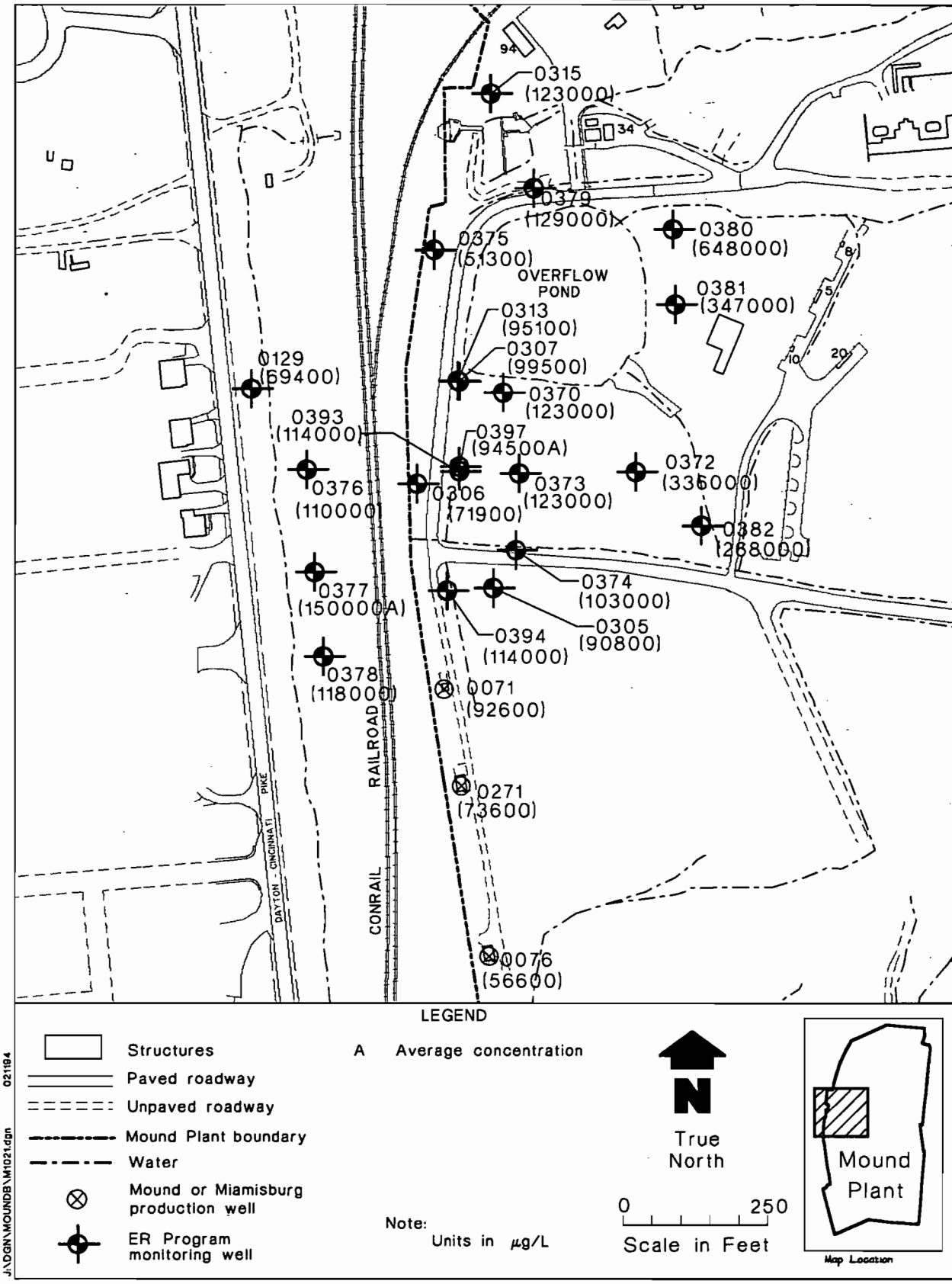


Figure 4.58. Sodium concentrations for wells in and adjacent to Area B, March 1993.

Thallium

No detections of thallium were reported for the March 1993 groundwater sampling. No detections were reported over the past four quarters, with two exceptions. In March 1992, the laboratory reported 50 B µg/L at well 0305 and 68 B µg/L at well 0313. During data validation, these results were qualified as estimated due to problems such as poor matrix spike recovery and poor post-digest spike recovery. These problems appear indicative of probable matrix interferences. Also, the laboratory failed to perform the Method of Standard Addition (MSA) to quantitate at least one of the extracts. The initial results on non-diluted sample extracts were nondetect. Re-analysis gave detected results that were high due to a 10X dilution. These re-analysis results may not be representative of actual sample composition for thallium due to the large differences between the first and second sample analysis. Additionally, well 0313 historically produces silty water and the sample result may not accurately reflect the dissolved concentration of thallium. Thallium was not detected in any other Operable Unit 1 groundwater sample taken between 1987 and March 1992, including these wells. Thallium has not been detected since the March 1992 samples. Based on the questionable validity of the data and historical results, these two results for wells 0305 and 0313 should be considered as inconclusive and not included in any risk assessment.

Vanadium

One non-qualified detection of vanadium was reported for March 1993 at well 0305 (12.7B). Well 0305 is located 50 ft south of Area B. No qualified detections were reported. No evidence of a source can be determined or described from the March 1993 data. Validated detections from the previous four quarters of data are summarized in Table A8dd of Appendix A8. This data summary indicates that only wells 0305 and 0313 usually reported positive values for vanadium. The values reported during the past four quarters range from 4.3 µg/L (0313, December 1992) to 31.4 µg/L (0313, June 1992).

Zinc

Nine detections, all qualified, for zinc were reported for the March 1993 groundwater sampling (Figure 4.59). Validated detections for the past four quarters are summarized in Table A8ee in Appendix A8. This data summary indicates that well 0313 consistently reported positive values for zinc. The values reported during the past four quarters range from 4.5J µg/L (0076, December 1992) to 915 µg/L (0063, September 1992).

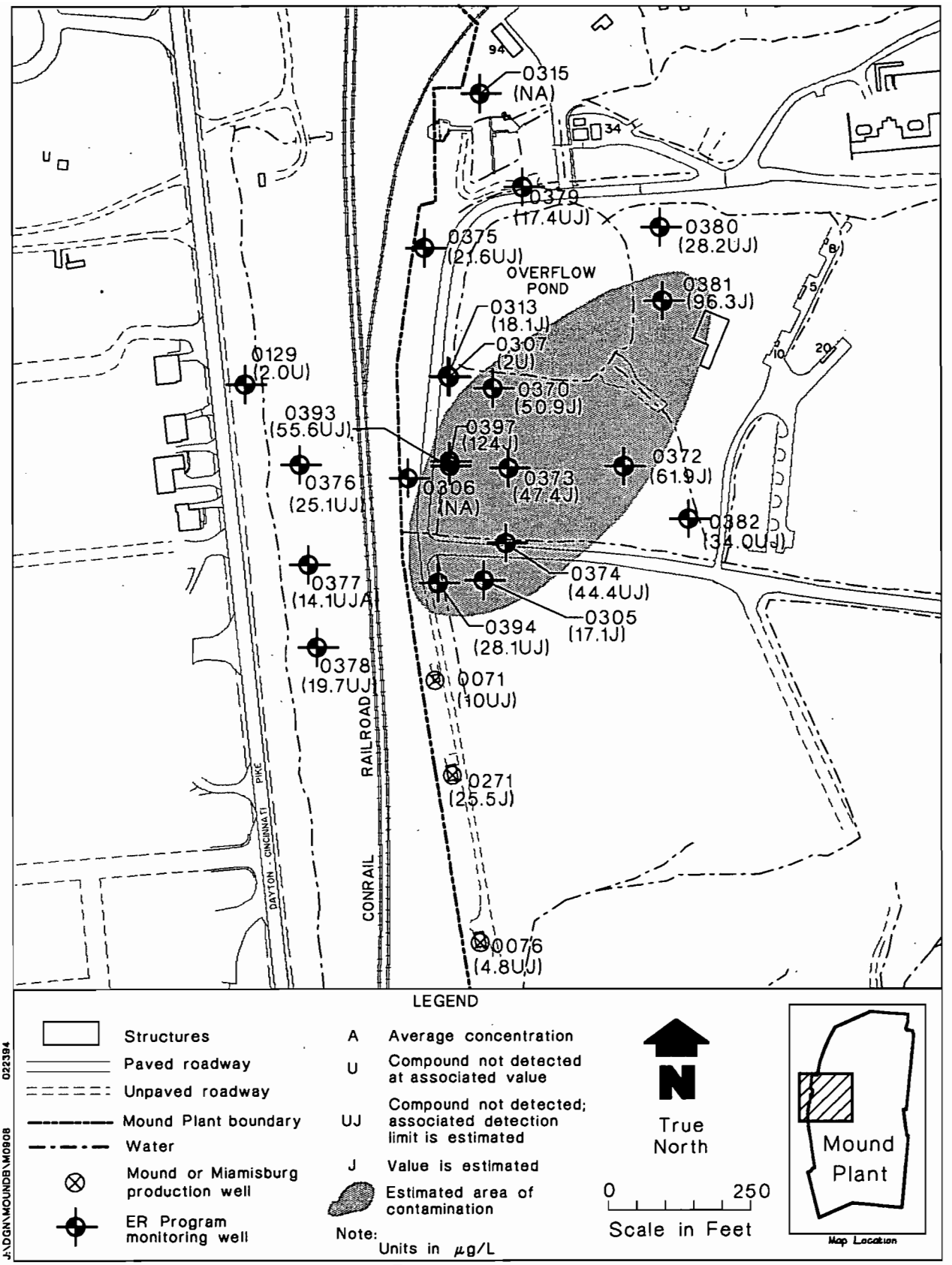


Figure 4.59. Zinc concentrations for wells in and adjacent to Area B, March 1993.

Radiological data were not collected for previously installed wells during the sampling events of December 1992 and March 1993. The most recent radiological data collected for previously installed wells was the September 1992 sampling event. Radiological data were collected during March 1993 for newly installed wells. Therefore, the following discussions utilize the September 1992 and March 1993 data for previously installed wells and newly installed wells, respectively.

Plutonium-239/240

Twelve detections of plutonium-239/240 were reported for March 1993 at wells 0370 (0.145 pCi/L), 0372 (0.182 pCi/L), 0373 (0.144 pCi/L), 0374 (0.196 pCi/L), 0377 (0.095 pCi/L), 0378 (0.186 pCi/L), 0379 (0.085 pCi/L), 0380 (0.151 pci/L), 0382 (0.117 pCi/L), 0393 (0.131 pCi/L), 0394 (0.133 pCi/L), and 0397 (0.120A pCi/L) (Figure 4.60). Wells 0377 and 0378 are located offsite, west of Area B. Well 0379 is located north of area B, upgradient of reported activities at Area B. Well 0394 is located south of Area B. All other wells are within Area B. Two detections of plutonium 239/240 were reported for September 1992 at wells 0307 (0.0488 pCi/L) and 0063 (0.679 pCi/L). Both wells are located in Area B. Well 0307 is the deeper well in the cluster with well 0313. Well 0313 did not have a detectable concentration of plutonium-239/240. No evidence of a source can be determined or described from these detections.

Plutonium-238

Three detections for plutonium-238 were reported for the March 1993 data at wells 0372 (0.036 pCi/L), 0375 (0.196 pCi/L), and 0376 (0.316 pCi/L). Wells 0375 and 0376 are located west of Area B. Well 0372 is located within Area B. No detections were reported for September 1992. Data locations are spatially insufficient to determine a source of the plutonium-238.

Potassium-40

No detections of potassium-40 were reported for either March 1993 or September 1992 groundwater sampling efforts.

Strontium-90

Only one detection of strontium-90 was reported for the March 1993 data at well 0372 (1.77 pCi/L). Well 0372 is located within Area B. No detections were reported for the September 1992 groundwater sampling event.

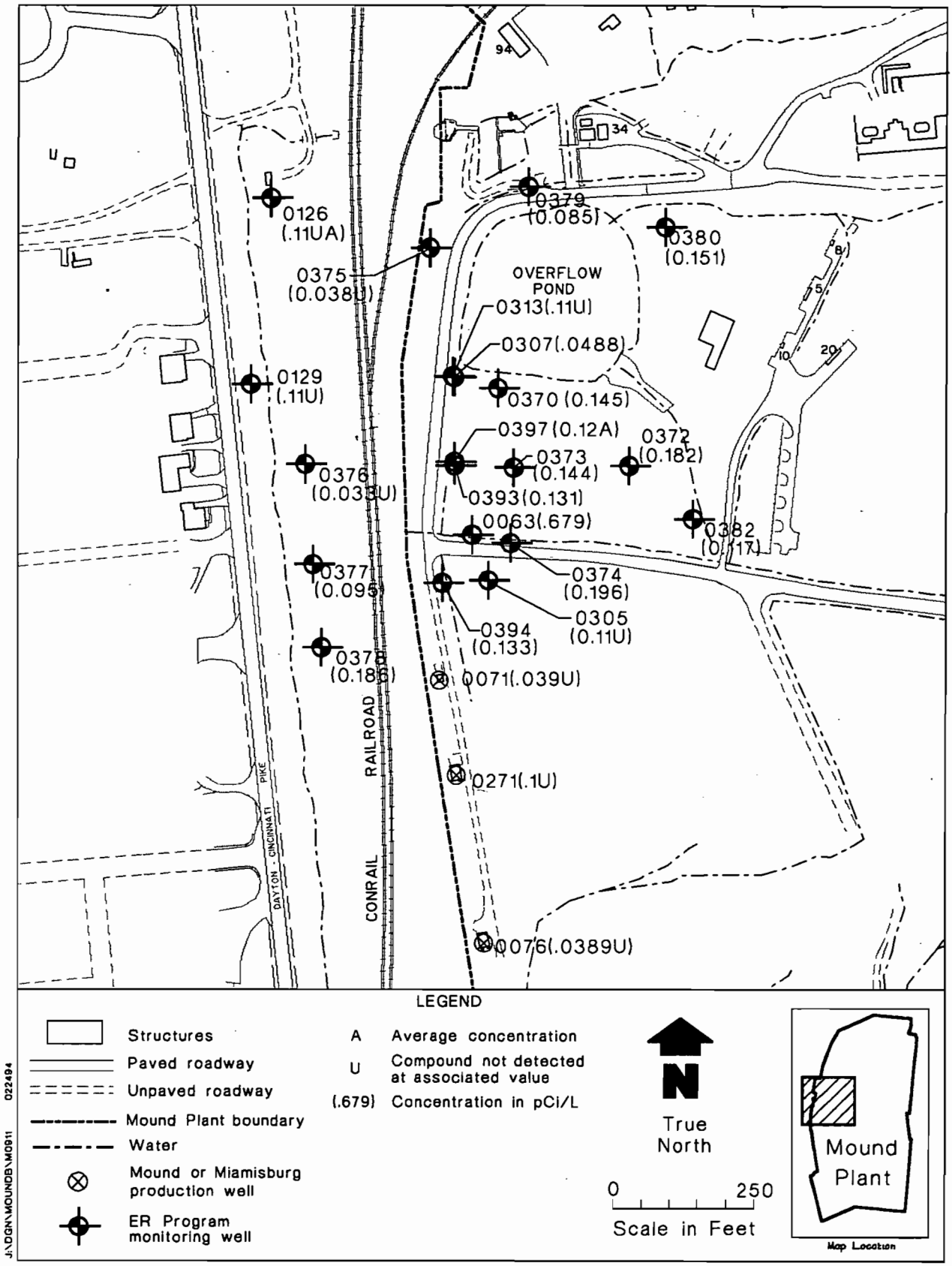


Figure 4.60. Plutonium 239/240 concentrations for wells in and adjacent to Area B, September 1992 and March 1993.

Actinium-227

March 1993 groundwater samples were not analyzed for actinium-227. Four detections were reported for September 1992 at wells 0126 (0.32 pCi/L), 0271 (0.355 pCi/L), 0307 (0.275 pCi/L), and 0313 (2.27 pCi/L).

Thorium-228

Two detections for thorium-228 were reported during March 1993 at wells 0372 (0.123 pCi/L) and 0397 (0.113 pCi/L). Both wells are located within Area B. One detection of thorium-228 was reported for September 1992 at well 0313 (0.293 pCi/L). Well 0313 is located in Area B and is the shallow well in the cluster with 0307. Well 0307 did not have a reportable concentration of thorium-228. Data locations were not spatially sufficient to determine a source of thorium-228.

Thorium-230

Nine detections of thorium-230 were reported in March 1993 at wells 0370 (0.189 pCi/L), 0372 (0.058 pCi/L), 0375 (0.163 pCi/L), 0376 (0.162 pCi/L), 0378 (0.234 pCi/L), 0380 (0.092 pCi/L), 0382 (0.101 pCi/L), 0393 (0.16 pCi/L), and 0394 (0.094 pCi/L) (Figure 4.61). Wells 0375, 0376, and 0378 are located west of Area B. Well 0394 is located south of Area B. The remaining wells are located within Area B. Seven detections of thorium-230 were reported for September 1992 at wells 0063 (3.17 pCi/L), 0313 (.225 pCi/L), 0307 (.323 pCi/L), 0129 (.18 pCi/L), 0071 (.613 pCi/L), 0271 (.142 pCi/L), and 0076 (.57 pCi/L) (Figure 4.61). Wells 0313, 0307, and 0063 are located in Area B. Well 0313 is the shallow well in the cluster with 0307. Well 0129 is located offsite, west of Area B. Wells 0071, 0271, and 0076 are located south of Area B. No evidence of a source can be determined or described from the September 1992 or March 1993 detections.

Tritium

Detections for tritium were reported in all wells sampled in March 1993, with the exception of well 0372 (Figure 4.62). The detected concentrations ranged from a minimum of 0.421 nCi/L at well 0380 to a maximum of 8.57 nCi/L at well 0394. Tritium was detected in all sampled wells in September 1992 except for bedrock well 0309, located south of Area B, and well cluster 0159, 0160, located offsite and southwest of Area B (Figure 4.62). Concentrations ranged from 1.420 nCi/L to 10.600 nCi/L. Tritium concentrations were generally highest in wells located in Area B. Tritium results reported in Table A7 (Appendix A) are expressed in pCi/L. Data were spatially insufficient to determine the source of the tritium contamination.

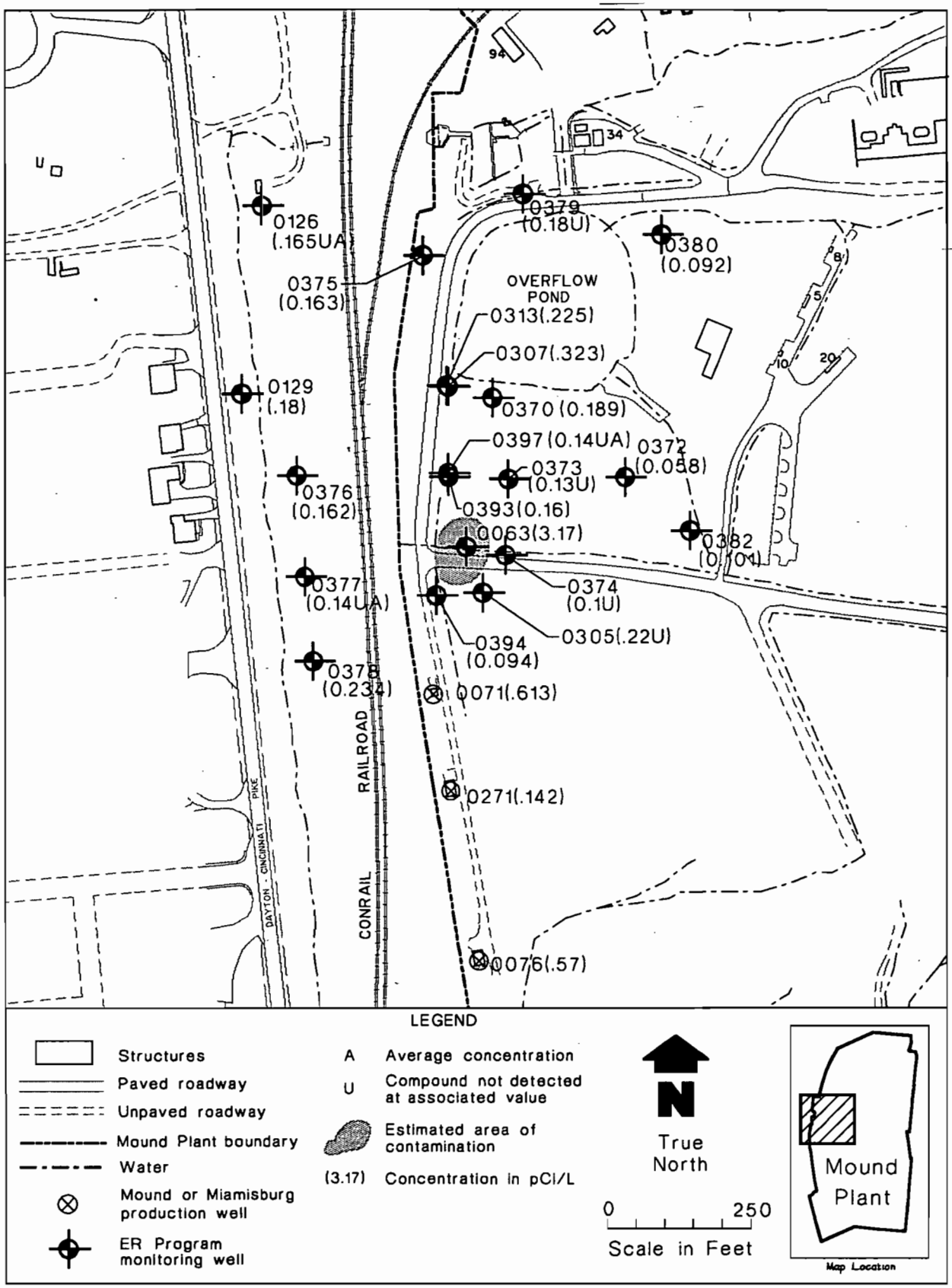


Figure 4.61. Thorium-230 concentrations for wells in and adjacent to Area B, September 1992 and March 1993.

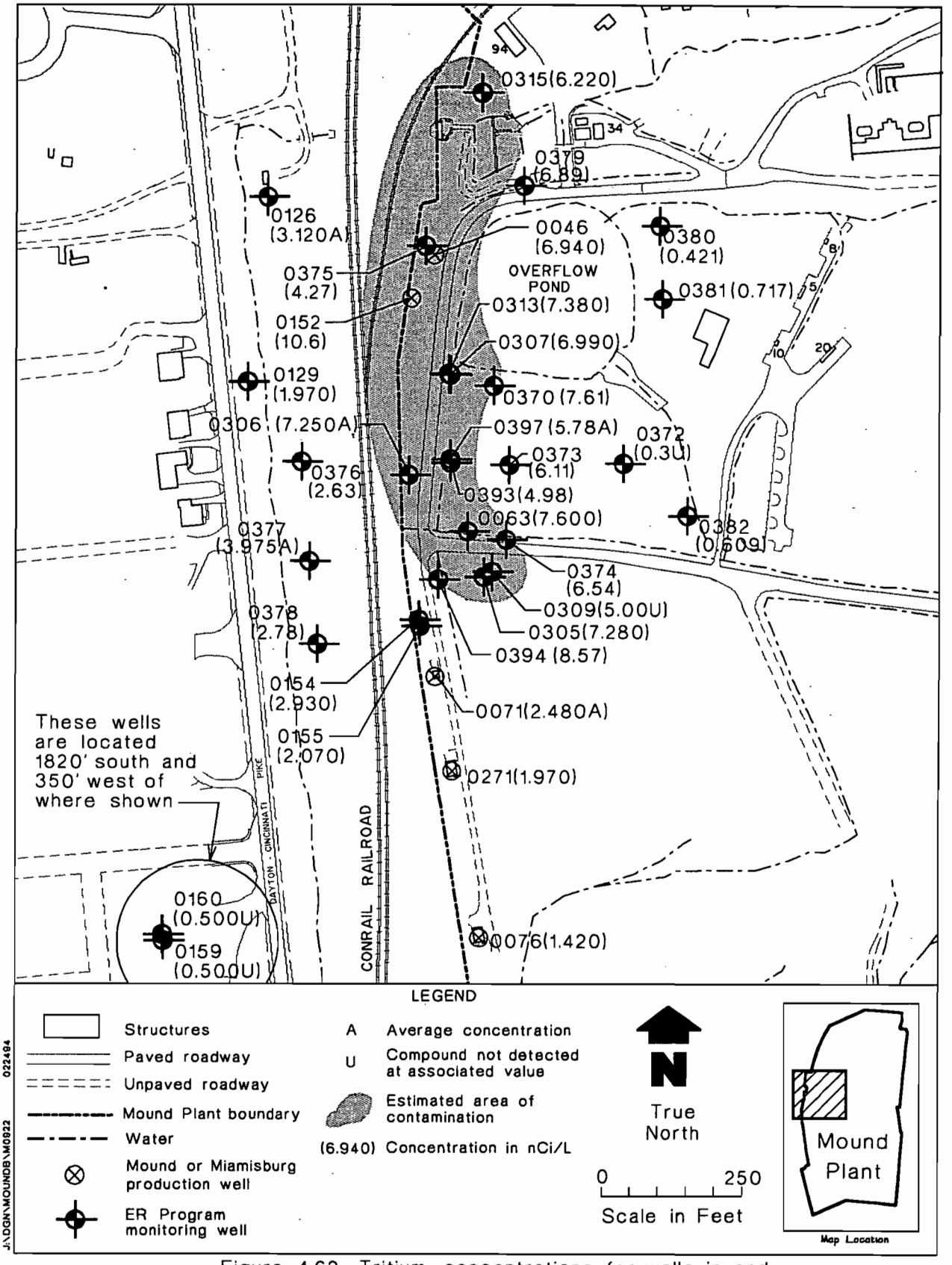


Figure 4.62. Tritium concentrations for wells in and adjacent to Area B, September 1992 and March 1993.

Uranium-234

All wells reported detections for uranium-234 for March 1993, with the exception of well 0380. The reported concentrations ranged from a minimum of 0.185 pCi/L at well 0374 to a maximum of 1.23 pCi/L at well 0374 (Figure 4.63). Seven detections of uranium-234 were reported for September 1992 at wells 0126 (.432A pCi/L), 0313 (.749 pCi/L), 0307 (1.03 pCi/L), 0063 (.451 pCi/L), 0305 (.635 pCi/L), 0071 (.701 pCi/L), and 0076 (.394 pCi/L) (Figure 4.63). Well 0126 is located offsite, west of the northern portion of Area B. Wells 0313 and 0307 are a clustered pair located on the western margin of Area B. Well 0313 is the shallow well in the cluster. Well 0063 is located along the southern margin of Area B. Well 0305 is located 50 ft south of Area B. Mound production wells 0071 and 0076 are located to the south of Area B. Data were spatially insufficient to determine the source of the uranium-234.

Uranium-235/236

Two detections were reported for March 1993 at well 0372 (0.047 pCi/L) and well 0373 (0.075 pCi/L). Both wells are located within Area B. One detection of uranium-235/236 was reported in September 1992 at well 0307 (0.121 pCi/L). Well 0307 is located in Area B and is the deep well in the cluster with 0313. No evidence of a source can be determined from these groundwater sampling events.

Uranium-238

Detections for uranium-238 were reported in all wells sampled during March 1993, with the exception of wells 0380 and 0382 (Figure 4.64). The reported concentrations ranged from a minimum of 0.133 pCi/L at well 0394 to a maximum of 2.3 pCi/L at well 0370. Eight detections of uranium-238 were reported for September 1992 at wells 0126 (0.338 pCi/L), 0129 (0.196 pCi/L), 0313 (0.718 pCi/L), 0307 (0.787 pCi/L), 0063 (0.451 pCi/L), 0305 (0.663 pCi/L), 0071 (0.488 pCi/L), and 0271 (0.348 pCi/L) (Figure 4.64). Wells 0126 and 0129 are located offsite to the west of Area B. Wells 0313 and 0307 are a clustered pair located on the western margin of Area B. Well 0313 is the shallow well in the cluster. Well 0063 is located along the southern margin of Area B. Well 0305 is located 50 ft south of Area B. Mound production wells 0071 and 0271 are located to the south of Area B. The highest uranium-238 concentrations were reported at wells 0313 and 0307. Data were spatially insufficient to determine the source of the uranium-238.

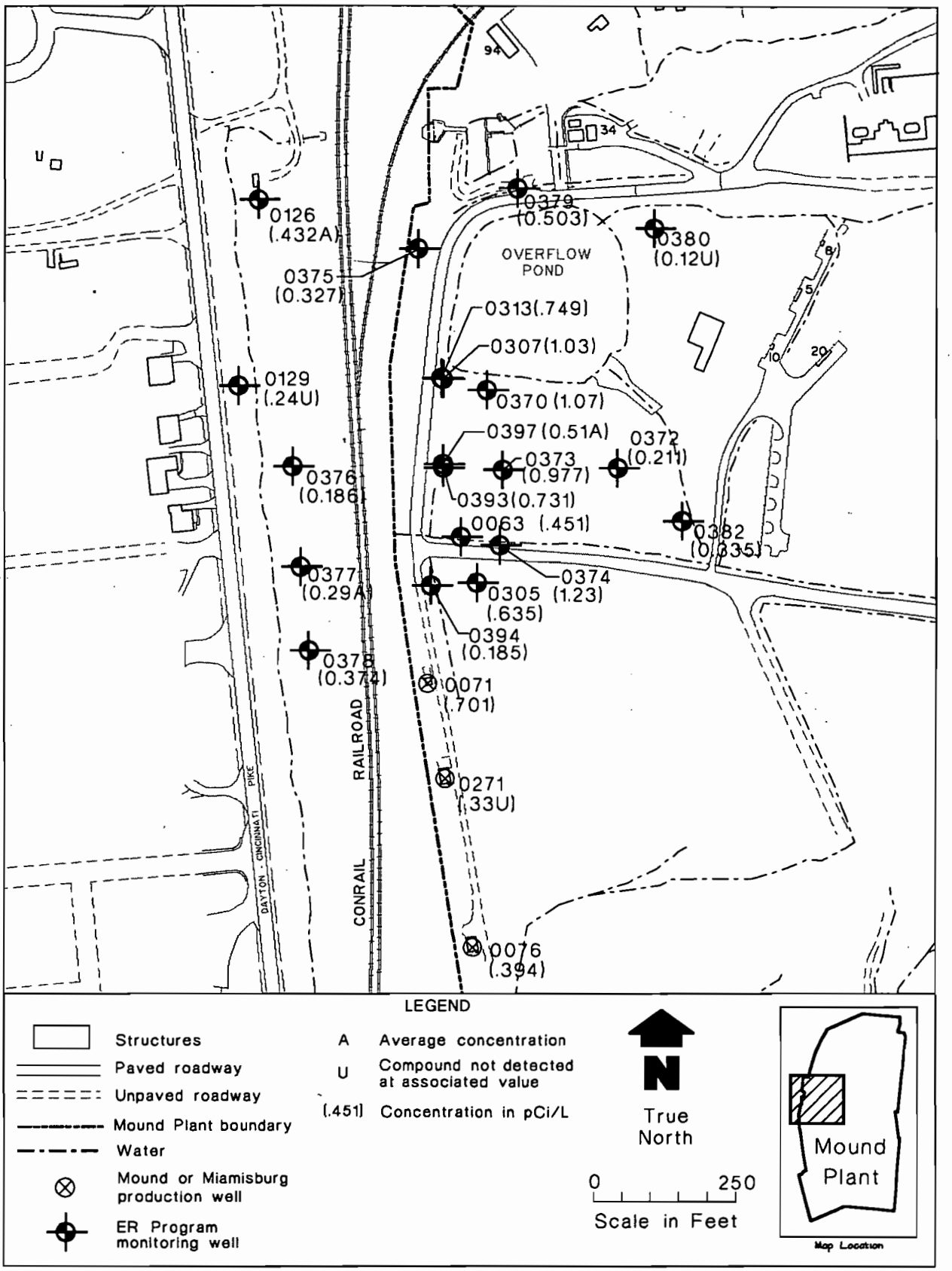


Figure 4.63. Uranium-234 concentrations for wells in and adjacent to Area B, September 1992 and March 1993.

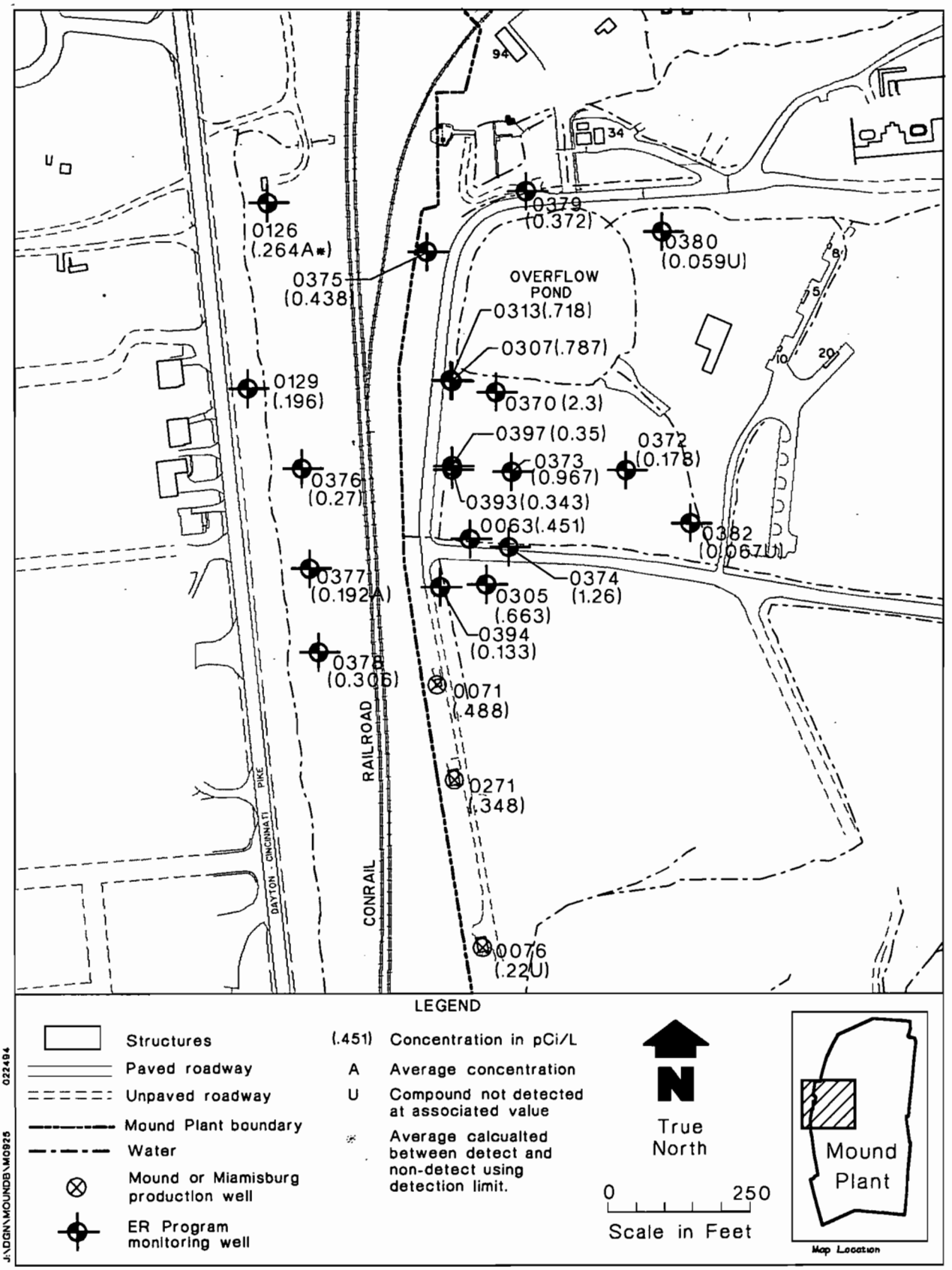


Figure 4.64. Uranium-238 concentrations for wells in and adjacent to Area B, September 1992 and March 1993.

Radium-226

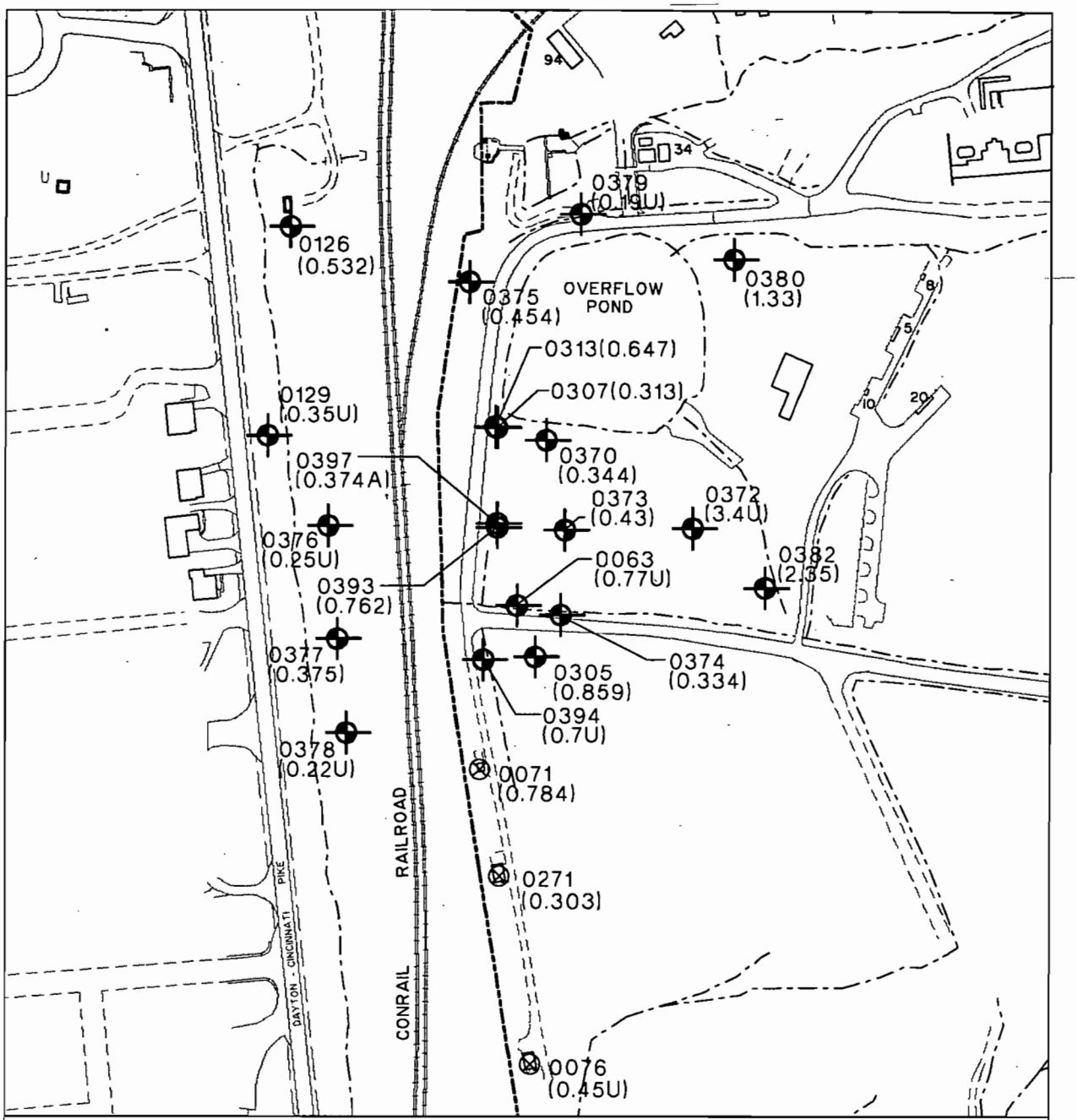
Nine detections for radium-226 were reported for March 1993 at wells 0370 (0.344 pCi/L), 0373 (0.43 pCi/L), 0374 (0.334 pCi/L), 0375 (0.454 pCi/L), 0377 (0.375 pCi/L), 0380 (1.33 pCi/L), 0382 (2.35 pCi/L), 0393 (0.762 pCi/L), and 0397 (0.374A pCi/L) (Figure 4.65). Wells 0375 and 0377 are located west of Area B. All other wells are located within Area B. Seven detections were reported for September 1992 at wells 0071 (0.784 pCi/L), 0118 (0.394 pci/L), 0126 (0.532 pCi/L), 0271 (0.303 pCi/L), 0305 (0.859 pCi/L), 0307 (0.313 pCi/L), and 0313 (0.647 pCi/L) (Figure 4.65). Mound production wells 0071 and 0271 are located to the south of Area B. Well 0118 is located offsite and north of Area B. Well 0126 is located offsite and west of Area B. Well 0305 is located just south of Area B. Wells 0307 and 0313 are a clustered pair located on the western margin of Area B. Well 0313 is the shallow well in the cluster. No evidence of a source can be determined or described from these detections.

A review of the VOC analytical data taken since 1991 shows that there has been no major change in the concentrations measured in wells in Area B. Concentrations appear to fluctuate seasonally, possibly caused by changes in the source of recharge with time. Another possible source is the flushing from unsaturated sediments by higher water levels.

The possible relation to flushing was examined by considering correlations between concentrations of various constituents and groundwater elevation. The graphs in Appendix L illustrate the observed relationships. These graphs were chosen because sufficient data were available to make a graph and they are generally representative of the variety of groundwater conditions found at Area B.

Some of these graphs indicate a strong correlation (PCE Concentration and Water Level - Well 0153 and TCE Concentration and Water Level - Well 0153). Some of these graphs indicate a moderate correlation (Tritium Concentration and Water Level - Well 0305 and TCE Concentration and Water Level - Well 0305). Some of these graphs indicate a weak correlation (PCE Concentration and Water Level - Well 0063, Iron Concentration and Water Level - Well 0063, PCE Concentration and Water Level - Well 0305, Manganese Concentration and Water Level - Well 0305, and Tritium Concentration and Water Level - Well 0315). Other graphs indicate no correlation (TCE Concentration and Water Level - Well 0046, Chromium Concentration and Water Level - Well 0313, and TCE Concentration and Water Level - Well 0315).

Generally, the correlation appears to be strongest for the volatiles (TCE and PCE) in the shallow groundwater directly west of the landfill, as represented by data from well 0153. Some correlation appears to exist between groundwater levels and metals and tritium concentration, but the correlation



LEGEND

- Structures
- Paved roadway
- Unpaved roadway
- Mound Plant boundary
- Water
- ⊗ Mound or Miamisburg production well
- ER Program monitoring well
- (.451) Concentration in pCi/L

A Average concentration

U Compound not detected at associated value

N True North

0 250 Scale in Feet

Mound Plant

Map Location

022294

J:\DGN\MOUNDB\M1028

Figure 4.65. Radium-226 concentrations for wells in and adjacent to Area B, September 1992 and March 1993.

tends to be weak to moderate. Given the lack of definite, strong, consistent correlations, comparisons of precipitation to groundwater quality were not performed. The correlations of water level and contaminant concentration serve to establish the relationship.

It is likely that pumping from well 0076 for the plant water supply also affects the concentration of VOCs within the groundwater and the potential for movement offsite by acting as a discharge point for groundwater. The probable explanation for the distribution of contamination within Area B is a combination of all these factors.

4.4. CONTAMINANT MIGRATION

Of primary concern is the potential for contaminant movement from Area B offsite and away from the Mound Plant, as well as the potential for movement toward the existing Mound Plant production wells. The following sections present information on the chemical and physical properties of the contaminants of concern and the potential for these contaminants to move from currently detected locations.

Concentrations of VOCs, polynuclear aromatic hydrocarbons, plutonium-238, thorium, and tritium have been detected in the groundwater and soils beneath Area B. The contaminants detected in Area B are believed to have resulted from past disposal activities within the area. The contaminated soils area is suspected as the primary source of VOCs in the groundwater because these soils were derived from the area encompassing the historic landfill. Landfill operations included the disposal of solvents and semivolatile oils. The contamination in these sediments probably migrated slowly from the source area, resulting in the attenuated concentrations observed in the monitoring wells.

The soils and groundwater data do not indicate a discernible pattern or a particular area where a potential source might exist, although the detections appear concentrated in the location of the historic landfill. The distribution of contaminants appears related to past disposal activities within Area B.

4.4.1. Constraints on VOC Migration

The migration rates of an organic compound in the saturated zone are controlled by the chemical and physical properties of the compound and the hydraulic and geochemical properties of the matrix (aquifer fabric). The primary VOCs of concern in groundwater in Area B are TCE, PCE, 1,2-DCE, tetrachloromethane, trichloromethane, and vinyl chloride. As discussed below, these contaminants are moderately to highly mobile within the groundwater system. The physical constraints limiting movement through Area B are the hydraulic conductivity, porosity, clay content, and organic content of the vadose zone materials.

Organic and Clay Mineral Content

Table IV.7 lists the percentages of organic content found in the core samples taken during the 1992 to 1993 well installation program. For the samples tested from boreholes within Area B, organic content values ranged from 0.5 to 3.9 percent, with an average of 1.6 percent. Because the boreholes were drilled within Area B, these data provide an estimate of the relative organic content within the nearby soils at similar depths.

The adsorption capacity of unconsolidated subsurface material is dependent on the specific clay minerals present. The natural soil type at Area B consists of the Miamian and Fairmont series soils. The Miamian series includes clay and silt loams. The Fairmont series includes silty clay loam. The clay mineralogy for these soil types is a mixed mineralogy class that consists of montmorrilinite, illite, stilbite, and kaolinite. Many of the soils at Area B are not natural soils, but reworked soils. Soil samples collected during the well installation program show that the reworked soils are similar in mineralogy to the natural, in-place soils. The difference between the two will be in the soil structure. For example, the reworked soils may be more compacted than the natural soils.

Contaminant migration could also be controlled by the soil structure. The properties of the unconsolidated materials were identified in geotechnical samples collected in 1992 to 1993. These samples identified varying fractions of gravel (0 to 75 percent), sand (6 to 77 percent), silt (0 to 47 percent), and clay (0 to 47 percent) and an organic content of 0.5 to 3.9 percent. Based on these results and the description of the soil types at Area B, the adsorption capacity of the clay fraction of soil may be a significant mechanism in controlling subsurface contaminant migration at Area B. Contaminants may preferentially migrate through macropores that exist between the sand and gravel particles.

Adsorption and Partitioning

The adsorption and partitioning of contaminants between the dissolved phase in groundwater and the adsorbed phase in soil are described in the following paragraph, transcribed from Freeze and Cherry (1979).

> "Adsorption reactions for contaminants in groundwater are normally viewed as being very rapid relative to flow velocity. The amount of the contaminant that is adsorbed by the solids (i.e., the degree of adsorption) is commonly a function of the concentration in solution. The partitioning of solutes between liquid and solid phases in a porous medium, as determined by laboratory experiments, is commonly expressed

in two-ordinate graphical form where mass adsorbed per unit mass of dry solids (S) is plotted against the concentration of the constituent in solution (C). These graphical relations of S versus C and their equivalent mathematical expressions are known as isotherms. For solute species at low to moderate concentrations, straight-line graphical relations are commonly obtained over large ranges of concentration. The S versus C data can be plotted as a straight line on an arithmetic plot. Such an isotherm is termed linear and can be expressed as

$$dS/dC = K_d$$

where K_d is known as the distribution coefficient. This parameter is widely used in studies of groundwater contamination. K_d is a valid representation of the partitioning between liquid and solid only if the isotherm is linear.

K_d values are normally reported in milliliters per gram (ml/g). Distribution coefficients for reactive solutes range from near zero to 1000 mL/g or greater. If K_d = 1 mL/g, the midconcentration point of the solute would be retarded relative to the bulk groundwater flow by a factor between 5 and 11. For K_d values that are orders of magnitude larger than 1, the solute is essentially immobile (Freeze and Cherry 1979)."

The K_d values calculated for the VOC contamination in Area B ranged from 0.04 (1,2-DCE) to 4.83 (PCE).

During the Stage 3 RI well installation, saturated soil samples were collected from three monitoring wells (0305, 0307, and 0313) along the southern and western periphery of Area B. Groundwater was also sampled at each of these wells. The solute contaminant concentration for each sample was determined and a K_d determined for 1,2-DCE, TCE, PCE. The K_d is calculated by dividing the adsorbed concentration by the dissolved concentration. The K_d values were 0.09 for 1,2-DCE, 1.21 for TCE, and 3.39 for PCE. Given the large range in variability of organic content in the soils in Area B, these numbers compare well to those calculated above.

4.4.2. Potential for Movement Offsite

The potential for movement of VOCs and radionuclides away from Area B in groundwater is evaluated by the physical properties of the aquifer and the physical and chemical properties of the contaminant in question. The physical and chemical properties of the vadose zone and aquifer materials are

discussed in subsection 4.4.1. The chemical and physical characteristics of the individual contaminants are discussed the following sections.

Chemical and Physical Properties of COCs

Table IV.18 summarizes the chemical and physical properties of those compounds identified as chemicals of concern, through the risk assessment (Section 5) that may be used in developing remedial technologies and actions. These chemicals of concern include PCE, TCE, vinyl chloride, tetrachloromethane, 1,2-*cis*-DCE, trichloromethane, benzo(a)pyrene, dioxins, Aroclor-1248, and alpha chlordane. The chemical and physical properties presented include water solubility, boiling point, melting point, vapor pressure, molecular weight, specific gravity, octanol-water partition coefficient (K_{ow}), soil adsorption coefficient (K_{oc}), and physical form (Table IV.18). Some additional source physical or chemical characteristics were not determined because of the indirect characterization approach or lack of available published information. Their characteristics include temperature, pH, viscosity, cohesiveness, photodegradation rates, and hydrolysis rates. The water solubility, K_{ow}, and K_{oc} are the most important controls of a chemical species' mobility in groundwater.

The K_{ow} is a function of the water solubility and of the sorptive capacity of the organic compound onto organic material in the soils. The K_{ow} is calculated experimentally by measuring the distribution of an organic chemical between octanol and water in contact with each other at equilibrium conditions. Compounds with high octanol/water coefficients tend to avoid the aqueous phase and may remain in environmental soils longer. Conversely, compounds with low coefficients tend to move in the aqueous phase and are considered mobile and transitory in the groundwater. No relative scale for persistence has been established.

The K_{oc} is also a function of water solubility and of the sorptive capacity of the organic compound onto organic material in the soils. The K_{oc} is calculated experimentally and expressed by the following formula:

$$K_{oc} = \frac{\text{g chemical/g organic carbon}}{\text{g chemical/g water}}$$

The following is a classification scheme for mobility of organic contaminants based on K_{oc} (NWWA 1989):

$K_{oc} < 75$ = Very High Mobility
$75 < K_{oc} < 100$ = High Mobility
$100 < K_{oc} < 500$ = Medium Mobility
$500 < K_{oc}$ = Low Mobility

Table IV.18. Chemical and Physical Properties of Chemicals of Concern at Area B

Contaminant	Water Solubility[a]	Boiling Point °C	Melting Point °C	Vapor Pressure[b]	Molecular Weight	Specific Gravity[c]	K_{ow}	K_{oc}	Physical Form
Trichloroethene	1100	86.7	-84.8	58.0	131.0	1.46[d]	263	104	Liquid
Tetrachloroethene	200	121.1	-22.4	18.5	166.0	1.59[d,e]	2512	238	Liquid
1,2-*cis*-Dichloroethene	800[f,g]	60[f]	-81.0[f]	200.0[f]	96.95[f]	1.28[f]	72.4[q]	35.0[q]	Liquid
Tetrachloromethane	805[g]	76.7	-23.0	115	154.0	1.59[d,e]	676	110	Liquid
Vinyl Chloride	8800	-13.4	-153.8	2976	62.5	0.91[h,i]	22.9	135	Liquid
Benzo(a)pyrene	0.003[j]	495[j]	177[j]	5.49×10^{-9}[j]	252.3[j]	1.351[i,k]	1.10×10^{6}[j]	3.98×10^{5}[j]	Solid
Aroclor 1248 (PCB)	0.006[j]	NA	-7[j]	4.94×10^{-4}[j]	288[j]	NA	1.29×10^{6}[j]	4.37×10^{5}[j]	Liquid
Alpha Chlordane[p]	0.056	175	105	9.8×10^{-6}	409.8	1.57[e,n]	3.47×10^{5}	3.80×10^{4}	Liquid
Dioxins[o]	0.0002[l]	412[j]	303[j]	7.20×10^{-10}[j]	322[j]	1.827[l,m]	4.37×10^{6}[j]	4.57×10^{6}[j]	Solid
Trichloromethane	7950	61.2	-63.5	197.0	119.4	1.48[o]	93.33	45.0	Liquid

All data were obtained from USEPA Database of Chemical Properties for SARA, Section 313 Chemicals, 1989, unless otherwise indicated.
NA - Not Available
[a]Water Solubility in mg/L at 25°C
[b]Vapor pressure in mmHg at 25°C
[c]Specific gravity at 20°C
[d]Windholz, M. (Ed), Merck Index, 9th edition, Merck & Co., 1976
[e]Determination at 25 C
[f]Verschueren, K., 1983
[g]Determination at 20 C
[h]Verschueren, K., 1977
[i]Determination at 15 C
[j]Montgomery and Welkom, 1990
[k]Determination at 0 C
[l]EPA 1980a (Dioxins, EPA-600/2-80-197)
[m]Determination at -1 C
[n]IRIS - The Integrated Risk Information System
[o]Values reported are for 2378-TCDD
[p]Values reported are for technical mixture of chlordane
[q]Values reported are for 1,2-DCE

Trichloroethene - Mobility and Persistence

The dominant process for removing TCE from shallow soil and surface water is volatilization into the atmosphere. Volatilization rates depend upon water temperature and movement, contaminant depth, and air movement above the water or soil surface. Once in the atmosphere, TCE is degraded through reaction with hydroxyl radicals to form hydrochloric acid, carbon monoxide, carbon dioxide, and carboxylic acid (ATSDR 1988).

The K_{oc} value (104) indicates that TCE has medium mobility through soils and will not partition significantly from water to soil. The relatively low K_{ow} value (263) indicates that TCE tends to move in an aqueous phase and that TCE is expected to leach from soils to groundwater. The low concentrations of TCE reported in the groundwater samples are well below the solubility limit; there is no evidence of dense, non-aqueous phase liquid (DNAPL) formation. Considering the low concentration, shallow source, and lack of vertical gradients, TCE should be transported by groundwater in the shallow parts of the aquifer. TCE should remain soluble in the groundwater and is not expected to partition back into the sediments.

TCE may biodegrade, although the process does not occur to any significant extent in surface soils (ATSDR 1988). TCE biodegrades to 1,2-*cis*-DCE (and possibly 1,2-*trans*-DCE) and then to chloroethane and vinyl chloride (Kloepfer et al. 1985; Wilson and Wilson 1985; Cline and Viste 1985; Barrio-Lage et al. 1986). Vinyl chloride and 1,2-*cis*-DCE behave very differently from TCE (see below). The rates of biodegradation of TCE in subsurface soils vary considerably with the type of soil, water chemistry, hydrologic conditions, microbe level, humus content, temperature, pH, Eh, amount of oxygen present, and amount of other nutrients present. Biodegradation of TCE to vinyl chloride has been accomplished within months under laboratory conditions (Barrio-Lage et al. 1986). However, field conditions are not accurately simulated by laboratory conditions. Hence, the biodegradation rate of TCE to 1,2-*cis*-DCE and, in turn, to vinyl chloride within and adjacent to Area B may be significantly slower than the rate observed under laboratory conditions. In the absence of biodegradation or volatilization, TCE may be relatively persistent in the environment.

Tetrachloroethene - Mobility and Persistence

PCE has a vapor pressure of 18.5 millimeters (mm) of mercury at 25°C and is reported to volatilize rapidly from water. Volatilization of PCE from surface water depends upon temperature, water movement, and depth, and the movement of air above the water surface.

The K_{oc} value (238) indicates that PCE has medium mobility through soils and will not partition significantly from water to soil. The relatively low K_{ow} value (2512) indicates that PCE tends to move in an aqueous phase and that PCE is expected to leach from soils to groundwater. The low concentrations of PCE reported in the groundwater samples are well below the solubility limit; there is no evidence of DNAPL formation. Considering the low concentration, shallow source, and lack of vertical gradients, PCE should be transported by groundwater in the shallow parts of the aquifer. PCE should remain soluble in the groundwater and is not expected to appreciably partition back into the sediments.

The most important transformation process for PCE in natural water systems and soils is biodegradation, even though this process does not occur rapidly (ATSDR 1987). Biodegradation rates of PCE in subsurface soils vary considerably with the type of soil, water chemistry, hydrologic conditions, types of microbes, humus content, temperature pH, Eh, amount of oxygen, and the presence of other nutrients. PCE biodegrades to TCE and, in turn, to 1,2-*cis*-DCE and then to vinyl chloride (Kloepfer et al. 1985; Wilson and Wilson 1985; Cline and Viste 1985; Barrio-Lage et al. 1986). The biodegradation products of PCE are much more mobile, as can be seen by comparing the K_{OC} and K_{OW} values in Table IV.18.

<u>1,2-*cis*-Dichloroethene - Mobility and Persistence</u>

The K_{oc} value (35.0) indicates that 1,2-*cis*-DCE tends to have high mobility in soils and will not partition significantly from water to soil. The low K_{ow} value (72.4) indicates that 1,2-*cis*-DCE tends to move in an aqueous phase and that 1,2-*cis*-DCE is expected to leach from soils to groundwater. The low concentrations of 1,2-*cis*-DCE reported in the groundwater samples are well below the solubility limit; there is no evidence of DNAPL formation. Considering the low concentration, shallow source, and lack of vertical gradients, 1,2-*cis*-DCE should be transported by groundwater in the shallow parts of the aquifer. 1,2-*cis*-DCE should remain soluble in the groundwater and is not expected to appreciably partition back into the sediments.

1,2-*cis*-DCE has a high vapor pressure (200 mm of mercury; Table IV.18), which allows it to volatilize rapidly to the atmosphere. Photooxidation in the atmosphere should reduce 1,2-*cis*-DCE to formic acid, hydrochloric acid, carbon monoxide, and formaldehyde.

Within saturated and unsaturated soils, 1,2-*cis*-DCE can be an intermediate biodegradation product of TCE and PCE, and can further biodegrade to vinyl chloride (Kloepfer et al. 1985; Wilson and Wilson 1985; Cline and Viste 1985; Barrio-Lage et al. 1986).

Vinyl chloride - Mobility and Persistence

The K_{oc} value (135) indicates that vinyl chloride tends to exhibit medium mobility in soils and should not partition significantly from water to soil. The low K_{ow} value (22.9) indicates that vinyl chloride tends to move in an aqueous phase and that vinyl chloride is expected to leach from soils to groundwater. The low concentrations of vinyl chloride reported in the groundwater samples are well below the solubility limit; there is no evidence of DNAPL formation. Considering the low concentration, shallow source, and lack of vertical gradients, vinyl chloride should be transported by groundwater in the shallow parts of the aquifer. Vinyl chloride should remain soluble in the groundwater and is not expected to appreciably partition back into the sediments.

Vinyl chloride has a very high vapor pressure (2976 mm of mercury; Table IV.18), which allows it to volatilize rapidly from surface water and soils. Once in the atmosphere, photo-oxidation reduces vinyl chloride to hydrogen chloride and carbon monoxide (ATSDR 1987).

Within saturated and unsaturated soils, vinyl chloride can be formed by the biodegradation of TCE, PCE, and 1,2-*cis*-DCE (Kloepfer et al. 1985; Wilson and Wilson 1985; Cline and Viste 1985; Barrio-Lage et al. 1986). Further biodegradation of vinyl chloride to carbon dioxide has been documented under laboratory conditions (Wilson and Wilson 1985), but it is not considered to be an important factor in natural environments (ATSDR 1987).

Tetrachloromethane - Mobility and Persistence

Tetrachloromethane has a high vapor pressure (115 mm Hg, Table IV.18) and volatilizes rapidly from surface water and soil into the atmosphere (Clement Associates 1985). Once in the atmosphere, it remains relatively stable and probably diffuses back to earth through the precipitation process (EPA 1979).

The K_{oc} value (110) indicates that tetrachloromethane tends to have medium mobility in soils and should not partition significantly from water to soil. The low K_{ow} value (676) indicates that tetrachloromethane tends to move in an aqueous phase and should be expected to leach from soils to groundwater. The low concentrations of tetrachloromethane reported in the groundwater samples are well below the solubility limit; there is no evidence of DNAPL formation. Considering the low concentration, shallow source, and lack of vertical gradients, tetrachloromethane should be transported by groundwater in the shallow parts of the aquifer. Tetrachloromethane should remain soluble in the groundwater and is not expected to appreciably partition back into the sediments.

Information related to the biodegradation of tetrachloromethane is not available.

Trichloromethane - Mobility and Persistence

Trichloromethane has a high vapor pressure (197 mm Hg, Table IV.18) and volatilizes rapidly from surface water and probably soil into the atmosphere. Once in the troposphere, trichloromethane is attacked by hydroxyl radicals, with the subsequent formation of phosgene and possible chlorine oxide radicals (Clement Associates 1985).

The K_{oc} value (45.0) indicates that trichloromethane tends to have high mobility in soils and should not partition significantly from water to soil. The low K_{ow} value (93.3) indicates that trichloromethane tends to move in an aqueous phase and that trichloromethane should be expected to leach from soils to groundwater. The low concentrations of trichloromethane reported in the groundwater samples are well below the solubility limit; there is no evidence of DNAPL formation. Considering the low concentration, shallow source, and lack of vertical gradients, trichloromethane should be transported by groundwater in the shallow parts of the aquifer. Trichloromethane should remain soluble in the groundwater and is not expected to appreciably partition back into the sediments.

Information related to the biodegradation of trichloromethane is not available.

Benzo(a)pyrene - Mobility and Persistence

Benzo(a)pyrene has a very low vapor pressure (5.49×10^{-8} mm Hg), very low solubility in water (0.003 mg/L), and high K_{oc} (3.98×10^{6}) and K_{ow} (1.10×10^{6}) values. These factors indicate that benzo(a)pyrene is strongly adsorbed to organic materials in soils. Volatilization is an insignificant transport process. Given the low solubility of benzo(a)pyrene in water and the preference for adsorption to organic materials in soil, groundwater transport of benzo(a)pyrene is unlikely. Biodegradation of polycyclic aromatic hydrocarbons is well documented and, although the process is slow, is probably the ultimate fate of benzo(a)pyrene.

Aroclor 1248 (PCB) - Mobility and Persistence

Aroclor 1248 has a very low vapor pressure (4.94×10^{-4} mm Hg), very low solubility in water (0.006 mg/L), and high K_{oc} (4.37×10^{5}) and K_{ow} (1.29×10^{6}) values. These factors indicate that Aroclor 1248 is a very inert and persistent compound (Clement Associates 1985). Volatilization is an insignificant transport process. Given the low solubility of Aroclor 1248 in water and the preference for adsorption to organic materials in soil, groundwater transport of Aroclor 1248 is unlikely.

Alpha Chlordane - Mobility and Persistence

Information specific to alpha chlordane is not readily available; the following discussion is based on published properties of the technical chlordane mixture. Chlordane has a relatively low vapor pressure (4.94×10^{-4} mm Hg) and volatilization from soils is a slow transport process. The high values for K_{oc} (3.80×10^{4}) and K_{ow} (3.47×10^{5}) indicate that chlordane will adsorb to organic materials in the soil. It is not expected to leach significantly into groundwater. Given the rather low solubility of chlordane in water (0.056 mg/L) and the preference for adsorption to organic materials in soil, groundwater transport of chlordane is not significant. Biodegradation of chlordane is a slow process and does not greatly contribute to its fate.

Dioxins - Mobility and Persistence

The information presented in Table IV.18 and in this discussion is specific to 2378-TCDD, but the generalities are applicable to the class of polychlorinated PCDDs. PCDDs have a very low vapor pressure (7.20×10^{-10} mm Hg) and volatilization from soils is an unlikely transport process. The high values for K_{oc} (4.57×10^{6}) and K_{ow} (4.37×10^{6}) indicate that PCDDs are strongly adsorbed to organic materials in the soil and not expected to leach significantly into groundwater. Given the very low solubility of PCDDs in water (0.0002 mg/L) and the preference for adsorption to organic materials in soil, groundwater transport of dissolved PCDDs is not likely, although water could transport PCDDs adsorbed onto particulates. Biodegradation of PCDDs does occur, but is a slow process; the half-life of PCDDs may be several years (Clement Associates 1985).

Plutonium - Mobility and Persistence

There are four main mechanisms by which contaminants present in Area B soils could be released to the environment. These are dissolution by precipitation and release via surface water runoff, dissolution by precipitation and infiltration, transport of contaminated sediments via surface water runoff, and the airborne transport of contaminated sediments. As demonstrated by previous studies at Mound Plant (summarized below), plutonium is relatively insoluble in water, so dissolution by precipitation followed by release via surface water runoff or infiltration is unlikely unless a strong acid driver is introduced.

Release of plutonium-contaminated sediments by way of water or wind may occur if the heavy vegetation cover is removed and the soil disturbed (e.g., by plowing). As both of these scenarios are unlikely under the present conditions, release of plutonium-contaminated sediments also appears to be unlikely. Although some runoff from the steep slopes of the landfill does occur during periods of

high rainfall, the vegetation prevents the removal of large quantities of soil or sediment particles from the area.

A fifth pathway that can result in the exposure of people or animals to radioactivity from the plutonium in Area B is exposure to direct radiation. At standard temperature, the plutonium-238 alpha particles (5.5 and 5.46 MeV) will travel about 3.6 cm. In addition, alpha particles are easily stopped or absorbed by very thin materials, such as a sheet of paper. Of the photons emitted, 17 KeV is the most abundant energy, with a half-value layer of about 0.14 cm. (One-half of the 17 KeV will be absorbed in only about 0.14 cm of soil.) Therefore, the heavy vegetation and any overlying soil layers would serve to eliminate or greatly absorb any plutonium-238 emissions from the area.

Radioactive decay will cause plutonium in soils and sediments to decrease by one-half every 87.74 years. Plutonium-238 particulate radiation has a relative abundance of 72 percent. During this decay, plutonium-238 emits an alpha particle (5.50 or 5.46 megaelectron volts [MeVs]) and transmutes into uranium-234, which transmutes to thorium-230. Characteristic x-rays (photons) with an energy of 99 kiloelectron volts (KeV) are also emitted by the uranium-234, although much less frequently than the alpha particles. The relative abundance of the photon radiation is 8×10^{-3} percent. Because uranium-234 has a half-life of 2.4×10^{5} years, the radioactivity due to uranium will be much less than that of plutonium-238. Plutonium-239 has a half-life of 2.4×10^{4} years and decays to uranium-235 by emission of an alpha particle. Plutonium-240 has a half-life of 6.5×10^{3} years and decays to uranium-236 by alpha particle emission.

The behavior of plutonium in Mound Plant environs is largely determined by its chemical characteristics. With a +4 valence, plutonium is a relatively strong positively charged ion (cation) that is strongly sorbed onto the soils and sediments through a cation exchange process (Rogers 1975). This sorption onto the natural soils and sediments at Mound Plant makes the plutonium relatively immobile. In general, plutonium will form insoluble fluorides, hydroxides, and oxides (Eisenbud 1987). Its solubility depends upon redox potential, pH, and the presence of organic ligands. Studies performed by Mound Plant in 1974 on plutonium-contaminated sediments demonstrated a very low solubility in water of 1×10^{-6} by identifying the distribution ratio (concentration of plutonium in the water/concentration of plutonium in the soil) (Rogers 1975). Very strong acids (e.g., 8M HNO3) are required to significantly increase the plutonium solubility. Given that the Mound plant calcareous soil/sediment is a natural buffer, an increase of plutonium solubility at Area B is unlikely.

Thorium - Mobility and Persistence

Although not a chemical of concern, thorium is discussed due to historic use and disposal.

There are four main mechanisms by which the thorium in Area B could be released to the environment. These are dissolution by precipitation and release via surface water runoff, dissolution by precipitation and infiltration, transport of sediments via surface water runoff, and the airborne transport of thorium-contaminated sediments. The mobility of thorium is very similar to that of plutonium. Therefore, the discussion of the release mechanisms of plutonium also applies to thorium.

Including artificially produced isotopes, there are 12 isotopes of thorium, from thorium-223 to thorium-234. Of these 12, five are naturally occurring: thorium-227, -228, -230, -232, and -234. Thorium-232 accounts for 99.99 percent of naturally occurring thorium. At Mound Plant, both thorium-232 and thorium-230 have been used or stored in the past. Thorium-232 has a half-life of 1.4×10^{10} years and decays with an energy of 4.01 MeV by alpha-particle emission, beta-particle emission, and gamma radiation to form daughter products (radium, actinium, radon, polonium, bismuth, and titanium) and eventually stable lead-208. Thorium-232 particulate radiation has a relative abundance of 76 percent.

Thorium-232 principal photon radiation is radium L x-rays with an energy of 84 KeV and a relative abundance of 1.6 percent. Thorium-230 has a half-life of 7.5×10^4 years. Its principal particulate radiation is alpha, with an energy of 4.68 MeV and a relative abundance of 76 percent. Its principal photon radiation is radium L x-rays with an energy of 68 KeV and a relative abundance of 0.6 percent. Its significant daughter products are radium-226 and radon-222.

The mobility and fate of thorium in soils is strongly influenced by its chemical characteristics. Thorium is a metallic element of the actinide series that is most commonly found in the +4 oxidation state (ATSDR 1989). In most cases, thorium will remain strongly sorbed to soil, and its mobility will be very low (Torstenfeelt 1986). The most common thorium compounds do not dissolve in water and do not evaporate from soil or water into the air (ATSDR 1989).

The water solubility of thorium is dependent on the compound in which it is found: chloride, fluoride, nitrate, and sulfate salt compounds are water soluble, whereas oxide, carbonate, hydroxide, oxalate, and phosphate salt compounds are water insoluble (CRC 1983). Leaching thorium into groundwater is possible in some soils with low sorption capacity and the ability to form soluble complexes. The concentration of dissolved thorium in some waters may increase due to the formation of soluble complexes with carbonates, humic materials, or other ligands in the water (LaFlamme and Murray 1987). In surface water, thorium will be present, sorbed onto suspended sediment, and the

concentration of soluble thorium will be low (Platford and Joshi 1987). Sediment resuspension and mixing may control the transport of particle-sorbed thorium in water.

Due to a low plant/soil transfer ratio (<0.01), thorium will not bioconcentrate in plants growing in thorium-rich soils (Garten 1978). However, soluble thorium compounds have greater bioavailability than insoluble thorium compounds (ATSDR 1989).

Tritium - Mobility and Persistence

Tritium is found in monitoring wells within Area B at concentrations above background concentrations of 0.1 to 1 nCi/L, but below the MCL of 20 nCi/L. Because tritium is an isotope of hydrogen, it readily exchanges with a hydrogen atom in water molecules to form tritiated water (HTO). In the environment, tritiated water released onto soils will behave like water; it will diffuse through the soils, mix with the soil particles, and may eventually reach groundwater (NCRP 1979). Once tritiated water enters the groundwater system, it moves with the groundwater. Tritium has a half-life of 12.3 years, decays by emission of beta particles, and has a maximum positron energy of 0.0186 MeV, with a relative abundance of 100 percent. It has no principal photon radiation. Its daughter products are not radioactive.

Strontium-90 - Mobility and Persistence

Strontium-90 has a half-life of 28.1 years. Strontium has a tendency to form comparatively soluble compounds and behaves chemically similar to calcium.

Actinium-227 - Mobility and Persistence

Actinium-227 (half-life 21.6 years) is a decay product of the plutonium-239 decay series. Its behavior in the environment should be similar to plutonium-239.

4.4.3. Rate and Direction of Migration

The direction of migration for subsurface contamination from Area B is along bedrock and topographic highs from east to west. Within the soils, the direction of migration would first be downward through the vadose zone until groundwater, fractures, bedding planes, or lower permeability units are encountered. At that time, the migration direction would be in the direction of groundwater flow or laterally along the discontinuity. Within the groundwater system, the direction of movement for dissolved components will be with the groundwater. In Area B, the groundwater flow direction is west

from the tributary valley, the area of the overflow pond and the site sanitary landfill, and the SM/PP Hill. Once within the main portion of the Buried Valley aquifer, the direction of movement will be to the south and southwest.

Table IV.19 shows representative contaminant flow velocity calculations for the Buried Valley aquifer in the vicinity of Area B. The retardation coefficient, Rd, is a measure of how much the chemical movement is retarded with respect to the groundwater flow (Table IV.19). Given the same amount of organic material within the aquifer matrix and an average groundwater velocity within the Buried Valley aquifer of 240 ft/yr, TCE is retarded the least with a possible velocity of 19.5 ft/yr within the Buried Valley aquifer. Dioxins are retarded the most (4.84×10^{-4} ft/yr) and trichloromethane and 1,2-*cis*-DCE fall between the two (41 ft/yr and 50 ft/yr, respectively). As is discussed above, all VOCs tend to remain in the groundwater and not partition appreciably back onto the soil. Thus, they would tend to move with the groundwater and not at the retarded velocities shown here. These are the conditions that were observed during the aquifer test.

Once a contaminant reaches the Buried Valley aquifer, it has the potential to move off-site quickly. However, these velocities assume there is no pumping within the Buried Valley aquifer. The pumping at well 0076 for the Mound Plant water supply creates a capture zone for the at least a portion of the contamination within the Buried Valley aquifer.

As discussed earlier, tritium is expected to move with the groundwater. Plutonium is not expected to move from contaminated soils.

4.4.4. Surface Water

Surface water flow and surface runoff are all controlled within Area B. The western and southern slopes of the site sanitary landfill drain into an open ditch to the southwest. From there, the water flows southward to join the main plant runoff. The balance of Area B drains into the overflow pond, moves into the plant stormwater system, and goes out through the plant NPDES discharge outfall 002.

Drainage on the Mound Plant Site as a whole is collected by an interconnecting series of retention basins, the plant drainage ditch, and the overflow pond in Area B. During periods of high flow, when the retention basins are filled to capacity, excess water flows into the overflow pond by way of a spillway located at the north side of the overflow pond. Thus, surface water from much of the plant enters Area B, then exits through a standpipe to the NPDES outfall.

As discussed in subsection 4.2, leakage through the clay liner of the overflow pond is not expected to be a significant current source of recharge to the unconsolidated material underlying Area B. Limited

Table IV.19. Representative Contaminant Flow Velocity Calculations

Contaminant	Kow (A)	log Koc	Koc	Kd (B)	Rd (C)	Ft/Yr Vw (D)	Ft/Yr Vc (E)
Trichloroethene	263	2.02	104	1.66	12.3	240	19.5
Trichloromethane	93.3	1.65	45.0	0.72	5.89	240	40.8
1,2-*cis*-dichloroethene	72.4	1.54	35.0	0.56	4.80	240	50.0
Dioxins	4.37×10^6	6.66	4.57×10^6	7.31×10^4	4.96×10^5	240	4.84×10^{-4}

(A) Kow = octanol/water partition coefficient values for Kow and Koc taken from Table IV.18.

(B) Kd = (Koc)(foc)
Kd = adsorption coefficient
foc = fraction of organic carbon in the soil

(C) Rd = 1 + (Pd/n)(Kd)
Rd = retardation coefficient
Pd = bulk density
n = porosity

(D) Vw = (k)(i)/(ne)
Vw = groundwater velocity
k = hydraulic conductivity
i = hydraulic gradient
ne = effective porosity

(E) Vc = Vw/Rd
Vc = contaminant flow velocity
Vw = groundwater velocity

Example calculation using trichloroethene

(1) foc = 0.016. Average percent organic matter (in alluvial sediments, glacial till, and slacio-fluvial outwash from geotechnical tests)
Kd = (104)(0.016) = 1.66

(2) Given bulk density is 1.9 g/cm^3 and porosity is 0.28 (from geotechnical tests), retardation factor is
Rd = 1 + (1.9/0.28)(1.66) = 12.3

(3) Assuming effective porosity is 0.25, gradient is 0.0003, and hydraulic conductivity is 550 ft/day, average groundwater velocity is
Vw = ((550)(0.0003)/0.25)(365) = 240 ft/yr

(5) Contaminant flow velocity is
Vc = 240/12.3 = 19.5 ft/yr

analytical data, provided in the RI Site-Wide Work Plan (DOE 1992b), suggested that the water and sediment in the overflow pond are not highly contaminated. The plant-wide surface water system will be the subject of an intensive investigation as part of the Operable Unit 9 (Site-Wide) RI. Any likely impacts of surface water contamination will be addressed therein. For the present purposes, the surface water within Area B will not be further investigated.

4.4.5. Air

Neither the Mound Plant air quality surveillance program described in Section 2 nor the health and safety monitoring during all field activities has documented measurable impact from Area B. Therefore, the RI does not further address air quality conditions. The air pathway is considered in the risk assessment (Section 5).

A more detailed discussion of onsite and offsite air monitoring was presented in the RI Site-Wide Work Plan (DOE 1992b), as was the planned program for assessing air quality impact of the Site.

5. BASELINE RISK ASSESSMENT

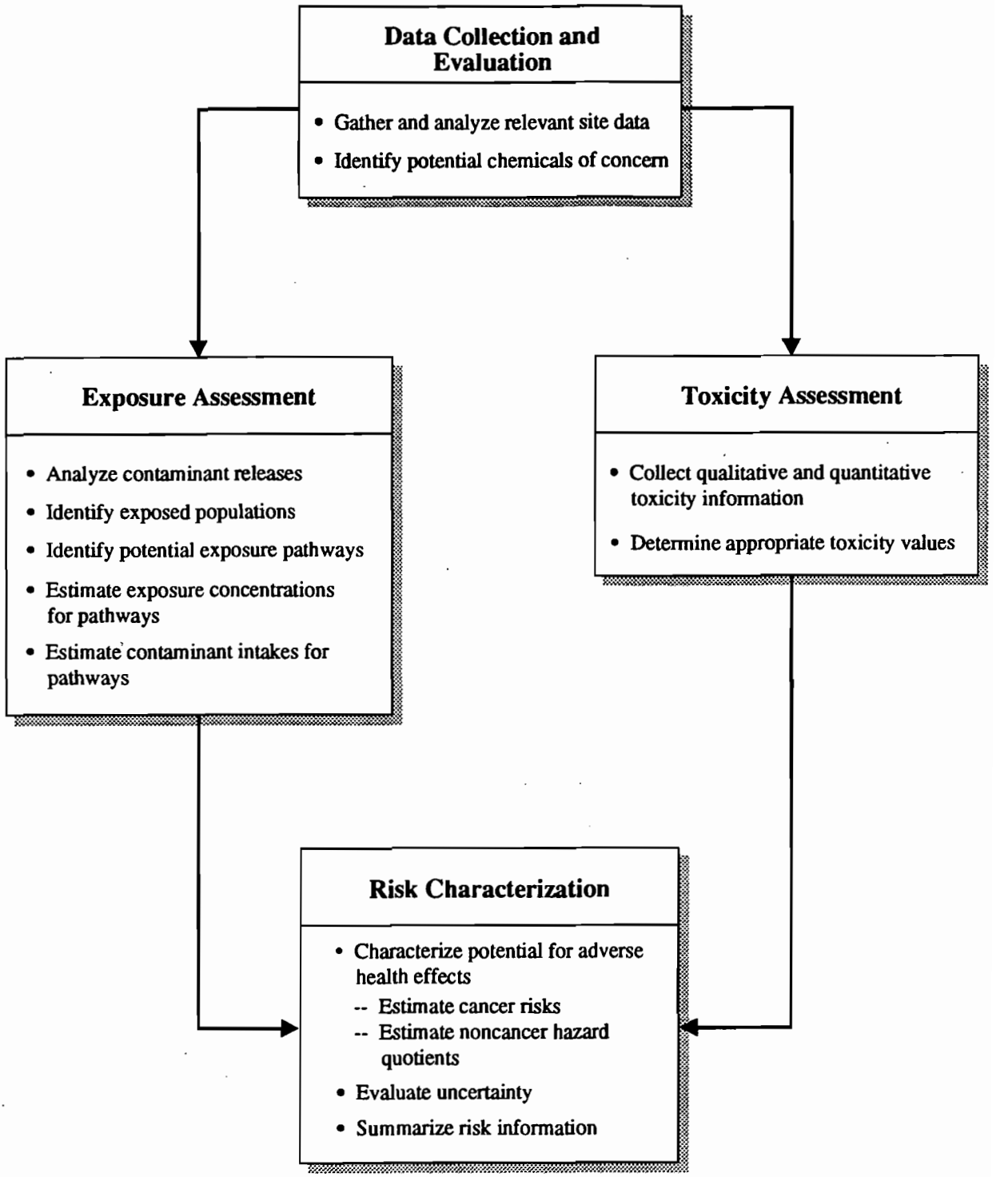
CERCLA established a national program for responding to releases of hazardous substances into the environment. The CERCLA mandate is to protect human health and the environment from current and potential threats posed by uncontrolled releases of hazardous substances. To help meet this mandate, a human health evaluation process, or baseline risk assessment, has been developed as part of the remedial response program (EPA 1988b). Because the Mound Plant is listed on the EPA National Priority List (NPL), the baseline risk assessment process has been conducted according to CERCLA guidance.

The baseline risk assessment for Area B of Operable Unit 1 addresses future public health risks that may exist, assuming that no remedial actions are performed. Therefore, the assessment serves as a baseline case that can be used to compare the relative effectiveness of alternative remedial strategies in reducing public health risks. This baseline risk assessment focuses on exposure of hypothetical future workers or residents to soil and groundwater contamination.

The baseline risk assessment estimates risk associated with potential pathways identified by the conceptual site model (presented below). It also identifies pathways that exceed acceptable risk, so that the FS process is focused on pathways that present a threat to human health and the environment. Any risk associated with a selected remedial action, such as landfill excavation, is not addressed as part of the baseline risk assessment. Releases and associated exposure risks that may occur as part of a remedial action will be addressed under adverse impacts in the FS.

Pertinent information on the content and preparation of health assessments at Superfund sites is contained in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a), and Risk Assessment Guidance for Superfund (EPA 1989a). The primary components of the baseline risk assessment are identified in Figure 5.1. These include the identification of chemicals of potential concern (COPCs), the exposure assessment, the toxicity assessment, and the risk characterization.

The ecological risk assessment will be performed on a site-wide basis during the Operable Unit 9 Site-Wide Remedial Investigation. The Mound Plant ecological risk assessment will be performed in conjunction with the site-wide ecological assessment. The site-wide ecological risk assessment will be based on data collected as part of the Operable Unit 9 remedial investigation, along with the information obtained from the site-wide ecological assessment and other studies that have evaluated ecological conditions around the Mound Plant facility.



Source: Modified from EPA 1988a.

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Figure 5.1. Baseline risk assessment.

5.1. SITE CONCEPTUAL MODEL

The site conceptual model for Mound Plant is shown in Figure 5.2. There are three primary sources at Mound Plant from which contaminants have entered or may continue to enter the environment at Area B: the historic waste disposal materials, the site sanitary landfill, and the overflow pond. These primary sources may have contaminated soils through primary release mechanisms that include leaching, infiltration, overflow, and runoff. These primary releases have all led to contaminated soil as a secondary source for further contaminant releases and potential exposures.

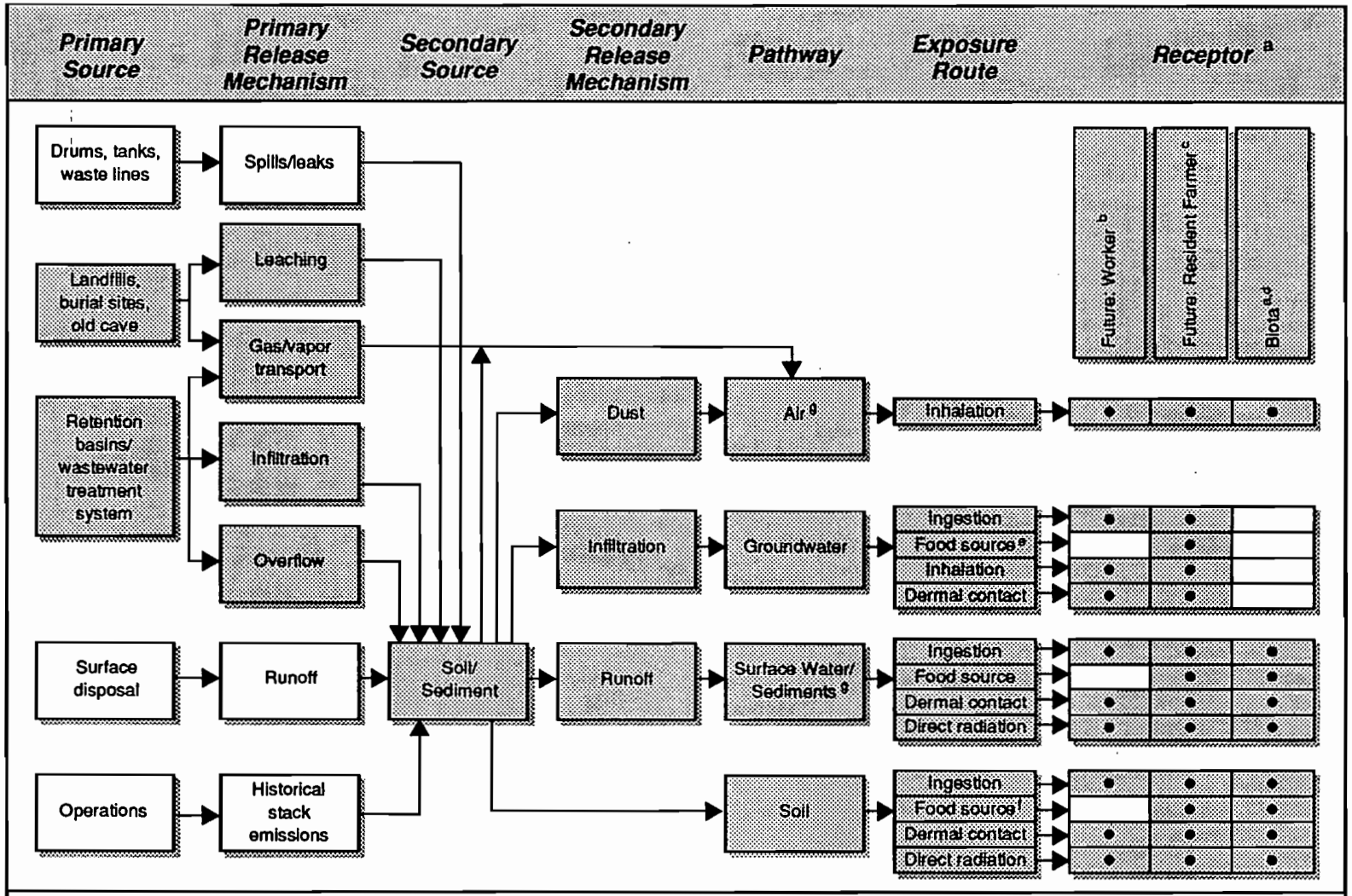
Contaminated soil represents a potential direct route of exposure to humans and biota through incidental ingestion, dermal contact, and external exposure to radiation. Secondary routes of exposure may occur due to uptake by plants, resuspension of dust, vapor transfer into the air, and groundwater contamination. Both flora and fauna incorporate contaminants from soil and provide a route of exposure for humans.

Air exposure pathways result from contaminated soil that may be resuspended into air by the natural action of wind or by human activity. Activities such as excavation or plowing and other agricultural field work can raise significant amounts of dust. Additionally, certain contaminants (such as volatile organics, tritium, or radon) may directly enter the breathing zone. These vapors or gases may pass through an environmental medium first (e.g., soil), or they may enter air directly from the source.

Groundwater can become contaminated by the leaching and further percolation of hazardous material from contaminated soil. Contamination in the groundwater represents potential exposure pathways, including ingestion, inhalation, and dermal contact, from use of current onsite wells and from hypothetical future development of onsite residential wells.

Surface water and associated sediments can become contaminated as a result of runoff and erosion from areas of contaminated soil, from seepage of contaminated groundwater, or, historically, from direct spills and effluent releases. Surface water exposure routes to be considered include ingestion of surface water, ingestion of fish that have fed in contaminated areas, incidental ingestion of sediment, dermal contact with surface waters and sediments, external exposure to radiation emitted from sediments, and ingestion of livestock products (beef and milk) from animals watered with contaminated surface water.

Investigations of Operable Unit 1 surface waters and sediments will be conducted during the Operable Unit 9 Site-Wide Remedial Investigation (DOE 1992b).



LEGEND

a ECOLOGICAL RISK assessment to be conducted in OU9.

b FUTURE WORKER – Works outside or within a building on the site as a laborer. Receptor is exposed to contaminants in environmental media; not an evaluation of occupational exposure.

c FUTURE RESIDENT FARMER – Establishes a farm onsite.

d TERRESTRIAL BIOTA – Analysis of terrestrial biota will include quantitative analysis to the extent possible but will not be possible for all exposure routes such as dermal contact.

e FOOD INGESTION from the groundwater pathway will be based on consumption of vegetables grown in gardens irrigated with contaminated groundwater.

f FOOD INGESTION from the soil pathway will include ingestion of plants that have taken up contaminants from soil.

g INVESTIGATION to be conducted in OU9 (DOE 1992b).

NOTE: Shaded areas indicate aspects relevant to Area B.

MND/OU1/RIR-ConMod/2-25-94

Figure 5.2. Conceptual pathway model for Area B, Operable Unit 1.

Chemicals and radionuclides present in different site media may themselves pose as a source for further contamination at the site. The following shows examples of this:

- trichloroethene can degrade to 1,1-dichloroethene and vinyl chloride, both of which are highly carcinogenic chemicals
- natural uranium (uranium-238) eventually decays into radium-226; significant inhalation, ingestion, and external radiation risks can results from exposure to radium-226 and its daughter products

Thus, the potential risks associated with a site may increase with time if chemicals and radionuclides decay into more hazardous constituents.

5.2. IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern are defined as those chemicals present within Operable Unit 1 resulting from past activities, and include only those chemicals detected above reportable levels or at concentrations above naturally occurring levels that have been determined not to be sampling or laboratory artifacts. Laboratory artifacts could include common laboratory contaminants such as acetone, 2-butanone, dichloromethane, toluene, and phthalate esters.

5.2.1. Data Information and Evaluation

The initial step in the Operable Unit 1 risk assessment data evaluation was to determine the quality of the field data. This was accomplished through data validation; the procedures used are discussed in subsection 3.5.4.

If a chemical was not detected in a sample, its representative concentration was estimated as being one-half the sample quantitation limit (EPA 1989a). This provides a reasonable estimate of the undetected chemical concentration. The actual concentration of the undetected chemical could range anywhere from 0 to the sample detection limit.

Chemical concentrations from samples that have field duplicates were averaged with their associated duplicate chemical concentrations. For example, if the concentrations for chromium in a groundwater sample and its associated field duplicate were 5 and 10 mg/L, respectively, then the representative concentration of the sample would be 7.5 mg/L. If the chemical was detected in either the sample or field duplicate, the representative chemical concentration was qualified as being detected.

Concentrations qualified with a "J" were retained without change for the risk assessment. However, concentrations qualified as "UJ" were considered as nondetects, and the concentration values were replaced with one-half their respective sample quantitation limits.

5.2.2. Chemicals of Potential Concern Selection Criteria

The development of COPCs consisted of three methods: frequency of detection analysis; statistical comparison of site data to site and regional background data; and comparison of essential nutrient concentrations to daily nutritional ranges. These methods and their respective results are presented below. Chemicals of potential concern were selected for both groundwater and soils.

Groundwater

The most recent four quarters of validated groundwater data (June 1992 to March 1993) were used for the determination of site COPCs. The use of these datasets for the screening of COPCs was considered appropriate for the following reasons: 1) the four datasets are comparable, considering the analytical protocols used; 2) the use of four consecutive quarters of analytical data takes into account seasonal variabilities associated with groundwater; and 3) the use of the most recent datasets provides a more accurate account of the present condition of Operable Unit 1 - Area B groundwater.

The groundwater data used in the risk assessment were obtained from the following Operable Unit 1 wells between June 1992 and March 1993: 0063, 0153, 0306, 0307, 0313, 0370, 0373, 0374, and 0397. These wells are located directly within Area B or are in downgradient areas directly adjacent to Area B.

The initial analysis of Area B groundwater data involved determining the distribution type of each chemical dataset. Chemical datasets were assumed to either be normally distributed, lognormally distributed, or nonparametric (i.e., having no characteristic distribution type). The determination of distribution type was performed using the Shapiro-Wilks "goodness-of-fit" test.

The Shapiro-Wilks test is used to analyze datasets and compute a significance level. The significance level of a statistical test is defined as the probability of falsely rejecting a true null hypothesis (i.e., dataset distribution is normal or lognormal). The null hypothesis is defined as a simple statistical hypothesis that is either accepted or rejected in favor of an alternative based on the results of an appropriate statistical test. If the significance level is found to be below an allowable significance level, the distribution type being tested is rejected as the appropriate type.

For the determination of distribution type, the allowable significance level was set at 5 percent (0.05) which is the common value used in environmental statistical analyses (Gilbert 1987). Goodness-of-fit tests are discussed in further detail in Appendix O.

The descriptive statistics of the chemicals detected in groundwater samples taken between June 1992 and March 1993 are presented in Table V.1. This table shows the frequency of detection, distribution type, mean, standard deviation, 95 percent upper confidence limit (UCL) of the mean, and the maximum detected concentration for each chemical dataset. The equations for computing the normal and lognormal mean, standard deviation, and 95 percent UCL of the mean are presented in Appendix O. If a chemical dataset was found to be nonparametric by the goodness-of-fit test, the dataset was assumed to be normally distributed. However, if the lognormal 95 percent UCL was found to be higher than the normal 95 percent UCL and less than the maximum detected concentration, the nonparametric dataset was assumed to be lognormally distributed.

Chemicals that are infrequently detected may be artifacts in the data due to sampling, analytical, or other problems and, therefore, may not be related to site operations (EPA 1989a). To assess this relationship, the amount of nondetect site data was compared to the amount of detected site data for each chemical per medium. The frequency of detected data for each chemical per medium was computed using the following equation:

$$\text{Detection Frequency} = \frac{\text{Total Number of Detections}}{\text{Total Number of Observations}} \times 100$$

Chemicals having a detection frequency of less than or equal to 5 percent, which is the typical percentage used in Superfund risk assessments, were not considered COPCs within the medium of interest. However, EPA guidance stipulates that if the detected concentration of an infrequently detected chemical (less than or equal to 5 percent) exists at high concentrations, the chemical should be retained as a COPC (EPA 1989a). EPA guidance does not specify the definition of a "high" concentration. Based on Ohio EPA guidance (EPA 1991b), a detected chemical concentration was considered "high" if it exceeds its method detection limit (MDL). Ohio EPA defines the MDL as the minimum concentration of a substance that can be measured (EPA 1991b). In the Risk Assessment Guidance for Superfund (EPA 1989a), the MDL is referred to as the sample quantitation limit (SQL).

The detection frequency, maximum detected concentration, and method detection limit for each chemical and radionuclide are presented in Table V.2a. Based on the frequency of detection analysis, none of the detected chemicals were eliminated as groundwater COPCs.

Table V.1. Statistical Summary of Chemicals Detected in Operable Unit 1, Area B Groundwater - June 1992 to March 1993

Chemical	Frequency of Detection	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Detected Concentration
Organic Chemicals (concentration values in μg/L)						
1,1,1-Trichloroethene	2/21	0.377	0.360	Nonparametric	0.592	1.6
1,2-*cis*-Dichloroethene	4/21	36.3	143	Nonparametric	103	640
1,2-Dichloroethane	1/21	0.282	0.188	Nonparametric	0.369	0.68
1,2-*trans*-Dichloroethene	1/21	0.605	0.470	Nonparametric	0.825	2.6
Bis(2-ethylhexyl)phthalate	1/10	4.66	1.44	Nonparametric	5.69	0.6
Chlordane (alpha)	1/10	0.0297	0.0142	Nonparametric	0.0398	0.07
Diethyl Phthalate	1/10	4.74	1.37	Nonparametric	5.72	0.9
Pyrene	1/10	4.72	1.43	Nonparametric	5.74	0.7
Tetrachloroethene	18/21	33.9	126	Nonparametric	158	270
Tetrachloromethane	14/21	1.80	1.59	Nonparametric	2.76	4.6
Trichloroethene	18/21	22.2	45.2	Nonparametric	56.1	210
Trichlorofluoromethane	2/19	1.54	2.61	Nonparametric	2.80	12
Trichloromethane	6/21	7.90	28.9	Nonparametric	21.4	130
Vinyl Chloride	1/21	0.960	0.854	Nonparametric	1.36	4.5
Inorganic Chemicals (concentration values in μg/L)						
Aluminum	9/16	490	848	Nonparametric	942	2330
Arsenic	4/16	1.40	1.13	Nonparametric	2.19	2.8
Barium	16/16	151	23.7	Normal	164	198
Calcium	19/19	158000	14900	Normal	165000	184000
Chloride	13/13	180000	59100	Normal	216000	284000
Chromium	9/16	109	146	Nonparametric	187	353
Cobalt	3/16	8.12	9.6	Nonparametric	15.7	19
Copper	9/16	22.9	30	Nonparametric	36	42.1
Iron	15/19	2990	3950	Nonparametric	4890	11400

Table V.1. (page 2 of 2)

Chemical	Frequency of Detection	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Detected Concentration
Lead	6/16	2.47	3.22	Lognormal	5.01	9.6
Magnesium	19/19	49483	6811	Lognormal	52460	71100
Manganese	19/19	171	444	Lognormal	578	504
Nickel	12/16	176	558	Lognormal	902	510
Nitrate Nitrite	13/13	1726	1034	Lognormal	2482	3400
Potassium	19/19	3942	547	Lognormal	4181	5230
Selenium	3/16	1.45	0.778	Nonparametric	1.86	3.2
Sodium	19/19	90591	15327	Lognormal	97319	123000
Sulfate	13/13	109454	8847	Lognormal	114074	129000
Vanadium	5/16	7.31	14.0	Nonparametric	20.1	31.4
Zinc	11/16	159.2	1240	Lognormal	1738	915
Radionuclides (concentration values in pCi/L)						
Actinium-227	2/7	5.13	4.02	Normal	8.84	2.27
Plutonium-238	2/12	0.296	0.888	Nonparametric	0.860	3.1
Plutonium-239/240	9/12	0.552	1.16	Lognormal	2.54	2.8
Radium-226	9/12	0.625	0.394	Lognormal	0.929	2.4
Strontium-90	5/12	0.558	0.447	Nonparametric	0.842	1.77
Thorium-228	2/12	0.129	0.0762	Lognormal	0.187	0.293
Thorium-230	8/12	0.354	0.687	Nonparametric	1.27	3.17
Thorium-232	1/12	0.0736	0.0712	Lognormal	0.144	0.252
Tritium	14/15	6980	2480	Nonparametric	8350	12500
Uranium-234	11/12	0.662	0.398	Normal	0.915	1.23
Uranium-235/236	3/8	0.0654	0.0419	Lognormal	0.118	0.121
Uranium-238	11/12	0.764	0.709	Lognormal	1.41	2.3

Table V.2a. Frequency of Detection Analysis - Operable Unit 1, Area B Groundwater - June 1992 to March 1993

Chemical	Frequency of Detection	Maximum Detected Concentration	Method Detection Limit (MDL)	Maximum Detected Concentration >MDL	Eliminate as COPC Based on Detection Frequency and MDL Comparison?
Organic Chemicals (concentration values in μg/L)					
Bis(2-ethylhexyl)phthalate	10.0%	0.6	11	No	No
Chlordane (alpha)	10.0%	0.07	0.052	Yes	No
1,2-Dichloroethane	4.8%	0.68	0.30	Yes	No
1,2-*cis*-Dichloroethene	19.0%	640	50	Yes	No
1,2-*trans*-Dichloroethene	4.8%	2.6	1.0	Yes	No
Diethyl Phthalate	10.0%	0.9	10	No	No
Pyrene	10.0%	0.7	10	No	No
Tetrachloroethene	85.7%	270	15	Yes	No
Tetrachloromethane	66.7%	4.6	1.0	Yes	No
Trichloroethene	85.7%	210	60	Yes	No
Trichlorofluoromethane	10.5%	12	2.0	Yes	No
Trichloromethane	28.6%	130	2.5	Yes	No
1,1,1-Trichloroethane	9.5%	1.6	0.30	Yes	No
Vinyl Chloride	4.8%	4.5	1.8	Yes	No
Inorganic Chemicals (concentration values in μg/L)					
Aluminum	56.3%	2330	37	Yes	No
Arsenic	25.0%	2.8	2.0	Yes	No
Barium	100.0%	198	3.0	Yes	No
Calcium	100.0%	184000	5000	Yes	No
Chloride	100.0%	284000	12500	Yes	No
Chromium	56.3%	353	10	Yes	No

Table V.2a. (page 2 of 3)

Chemical	Frequency of Detection	Maximum Detected Concentration	Method Detection Limit (MDL)	Maximum Detected Concentration >MDL	Eliminate as COPC Based on Detection Frequency and MDL Comparison?
Cobalt	18.8%	19	4.0	Yes	No
Copper	56.3%	42.1	2.0	Yes	No
Iron	78.9%	11400	10	Yes	No
Lead	37.5%	9.6	2.0	Yes	No
Magnesium	100.0%	71100	5000	Yes	No
Manganese	100.0%	504	2.0	Yes	No
Nickel	75.0%	510	12	Yes	No
Nitrate Nitrite	100.0%	3400	500	Yes	No
Potassium	100.0%	5230	678	Yes	No
Selenium	18.7%	3.2	5.0	No	No
Sodium	100.0%	123000	34	Yes	No
Sulfate	100.0%	129000	10000	Yes	No
Vanadium	31.3%	31.4	10	Yes	No
Zinc	68.8%	915	7.0	Yes	No
Radionuclides (concentration values in pCi/L)					
Actinium-227	28.6%	2.27	1.0	Yes	No
Plutonium-238	16.7%	3.1	0.50	Yes	No
Plutonium-239/240	75.0%	2.8	0.40	Yes	No
Radium-226	75.0%	2.4	2.0	Yes	No
Strontium-90	41.7%	1.77	0.56	Yes	No
Thorium-228	16.7%	0.293	1.0	No	No
Thorium-230	66.7%	3.17	1.0	Yes	No

Table V.2a. (page 3 of 3)

Chemical	Frequency of Detection	Maximum Detected Concentration	Method Detection Limit (MDL)	Maximum Detected Concentration >MDL	Eliminate as COPC Based on Detection Frequency and MDL Comparison?
Thorium-232	8.3%	0.252	1.0	No	No
Tritium	93.3%	12500	460	Yes	No
Uranium-234	91.7%	1.23	0.06	Yes	No
Uranium-235/236	37.5%	0.121	1.0	No	No
Uranium-238	91.7%	2.3	0.030	Yes	No

Table V.2b presents a comparison of maximum detected groundwater concentrations with applicable state and regulatory standards. Regulatory standards were not used in the development of COPCs. This table was provided to show whether or not detected chemical concentrations exceed regulatory limits.

For the purposes of COPC selection, background data are defined as data obtained from locations near the site that have not been affected by the site's activities (EPA 1989a). Based on this criteria, seven wells from Operable Unit 9 were selected as background for the Operable Unit 1 - Area B risk assessment. These wells are the following: 0327, 0328, 0330, 0333, 0334, 0336, and 0337. Only one round of background groundwater samples, taken in September 1993, was available for the risk assessment. A statistical summary of the September 1993 background data is presented in Table V.3. The September 1993 background sample results are presented in Appendix M.

The screening of COPCs based on site/background statistical comparisons was only performed on inorganic elements and radionuclides commonly found in the environment. Organic compounds, strontium-90, tritium, and plutonium were assumed to be nonexistent in unaffected or background areas. As a result, statistical comparisons of organic compounds, strontium-90, tritium, and plutonium in site and background samples was not conducted.

An initial comparison of site and background data was performed by comparing maximum detected concentrations with background ranges. The results of this comparison are presented in Table V.4. If the maximum detected concentration of an element fell within the background range, the element was eliminated as a COPC. As a result, arsenic, barium, lead, nitrate+nitrite, and thorium-228 were eliminated as groundwater COPCs.

Site and background datasets were statistically compared using two methods: the T-Test and the Mann-Whitney Test. The T-Test is a statistical test that determines whether or not a null hypothesis is rejected. The null hypothesis that is analyzed by the T-Test specifies that there is no difference between site and background mean concentrations. The T-Test can only be used if both site and background dataset distributions are approximately normal or lognormal. If the site and background datasets have different distribution types, the T-Test cannot be used. In addition, if either or both datasets are nonparametric, the T-Test cannot be used.

The T-Test compares the site and background datasets and computes a one-tailed test significance level. For the comparison of site and background data, the allowable one-tailed significance level was set at 5 percent (0.05), which is the minimum allowable value for groundwater data analyses (EPA 1989h). If the computed significance level is greater than or equal to 5 percent, the null hypothesis

Table V.2b. Regulatory Comparison - Operable Unit 1, Area B Groundwater - June 1992 to March 1993

Chemical	Maximum Detected Concentration	Federal Maximum Contaminant Level	Ohio Drinking Water Standard	Maximum Concentration Exceeds Regulatory Standards
Organic Chemicals (concentration values in μg/L)				
Bis(2-ethylhexyl)phthalate	0.6	NA	NA	----
Chlordane (alpha)	0.07	2	2	No
1,2-Dichloroethane	0.68	5	5	No
1,2-*cis*-Dichloroethene	640	70	70	Yes
1,2-*trans*-Dichloroethene	2.6	100	100	No
Diethyl Phthalate	0.9	NA	NA	----
Pyrene	0.7	NA	NA	----
Tetrachloroethene	270	5	5	Yes
Tetrachloromethane	4.6	5	5	No
Trichloroethene	210	5	5	Yes
Trichlorofluoromethane	12	NA	NA	----
Trichloromethane	130	100	100	Yes
1,1,1-Trichloroethane	1.6	200	200	No
Vinyl Chloride	4.5	2	2	Yes
Inorganic Chemicals (concentration values in μg/L)				
Aluminum	2330	200[a]	NA	Yes
Arsenic	2.8	50	50	No
Barium	198	2000	2000	No
Calcium	184000	NA	NA	----
Chloride	284000	250000[a]	NA	Yes
Chromium	353	100	100	Yes

Table V.2b. (page 2 of 3)

Chemical	Maximum Detected Concentration	Federal Maximum Contaminant Level	Ohio Drinking Water Standard	Maximum Concentration Exceeds Regulatory Standards
Cobalt	19	NA	NA	----
Copper	42.1	1300[b]	1300	No
Iron	11400	300[a]	NA	Yes
Lead	9.6	15	15	No
Magnesium	71100	NA	NA	----
Manganese	504	200[a]	NA	Yes
Nickel	510	100	100	Yes
Nitrate Nitrite	3400	10000	10000	No
Potassium	5230	NA	NA	----
Selenium	3.2	50	50	No
Sodium	123000	NA	NA	----
Sulfate	129000	250000[a]	NA	No
Vanadium	31.4	NA	NA	----
Zinc	915	5000[a]	NA	No
Radionuclides (concentration values in pCi/L)				
Actinium-227	2.27	NA	NA	----
Plutonium-238	3.1	NA	NA	----
Plutonium-239/240	2.8	NA	NA	----
Radium-226	2.4	20[c]	NA	No
Strontium-90	1.77	NA	NA	----
Thorium-228	0.293	NA	NA	----
Thorium-230	3.17	NA	NA	----

Table V.2b. (page 3 of 3)

Chemical	Maximum Detected Concentration	Federal Maximum Contaminant Level	Ohio Drinking Water Standard	Maximum Concentration Exceeds Regulatory Standards
Thorium-232	0.252	NA	NA	----
Tritium	12500	NA	NA	----
Uranium-234	1.23	NA	NA	----
Uranium-235/236	0.121	NA	NA	----
Uranium-238	2.3	NA	NA	----

[a]Secondary maximum contaminant level (SMCL)
[b]Maximum contaminant level goal (MCLG)
[c]Proposed
NA - Not Available

Table V.3. Operable Unit 9 Background Groundwater Statistics (Inorganics and Radionuclides) - September 1993

Chemical	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Concentration
Inorganics (concentration values in μg/L)					
Aluminum	38.2	57.8	Lognormal	198	161
Arsenic	5.61	10.4	Lognormal	50.8	30.2
Barium	151	76.9	Lognormal	245	253
Calcium	99000	6270	Normal	105000	107000
Chloride	73800	41200	Normal	112000	136000
Chromium	40.9	146	Lognormal	1262	177
Cobalt	1.05	0.650	Nonparametric	1.96	2.3
Copper	1.50	1.09	Lognormal	3.05	4.5
Iron	1230	1140	Normal	2290	2800
Lead	2.52	3.35	Nonparametric	11.6	11.9
Magnesium	36442	3045	Lognormal	38859	39900
Manganese	117	536	Lognormal	8444	163
Nickel	64.1	442	Lognormal	7740	137
Nitrate Nitrite	2180	2220	Nonparametric	4230	4600
Potassium	3741	1922	Lognormal	6089	7770
Selenium	0.804	0.280	Nonparametric	0.97	0.25
Sodium	39600	22100	Normal	60100	63700
Sulfate	87944	193963	Lognormal	972511	126000
Vanadium	7.4	10.1	Normal	13	19.5
Zinc	14.5	20.8	Lognormal	71.7	73.0
Radionuclides (concentration values in pCi/L)					
Radium-226	0.420	0.110	Lognormal	0.528	0.634
Thorium-228	0.476	0.135	Lognormal	0.610	0.605
Thorium-230	0.127	0.0855	Lognormal	0.264	0.316
Thorium-232	0.106	0.0499	Lognormal	0.168 [a]	0.225
Uranium-234	0.437	0.155	Normal	0.599	0.633
Uranium-235/236	0.0338	0.00548	Nonparametric	0.0390[a]	0.045
Uranium-238	0.320	0.212	Lognormal	0.659	0.536

[a]Non-detected element/compound

Table V.4. Comparison of Area B Maximum Detected Concentrations with Operable Unit 9 Background Ranges

Chemical	Area B Maximum Detected Concentration	Operable Unit 9 Background Range	Maximum Concentration > Background Range?
Inorganic Chemicals (concentration values in μg/L)			
Aluminum	2,330	6.0 - 161	Yes
Arsenic	2.8	2.5 - 30.2	No
Barium	198	85.8 - 253	No
Calcium	184,000	86,800 - 107,000	Yes
Chloride	284,000	30,950 - 136,000	Yes
Chromium	353	2.0 - 177	Yes
Cobalt	19	0.6 - 2.3	Yes
Copper	42.1	0.9 - 4.5	Yes
Iron	11,400	49.0 - 2,800	Yes
Lead	9.6	1.0 - 11.9	No
Magnesium	71,100	30,300 - 39,900	Yes
Manganese	504	2.2 - 163	Yes
Nickel	510	1.0 - 137	Yes
Nitrate, Nitrite	3,400	10.0 - 4,600	No
Potassium	5,230	1,650 - 7,770	No
Selenium	3.2	< 0.25	Yes
Sodium	123,000	14,400 - 63,700	Yes
Sulfate	129,000	2,500 - 126,000	Yes
Vanadium	31.4	0.38 - 19.5	Yes
Zinc	915	3.1 - 73.0	Yes
Radionuclides (concentration values in pCi/L)			
Radium-226	2.4	0.30 - 0.63	Yes
Thorium-228	0.293	0.29 - 0.61	No
Thorium-230	3.17	0.065 - 0.32	Yes
Thorium-232	0.252	0.06 - 0.23[a]	Yes
Uranium-234	1.23	0.23 - 0.63	Yes
Uranium-235/236	0.121	0.030 - 0.045[a]	Yes
Uranium-238	2.3	0.098 - 0.54	Yes

[a] Non-detected compound/element

specifying no difference between site and background is not rejected. However, if the significance level is less than 5 percent, the null hypothesis is rejected. If the null hypothesis is rejected within a particular medium of concern, the chemical was retained as a possible COPC within that medium.

If the T-Test rejects the null hypothesis, a comparison of the background and site 95 percent UCLs of the mean was performed. If the 95 percent UCL of the site mean exceeds that of the background mean within a particular medium of concern, the chemical was retained as a COPC within that medium.

If the site and background datasets are not both normally or lognormally distributed, the Mann-Whitney Test must be used. The Mann-Whitney is a nonparametric test that compares the site and background datasets using a ranking procedure. Like the T-Test, the Mann-Whitney Test computes a one-tailed test significance level, which is analyzed in the same manner as described for the T-Test. In addition to the significance level, the Mann-Whitney Test computes a rank for each dataset. If the rank of the background dataset is equal to or higher than that of the site, the site concentration levels are assumed to be statistically less than or equivalent to the background levels. If the site rank exceeds the background rank and the one-tailed significance level is less than 5 percent within a particular medium of concern, the chemical was retained as a COPC within that medium.

The T-Test and Mann-Whitney Test are discussed in further detail in Appendix O.

Table V.5 summarizes the results of the statistical comparisons between Area B and Operable Unit 9 background groundwater chemical concentration levels. Calcium, chloride, cobalt, copper, magnesium, selenium, sodium, uranium-235/236, and uranium-238 were found to have concentration levels that exceed background.

Calcium, chloride, copper, magnesium, selenium, and sodium are considered essential nutrients to humans. These elements were found to exist in Area B groundwater at levels that exceed Operable Unit 9 background levels. However, assuming ingestion of 2 liters per day, these concentrations would correspond to intakes well within nutritional ranges. As such, these constituents were eliminated as COPCs. The detected concentrations and nutritional values are shown in Table V.6.

Cobalt does not have a recommended dietary allowance, although it is a component of vitamin B_{12}. Based on a 2 liter/day ingestion rate, intakes of cobalt are within typical dietary ranges. In addition, the estimated daily intake of cobalt from groundwater ingestion is several orders of magnitude lower than the reported human toxic intake level of 500 mg-cobalt/day (Bowen 1979). Since cobalt does not have a reference dose and because intakes that would correspond to detected levels are within typical dietary ranges, cobalt was eliminated as a COPC.

Table V.5. Statistical Comparison of Area B Groundwater Data to Operable Unit 9 Background Data

Chemical	Site and Background Data Both Normally or Lognormally Distributed?	T-Test One-Tailed Significance Level	Site 95% UCL > Background 95% UCL?	Mann-Whitney One-Tailed Significance Level	Site Rank > Background Rank?	Retain as a Possible COPC based on Background Comparison?
Inorganic Chemicals						
Aluminum	No	N/A	N/A	0.29	Yes	No
Calcium	Yes	0.000	Yes	N/A	N/A	Yes
Chloride	Yes	0.000	Yes	N/A	N/A	Yes
Chromium	No	N/A	N/A	0.46	Yes	No
Cobalt	No	N/A	N/A	0.000	Yes	Yes
Copper	No	N/A	N/A	0.007	Yes	Yes
Iron	No	N/A	N/A	0.42	Yes	No
Magnesium	Yes	0.000	Yes	N/A	N/A	Yes
Manganese	Yes	0.08	No	N/A	N/A	No
Nickel	Yes	0.02	No	N/A	N/A	No
Selenium	No	N/A	N/A	0.001	Yes	Yes
Sodium	No	N/A	N/A	0.000	Yes	Yes
Sulfate	Yes	0.03	No	N/A	N/A	No
Vanadium	No	N/A	N/A	0.10	No	No
Zinc	Yes	0.14	Yes	N/A	N/A	No

Table V.5. (page 2 of 2)

Chemical	Site and Background Data Both Normally or Lognormally Distributed?	T-Test One-Tailed Significance Level	Site 95% UCL > Background 95% UCL?	Mann-Whitney One-Tailed Significance Level	Site Rank > Background Rank?	Retain as a Possible COPC based on Background Comparison?
Radionuclides						
Radium-226	Yes	0.11	Yes	N/A	N/A	Yes
Thorium-230	No	N/A	N/A	0.38	No	No
Thorium-232	Yes	0.06	No	N/A	N/A	No
Uranium-234	Yes	0.10	Yes	N/A	N/A	No
Uranium-235/236	No	N/A	N/A	0.02	Yes	Yes
Uranium-238	Yes	0.03	Yes	N/A	N/A	Yes

N/A - Not Applicable

Table V.6. Nutritional Values for Nutrient Inorganics

	Nutritional Value (mg/day)	Concentration Term[a] (mg/L)	Equivalent Daily Quantity (mg)
Calcium	1200 [1]	165	330
Chloride	750 [2]	216	432
Copper	3 [3]	0.036	0.072
Magnesium	400 [1]	52	104
Selenium	75 [1]	0.0019	0.0038
Sodium	500 [2]	97	194

[a]95% of UCL of the mean if less than the maximum detected concentration; otherwise, the maximum detected concentration is used.
[1]Recommended Dietary Allowance (RDA) for adults.
[2]Estimated Minimum Requirement for adults.
[3]Estimated Safe and Adequate Daily Dietary Intakes (ESADDI) for adults.

Ref: National Research Council, 1989

Radionuclides were retained as COPCs if they were detected in groundwater and are daughter products of radionuclides with concentration levels exceeding background. These daughter radionuclides were retained as COPCs even if their concentration levels were found to be equivalent to background.

Soil

Borehole core data taken from depths of 0 to 6 ft below land surface were used for the risk assessment. The use of 6 ft of soil depth is considered conservative because chemical levels were generally found to be higher at depths below 18 inches. In addition, chemicals that were not detected in the surface soil were detected at deeper depths. Thus, the number of chemicals detected within the top 6 ft of soil is much larger than the total number detected in the surface soil, which results in a large COPC list for soil.

Table V.7 presents the summary statistics of chemicals detected in Area B soils. The procedures used to compute groundwater statistics were utilized in computing the soil statistics.

A frequency of detection analysis identical to that performed for groundwater was conducted for chemicals detected in Area B soils. Based on frequency of detection analysis, 2-butanone, 2-hexanone, acetone, carbon disulfide, diethyl phthalate, and xylenes (total) were eliminated as soil COPCs. The results of the frequency of detection analysis are presented in Table V.8.

Appropriate Mound Plant background soil data was not available at the time this risk assessment was being developed. As a result, Area B data was compared to background data taken from other sites within Ohio. Inorganic data was statistically compared to Wright-Patterson Air Force Base background data while radionuclide soil data was compared to background ranges in Fernald, Ohio, and background ranges developed by the University of Cincinnati for Mound (Motahamelian 1990). The use of these sites' background data for comparison was deemed appropriate because they are near Mound Plant. In addition, Mound Plant and these sites have similar geological characteristics.

Table V.9 presents the comparison of maximum detected Area B inorganic concentrations to Wright-Patterson Air Force Base background ranges. The maximum detected concentrations of calcium, copper, lead, magnesium, silver, and sodium exceeded their Wright-Patterson background concentration ranges. These elements were then statistically compared to background sample data taken from Area A/C at Wright-Patterson Air Force Base using the T-Test and Mann-Whitney Test. The Area A/C background sample results are presented in Tables V.10a and V.10b. The statistical comparison results are presented in Table V.11. Silver is the only element with concentration levels exceeding background levels.

Table V.7. Statistical Summary of Chemicals Detected in Operable Unit 1, Area B Soil (0-6 ft)

Chemical	Frequency of Detection	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Detected Concentration
Organic Chemicals (concentration values in μg/kg)						
1,2,3,4,6,7,8-HpCDF	2/4	0.0025	0.0029	Normal	0.0072	0.0063
1,2,3,4,6,7,8-HpCDD	2/4	0.0108	0.0141	Normal	0.0333	0.0303
1,2,3,4,7,8,9-HpCDF	1/4	0.0004	0.0002	Normal	0.0007	0.00062
1,2,3,4,7,8-HxCDD	1/4	0.0004	0.0002	Normal	0.0007	0.00065
1,2,3,4,7,8-HxCDF	2/4	0.0012	0.0011	Normal	0.0029	0.0022
1,2,3,5,7,8-HxCDF	2/4	0.0006	0.0005	Normal	0.0014	0.0012
1,2,3,6,7,8-HxCDD	1/4	0.0007	0.0007	Normal	0.0019	0.0017
1,2,3,7,8,9-HxCDD	1/4	0.0007	0.0007	Normal	0.0019	0.0018
1,2,3,7,8-PCDF	2/4	0.0007	0.0004	Normal	0.0013	0.0011
2,3,4,6,7,8-HxCDF	2/4	0.0006	0.0004	Normal	0.0012	0.001
2,3,4,7,8-PCDF	2/4	0.001	0.0007	Normal	0.0021	0.0016
2,3,7,8-TCDD	2/4	0.0034	0.0043	Normal	0.0102	0.0096
2,3,7,8-TCDF	2/4	0.0014	0.0014	Normal	0.0036	0.0028
OCDD	2/4	0.0944	0.127	Normal	0.296	0.273
OCDF	2/4	0.0036	0.0047	Normal	0.011	0.0103
1,2-Dichloroethene	5/31	6.04	8.13	Nonparametric	9.02	37.0
2-Butanone	1/31	5.83	1.97	Nonparametric	6.52	1.00
2-Hexanone	1/31	5.77	1.22	Nonparametric	6.18	2.00
4-Methylphenol	2/21	200	28.3	Nonparametric	213	290
Acetone	1/31	5.75	0.75	Nonparametric	6.03	3.00
Aroclor-1248	11/21	47.8	84.2	Nonparametric	86.1	410
Benzo(a)anthracene	6/21	169	87.1	Nonparametric	209	230
Benzo(a)pyrene	8/21	161	91.1	Nonparametric	206	230
Benzo(b)fluoranthene	7/21	176	99.4	Nonparametric	225	380
Benzo(k)fluoranthene	3/21	185	65.7	Nonparametric	214	140
Benzoic Acid	10/21	953	339	Nonparametric	1104	1700
Bis(2-ethylhexyl)phthalate	4/21	231	273	Nonparametric	356	1400
Carbon Disulfide	1/31	3.64	1.26	Nonparametric	4.10	3.00

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Chemical	Frequency of Detection	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Detected Concentration
Chrysene	7/21	166	75.3	Nonparametric	201	230
Dichloromethane	1/31	4.84	6.95	Nonparametric	7.39	41.8
Diethyl Phthalate	1/21	191	27.6	Nonparametric	202	110
Endosulfan Sulfate	1/21	2.03	0.345	Nonparametric	2.17	3.90
Fluoranthene	11/21	155	111	Nonparametric	213	320
Indeno(1,2,3-cd)pyrene	2/21	186	35.1	Nonparametric	222	133
Phenol	2/21	186	43.6	Nonparametric	205	110
Pyrene	11/21	149	104	Lognormal	203	280
Tetrachloroethylene	2/21	3.7	1.28	Nonparametric	4.17	5.00
Toluene	2/31	3.56	1.46	Nonparametric	4.09	8.00
Trichloroethylene	5/31	7.23	12.0	Nonparametric	11.6	64.0
Vinyl Chloride	2/31	5.72	1.26	Nonparametric	6.14	4.00
Xylenes (Total)	1/31	3.51	1.21	Nonparametric	3.95	2.00
Inorganic Chemicals (concentration values in μg/kg)						
Aluminum	18/18	5190000	1330000	Normal	5850000	8170000
Arsenic	18/18	5120	1160	Normal	5690	8800
Barium	18/18	41800	10900	Normal	47200	58100
Beryllium	4/18	526	663	Nonparametric	1006	350
Cadmium	1/18	619	419	Nonparametric	873	310
Calcium	18/18	106000000	17600000	Normal	115000000	133000000
Chromium	14/15	7280	1460	Normal	8090	10200
Cobalt	15/16	5750	5060	Nonparametric	8440	6500
Copper	17/18	14455	13070	Nonparametric	22852	42700
Fluoride	17/18	2822	2418	Lognormal	4381	5850
Iron	18/18	11600000	1990000	Normal	12500000	16300000
Lead	17/18	12600	16100	Nonparametric	20600	75400
Lithium	5/18	8800	5500	Nonparametric	11500	18100
Magnesium	18/18	41900000	8040000	Normal	45900000	58700000

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Chemical	Frequency of Detection	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Detected Concentration
Manganese	18/18	319000	86600	Normal	363000	606000
Mercury	5/18	116	150	Nonparametric	191	560
Nickel	14/18	11200	5400	Normal	13900	17100
Nitrate	14/18	3992	3716	Lognormal	6375	16900
Potassium	18/18	946524	339619	Lognormal	1117557	1750000
Silver	12/18	2951	3624	Lognormal	5586	4200
Sodium	11/18	309992	246055	Nonparametric	458283	398000
Thallium	3/18	1040	309	Normal	1190	770
Vanadium	16/16	13700	2940	Normal	15300	18800
Zinc	15/18	38600	21700	Normal	49400	79400
Radionuclides (concentration values in pCi/g)						
Cesium-137	3/20	0.0727	0.0231	Lognormal	0.0828	0.0997
Plutonium-238	18/21	1.07	3.57	Lognormal	3.98	8.75
Plutonium-239/240	13/21	0.0910	0.0501	Lognormal	0.116	0.237
Potassium-40	20/20	13.3	1.97	Lognormal	14.2	18.6
Radium-226	20/20	0.811	0.121	Lognormal	0.862	1.08
Strontium-90	6/20	0.506	0.188	Nonparametric	0.594	0.627
Thorium-228	19/21	0.656	0.230	Lognormal	0.758	1.30
Thorium-230	20/21	0.923	0.272	Normal	1.05	1.40
Thorium-232	19/21	0.537	0.188	Normal	0.622	1.04
Tritium	24/30	0.956	2.69	Lognormal	2.23	4.53
Uranium-234	21/21	0.699	0.117	Normal	0.752	0.936
Uranium-235/236	7/21	0.0596	0.0213	Lognormal	0.0691	0.0810
Uranium-238	21/21	0.767	0.138	Lognormal	0.823	1.10

Table V.8. Frequency of Detection Analysis - Operable Unit 1, Area B Soil (0-6 ft)

Chemical	Frequency of Detection	Maximum Detected Concentration	Method Detection Limit (MDL)	Maximum Detected Concentration > MDL	Eliminate as COPC based on Detection Frequency and MDL Comparison?
Organic Chemicals (concentration values in μg/kg)					
1,2,3,4,6,7,8-HpCDF	50.0%	0.0063	0.0025	Yes	No
1,2,3,4,6,7,8-HpCDD	50.0%	0.0303	0.0025	Yes	No
1,2,3,4,7,8,9-HpCDF	25.0%	0.00062	0.0025	No	No
1,2,3,4,7,8-HxCDD	25.0%	0.00065	0.0025	No	No
1,2,3,4,7,8-HxCDF	50.0%	0.0022	0.0025	No	No
1,2,3,5,7,8-HxCDF	50.0%	0.0012	0.0025	No	No
1,2,3,6,7,8-HxCDD	25.0%	0.0017	0.0025	No	No
1,2,3,7,8,9-HxCDD	25.0%	0.0018	0.0025	No	No
1,2,3,7,8-PCDF	50.0%	0.0011	0.002	No	No
2,3,4,6,7,8-HxCDF	50.0%	0.001	0.0025	No	No
2,3,4,7,8-PCDF	50.0%	0.0016	0.002	No	No
2,3,7,8-TCDD	50.0%	0.0096	0.001	Yes	No
2,3,7,8-TCDF	50.0%	0.0028	0.001	Yes	No
OCDD	50.0%	0.273	0.005	Yes	No
OCDF	50.0%	0.0103	0.005	Yes	No
1,2-Dichloroethene	16.1%	37.0	12	Yes	No
2-Butanone	3.2%	1.00	12	No	Yes
2-Hexanone	3.2%	2.00	5	No	Yes
4-Methylphenol	9.5%	290	460	No	No
Acetone	3.2%	3.00	12	No	Yes
Aroclor-1248	52.4%	410	33	Yes	No
Benzo(a)anthracene	28.6%	230	410	No	No
Benzo(a)pyrene	38.1%	230	410	No	No
Benzo(b)fluoranthene	33.3%	380	410	No	No
Benzo(k)fluoranthene	14.3%	140	410	No	No
Benzoic Acid	47.6%	1700	2000	No	No
Bis(2-ethylhexyl)phthalate	19.0%	1400	350	Yes	No
Carbon Disulfide	3.2%	3.00	6	No	Yes

Table V.8. (page 2 of 3)

Chemical	Frequency of Detection	Maximum Detected Concentration	Method Detection Limit (MDL)	Maximum Detected Concentration > MDL	Eliminate as COPC based on Detection Frequency and MDL Comparison?
Chrysene	33.3%	230	410	No	No
Dichloromethane	3.2%	41.8	5	Yes	No
Diethyl Phthalate	4.8%	110	370	No	Yes
Endosulfan (Sulfate)	4.8%	3.90	3.7	Yes	No
Fluoranthene	52.4%	320	410	No	No
Indeno(1,2,3-cd)pyrene	9.5%	133	380	No	No
Phenol	9.5%	110	380	No	No
Pyrene	52.4%	280	410	No	No
Tetrachloroethylene	9.5%	5.00	6	No	No
Toluene	6.5%	8.00	11	No	No
Trichloroethylene	16.1%	64.0	6	Yes	No
Vinyl Chloride	6.5%	4.00	12	No	No
Xylenes (Total)	3.2%	2.00	12	No	Yes
Inorganic Chemicals (concentration values in μg/kg)					
Aluminum	100.0%	8170000	12000	Yes	No
Arsenic	100.0%	8800	2200	Yes	No
Barium	100.0%	58100	15000	Yes	No
Beryllium	22.2%	350	590	No	No
Cadmium	5.6%	310	560	No	No
Calcium	100.0%	133000000	14800000	Yes	o
Chromium	93.3%	10200	3000	Yes	No
Cobalt	93.8%	6500	15000	No	No
Copper	94.4%	42700	1000	Yes	No
Fluoride	94.4%	5850	570	Yes	No
Iron	100.0%	16300000	29000	Yes	No
Lead	94.4%	75400	720	Yes	No
Lithium	27.8%	18100	6000	Yes	No
Magnesium	100.0%	58700000	13500000	Yes	No
Manganese	100.0%	606000	4000	Yes	No

Table V.8. (page 3 of 3)

Chemical	Frequency of Detection	Maximum Detected Concentration	Method Detection Limit (MDL)	Maximum Detected Concentration > MDL	Eliminate as COPC based on Detection Frequency and MDL Comparison?
Mercury	27.8%	560	140	Yes	No
Nickel	77.8%	17100	9000	Yes	No
Nitrate	77.8%	16900	1510	Yes	No
Potassium	100.0%	1750000	2980000	No	No
Silver	66.7%	4200	3000	Yes	No
Sodium	61.1%	398000	1250000	No	No
Thallium	16.7%	770	2000	No	No
Vanadium	100.0%	18800	3000	Yes	No
Zinc	83.3%	79400	6000	Yes	No
Radionuclides (concentration values in pCi/g)					
Cesium-137	15.0%	0.0997	0.8	No	No
Plutonium-238	85.7%	8.75	0.036	Yes	No
Plutonium-239/240	61.9%	0.237	0.107	Yes	No
Potassium-40	100.0%	18.6	0.8	Yes	No
Radium-226	100.0%	1.08	0.1	Yes	No
Strontium-90	30.0%	0.627	0.465	Yes	No
Thorium-228	90.5%	1.30	0.0213	Yes	No
Thorium-230	95.2%	1.40	1	Yes	No
Thorium-232	90.5%	1.04	0.0213	Yes	No
Tritium	80.0%	4.53	0.06	Yes	No
Uranium-234	100.0%	0.936	0.166	Yes	No
Uranium-235/236	33.3%	0.0810	0.022	Yes	No
Uranium-238	100.0%	1.10	0.128.6	Yes	No

Table V.9. Comparison of Area B Maximum Detected Concentrations with Wright-Patterson Air Force Base Background Ranges

Chemical	Area B Maximum Detected Concentration	Wright-Patterson Air Force Base Background Range[a]	Maximum Concentration > Background Range
Inorganic Chemicals (concentration values in μg/kg)			
Aluminum	8,170,000	518,000 - 20,100,000	No
Arsenic	8,800	3,000 - 12,000	No
Barium	58,100	6,000 - 120,000	No
Beryllium	350	200 - 1,300	No
Cadmium	310	800 - 1,300	No
Calcium	133,000,000	238,000 - 129,000,000	Yes
Chromium	10,200	2,000 - 28,000	No
Cobalt	6,500	6,000 - 14,000	No
Copper	42,700	7,000 - 32,000	Yes
Iron	16,300,000	888,000 - 37,000,000	No
Lead	75,400	10,000 - 52,000	Yes
Lithium	18,100	700 - 64,000[b]	No
Magnesium	58,700,000	109,000 - 57,800,000	Yes
Manganese	606,000	59,000 - 920,000	No
Mercury	560	100 - 690	No
Nickel	17,100	6,000 - 36,000	No
Potassium	1,750,000	145,000 - 2,370,000	No
Silver	4,200	700 - 1,300	Yes
Sodium	398,000	105,000 - 320,000	Yes
Thallium	770	600 - 1,000	No
Vanadium	18,800	1,000 - 43,000	No
Zinc	79,400	5,000 - 101,000	No

[a]References: DOE 1993g
DOE 1992j
DOE 1993h

[b] Was not analyzed for at Wright-Patterson; national range used (Kabata-Pendias 1992)

Table V.10a. Data Summary Table: Soil - Background (Area A/C) - Wright-Patterson Air Force Base, Fairborn

SAIC ID Number Collected Data Associated Field QC Samples	Units	SB2-3-1 7/12/91 FB-12 TB-F RB-12	SB2-3-6 7/12/91 FB-12 TB-F RB-12	SB3-4-2 7/15/91 FB-13 TB-6 RB-12	SB3-4-3 7/15/91 FB-13 TB-6 RB-12	SB11-3-5 7/9/91 TB-A,B,C FB-12 RB-11	SB11-3-5 RR 7/9/91 TB-A,B,C FB-12 RB-11	SB11-3-6 7/9/91 TB-A,R,C FB-12 EB-11
Calcium	mg/kg	47400.0	96200.0	NA	NA	129000	NA	120000
Copper	mg/kg	17.3	15.2	NA	NA	7.2	NA	7.9 J
Lead	mg/kg	12.4	5.3 J	3.4 J	10.8 J	3.3 J	NA	2.9 J
Magnesium	mg/kg	19500.0 J	34300.0 J	NA	NA	49700	NA	57800
Sodium	mg/kg	105.0 J	154.0 J	NA	NA	183 J	NA	159 J

Table V.10b. Statistical Results of Wright-Patterson Background Data (Area A/C)

Chemical	Mean	Standard Deviation	Distribution Type	95% UCL of the Mean	Maximum Detected Concentration
Inorganic Chemicals (concentration values in mg/kg)					
Calcium	98200	36600	Normal	156000	129000
Copper	12.2	5.74	Lognormal	24.2	17.3
Lead	6.51	4.59	Normal	21.7	12.4
Magnesium	40500	16900	Normal	67400	57800
Sodium	151	36.6	Lognormal	205	183

NA - not analyzed
J - estimated value
U - Compound/element was included in analysis, but was not detected.

Reference: DOE 1993h

Table V.11. Statistical Comparison of Area B Soil Data to Wright-Patterson Air Force Base Background Soil Data (Area A/C)

Chemical	Site and Background Data Both Normally or Lognormally Distributed?	T-Test One-Tailed Significance Level	Site 95% UCL > Background 95% UCL	Mann-Whitney One-Tailed Significance Level	Site Rank > Background Rank	Retain as a COPC
Calcium	Yes	0.35	No	N/A	N/A	No
Copper	No	N/A	N/A	0.50	No	No
Lead	No	N/A	N/A	0.06	Yes	No
Magnesium	Yes	0.44	No	N/A	N/A	No
Sodium	No	N/A	N/A	0.22	Yes	No

N/A - Not Applicable

No Wright-Patterson background data were available for fluoride or nitrate. As a result, these elements were retained as COPCs for the risk assessment.

Table V.12 presents the comparison of maximum detected Area B radionuclide concentrations to Fernald and Mound Plant soil background ranges. The Fernald background range represents radionuclide concentrations that were detected in a depth interval of 0 to 54 inches below land surface. The Mound Plant background range represents radionuclide concentrations that were detected in the surface soil.

Radionuclides were retained as COPCs if they were detected in soil and are daughter products of radionuclides with concentration levels exceeding background. These daughter radionuclides were retained as COPCs even if their concentration levels were found to be equivalent to background.

Surface Water/Sediments

An investigation of Operable Unit 1 surface waters and sediments will be addressed in the Operable Unit 9 Site-Wide Remedial Investigation (DOE 1992b).

Air

An investigation of Operable Unit 1 air will be addressed in the Operable Unit 9 Site-Wide Remedial Investigation (DOE 1992b).

5.2.3. Summary of Chemicals of Potential Concern

Groundwater

The organic COPCs for groundwater are:

- 1,1,1-TCA,
- 1,2-*cis*-DCE,
- *bis*(2-ethylhexyl)phthalate,
- chlordane (alpha),
- diethyl phthalate,
- pyrene,
- PCE,
- tetrachloromethane,
- TCE,
- trichloromethane,

Table V.12. Comparison of Background and Site Radionuclide Concentrations in Soil

Radionuclide	Maximum Detected concentration - Area B (pCi/g)	95% UCL of the Mean - Area B (pCi/g)	Maximum Detected Mound Background Concentration[a] (pCi/g)	Average Background Concentration - Mound[a] (pCi/g)	Detected Background Concentration Range - Fernald[b,c] (pCi/g)
Cesium-137	0.0997	0.0828	1.21	0.44	0.15 - 0.71
Potassium-40	18.6	14.2	18.4	1.54	8.6 - 31.0
Radium-226	1.08	0.862	2.58	1.42	0.59 - 1.61
Thorium-228	1.30	0.774	2.03	0.96	0.60 - 1.43
Thorium-230	1.40	1.05	NA	NA	0.62 - 2.34
Thorium-232	1.04	0.622	1.95	0.94	0.63 - 1.52
Uranium-234	0.936	0.752	NA	NA	0.48 - 1.31
Uranium-235/236	0.081	0.691	NA	NA	0.03 - 0.20
Uranium-238	1.10	0.823	2.96	1.49	0.60 - 1.33

NA - Not available

[a]Motahamelian 1990
[b]DOE 1993 ?
[c]Depth interval = 0-54"

- trichlorofluoromethane, and
- vinyl chloride.

The radioactive COPCs (that exceeded background levels) are:

- actinium-227,
- plutonium-238,
- plutonium-239/240,
- strontium-90,
- tritium,
- uranium-235, 236, and
- uranium-238.

The risks resulting from exposure to these chemicals and radionuclides were quantitatively assessed.

The following radionuclides were retained as groundwater COPCs because they are daughter products of the radionuclides that were found to exceed background levels:

- radium-226,
- thorium-228,
- thorium-230,
- thorium-232, and
- uranium-234.

The risks resulting from exposure to these radionuclides were assessed separately from the other groundwater COPCs since their concentration levels were found to be equivalent to background.

Soil

The organic COPCs for soils are:

- 1,2,3,4,6,7,8-HpCDF,
- 1,2,3,4,6,7,8-HpCDD,
- 1,2,3,4,7,8,9-HpCDF,
- 1,2,3,4,7,8-HxCDD,
- 1,2,3,4,7,8-HxCDF,
- 1,2,3,5,7,8-HxCDF,
- 1,2,3,6,7,8-HxCDD,
- 1,2,3,7,8,9-HxCDD,
- 1,2,3,7,8-PeCDF,
- 2,3,4,6,7,8-HxCDF,
- 2,3,4,7,8-PeCDF,
- 2,3,7,8-TCDD,
- 2,3,7,8-TCDF,

- OCDD,
- OCDF,
- 1,2-DCE,
- 4-methyphenol,
- aroclor-1248,
- benzo(a)anthracene,
- benzo(a)pyrene,
- benzo(b)fluoranthene,
- benzo(k)fluoranthene,
- benzoic acid,
- *bis*(2-ethylhexyl)phthalate,
- vinyl chloride,
- chrysene,
- dichloromethane
- fluoranthene,
- indeno(1,2,3-cd)pyrene,
- phenol
- pyrene,
- PCE,
- toluene, and
- TCE.

Inorganic COPCs consist of:

- fluoride,
- nitrate, and
- silver.

The radioactive COPCs (that exceeded background levels) are:

- plutonium-238,
- plutonium-239/240,
- strontium-90, and
- tritium.

The risks resulting from exposure to these chemicals and radionuclides were quantitatively assessed.

The following radionuclides were retained as soil COPCs because they are daughter products of the radionuclides that were found to exceed background levels:

- thorium-228,
- thorium-232, and
- uranium-235/236.

The risks resulting from exposure to these radionuclides were assessed separately from the other soil COPCs since their concentration levels were found to be equivalent to background.

5.3. EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the type and magnitude of exposures to COPCs that are present at or migrating from Area B. The exposure pathway is the mechanism by which an individual or population is exposed to chemicals at or originating from a site. Each exposure pathway requires a source or release from a source, an exposure point, and an exposure route.

5.3.1. Exposure Setting

The exposure setting, which includes Area B climate, vegetation, groundwater hydrology, and other characteristics, is described in detail in Section 2. The nearest populations are present at less than 750 ft west of Operable Unit 1 within the city of Miamisburg. The 1990 census gives the population of Miamisburg as 17,834, Dayton as 182,044, and Montgomery County as 573,809. Miamisburg is predominately a residential community, with some supportive commercial facilities and limited industrial and agricultural development.

Most of the residential, commercial, and industrial development within a 5-mile radius of the site is concentrated on the Great Miami River floodplain. The adjacent upland areas are used primarily for residences and agriculture or are unused open spaces. Agricultural land within a 5-mile radius of the site is primarily used for corn and soybean production and livestock grazing.

The major water body in the vicinity of Operable Unit 1 is the Great Miami River. It is approximately 150 to 200 ft wide in this area. The river is used for pleasure boating and sport fishing, primarily during the summer. Swimming is not permitted in the river.

5.3.2. Characterization of Exposure Pathways

Operable Unit 1 is located within a government-owned and restricted facility. Unrestricted access and development of the site is possible only if the DOE releases the property. No one presently lives on or otherwise uses the property, and current workers do not work on a continual basis within Area B.

Three Operable Unit 1 production wells supply or have supplied water to the Mound Plant. One well, production well 0071, is no longer in use because volatile organic contaminants were detected at concentrations exceeding EPA MCLs and Ohio drinking water standards. The other two wells, production wells 0076 and 0271, are still in use and have organic concentrations that are below EPA MCLs and Ohio drinking water standards (EG&G 1992). Since Mound Plant is taking water that

meets acceptable drinking water standards from Operable Unit 1, a current worker scenario was not considered for the baseline risk assessment.

This baseline risk assessment involves 1) the determination of contaminant concentrations at exposure points for a future resident farmer scenario and future indoor and outdoor industrial park worker scenarios, and 2) the estimation of contaminant intake through potential exposure pathways. The future onsite farmer resident scenario is considered the most conservative situation for the following reasons:

- the future onsite farmer would be exposed to concentrations that are much higher than the concentrations a current offsite resident would experience, because the farmer is assumed to be located at the contaminant source;
- the future onsite farmer would be exposed to Area B contaminant concentrations for a much longer period of time than an onsite worker; and
- the future onsite farmer scenario evaluates the greatest number of exposure pathways.

Two types of exposures will be evaluated for the future farmer resident scenario. These exposure types are denoted as the reasonable maximum exposure (RME) and the central tendency exposure (CTE). The RME is defined as a "reasonable worst case" that is conservatively high, yet still has a reasonable likelihood of occurring (HRI 1993). Key features of an RME are that one would expect at least 90 percent of actual exposures to be lower and that it could occur (HRI 1993). The CTE, on the other hand, is an "average case." Fifty percent of actual exposures are expected to be lower or higher than the CTE. High exposures will typically fall between the CTE and the RME.

It is assumed that the future farmer resident will remain at that location for 30 years for the RME, which is a reasonable upper bound for individuals living at any one residence in the course of their lifetimes (EPA 1991). For the CTE, it is assumed that the resident will live on the site for 9 years (EPA 1989a). For both the RME and CTE, the source of water is assumed to be a contaminated onsite well. It is also assumed that all domestic uses of water, which include drinking, cooking, washing, cleaning, and irrigation of garden produce, come solely from the contaminated onsite well.

The exposure scenario for the future farmer resident includes all potential pathways identified in the site conceptual model that could lead to quantifiable exposure. The farmer is assumed to be exposed through the following routes:

- ingestion of groundwater,
- incidental ingestion of and dermal contact with surface water while swimming,

- dermal contact and inhalation of VOCs while showering in groundwater,
- inhalation of resuspended dust while plowing/cultivating crops and garden produce and under usual dust resuspension conditions,
- incidental ingestion of soil,
- external exposure to radiation emitted from radionuclides in soil,
- dermal contact with chemicals in soil,
- ingestion of homegrown produce grown in contaminated soil, and
- ingestion of livestock that have ingested contaminated soil and contaminated plants.

For the RME, it is assumed that the future onsite industrial park worker will work within the Area B location for 25 years (EPA 1991). For the CTE, it is assumed that the worker will be employed on the site for 9 years (assumed equal to residential). As with the future farmer resident, the source of water for the industrial park comes from contaminated onsite wells that workers use for showering at the end of the workday.

In the future indoor industrial worker scenario, it is assumed that the worker performs job duties within a structure or building for 8 hours a day and 250 days a year (EPA 1991). The indoor worker is assumed to be exposed through the following routes:

- ingestion of groundwater,
- inhalation of indoor vapors,
- inhalation of indoor particulates,
- inhalation of VOCs while showering using groundwater, and
- dermal contact with contaminants while showering using groundwater.

For the future outdoor industrial worker scenario, the following exposure routes were evaluated:

- ingestion of groundwater,
- inhalation of outdoor particulates and vapors,
- ingestion of soil,
- dermal contact with chemicals in soil,

- inhalation of VOCs while showering using groundwater, and
- dermal contact with chemicals while showering using groundwater.

5.3.3. Quantification of Exposure

The following subsection presents the mathematical models that were used to calculate the estimated daily intakes for the human exposure routes identified above. The models are presented in tabular form; each table includes definitions and assumptions used. Estimated daily intakes were calculated using the 95 percent UCL of the normal or lognormal mean for each COPC (EPA 1992a). The maximum detected concentration was used only if it was found to be less than the 95 percent UCL. Intakes were computed for hypothetical future workers and residents (an adult and a child aged 1 to 7 years).

5.3.3.1. Exposure Factors and Exposure Algorithms

Exposure point concentrations for organics, inorganics, and radionuclides were estimated for the future resident farmer scenario and, where appropriate, for the future indoor and outdoor industrial workers. These concentrations were estimated using the 95 percent UCL of the normal or lognormal mean. However, if the 95 percent UCL for a COPC exceeded the maximum detected concentration within a medium of concern, the maximum detected value was used as the exposure point concentration (EPA 1992a).

Ingestion of Soil

Soil ingestion is a significant exposure route of concern, particularly in children. Children may consume greater quantities of outdoor soil than adults because of their tendency to place their fingers and other objects that have come into contact with soil into their mouths. COPC intakes for children were based on exposure factors estimated for children aged 1 through 7 years. This age group is estimated to have the highest exposure by direct soil ingestion. The model and assumptions used to estimate intake from soil ingestion are shown in Table V.13.

Ingestion of Groundwater

The model and assumptions used to estimate chemical and radionuclide intakes through the drinking water ingestion route are shown in Table V.14. The drinking water RME and CTE are evaluated for both the adult and child, along with the onsite future worker.

Table V.13. Ingestion of Soil

$$\text{Chemical:}\quad CI = \frac{C_S \times IR \times CF_1 \times FI \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide:}\quad RI = R_S \times IR \times CF_2 \times FI \times EF \times ED$$

Where:

CI = Chemical intake (mg/kg/day)
RI = Radionuclide intake (pCi)
R_S = Radionuclide concentration in soil (pCi/g)
C_S = Chemical concentration in soil (mg/kg)
CF_1 = Conversion factor (10^{-6} kg/mg)
CF_2 = Conversion factor (10^{-3} g/mg)
IR = Ingestion rate (mg/day)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Outdoor Industrial Worker	Future Resident Farmer		Outdoor Industrial Worker
	Child	Adult		Child	Adult	
IR	200 mg/day	100 mg/day	50 mg/day	200 mg/day	100 mg/day	50 mg/day
FI	1.0	1.0	1.0	1.0	1.0	1.0
EF	350 days/yr	350 days/yr	250 days/yr	274 days/yr	274 days/yr	250 days/yr
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
AT - Cancer	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days
AT - Noncancer	2,190 days	8,760 days	9,125 days	1,095 days	3,285 days	3,285 days

References:
EPA 1991
EPA 1989a
EPA 1989b
EPA 1989c

Table V.14. Ingestion of Chemicals/Radionuclides in Drinking Water

$$\text{Chemical:} \quad CI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide:} \quad RI = RW \times IR \times EF \times ED$$

Where:

RI = Radionuclide intake from drinking water (pCi)
CI = Chemical intake from drinking water (mg/kg day)
RW = Radionuclide concentration in groundwater (pCi/L)
CW = Chemical concentration in groundwater (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days)

Exposure Assumption:

	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
Parameter	Child	Adult		Child	Adult	
IR	1 L/day	2 L/day	1 L/day	0.7 L/day	1.4 L/day	0.7 L/day
EF	350 days/yr	350 days/yr	250 days/yr	350 days/yr	350 days/yr	250 days/yr
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
AT - Cancer	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days
AT - Noncancer	2,190 days	8,760 days	9,125 days	1,095 days	3,285 days	3,285 days

References:
EPA 1991
EPA 1989a
EPA 1989b

Ingestion of Garden Produce

The ingestion of garden vegetables and fruit exposed to contaminated water used for irrigation purposes is a potential route for future residents. Three general categories of edible plants grown in home gardens were considered: leafy vegetables, such as lettuce; garden fruit, such as tomatoes; and root vegetables, such as carrots. The equations and assumptions used in calculating the estimated daily intakes of contaminants through ingestion of leafy vegetables, garden fruit, and root vegetables exposed to contaminated water are presented in Tables V.15. and V.16.

Ingestion of Beef and Milk

The chemical/radionuclide concentration in beef and milk is a function of the following three processes:

- ingestion of chemicals/radionuclides by cattle from feed,
- ingestion of chemicals/radionuclides by cattle from soil while grazing, and
- ingestion of chemicals/radionuclides by cattle from water.

The equations and parameters used in calculating the intakes of chemicals and radionuclides from beef and milk ingestion are presented in Tables V.17 and V.18.

Incidental Ingestion of Water While Swimming

The model and assumptions used to estimate chemical intake from the incidental ingestion of water while swimming are shown in Table V.19. It is assumed that the resident farmer has a swimming pool that is filled with groundwater.

Inhalation Exposure

The model and assumptions used to estimate intake from the inhalation route for resuspended indoor and outdoor soils and volatilized vapors are shown in Tables V.20, V.21, and V.22. The model and assumptions used to estimate intake from inhalation while showering are shown in Table V.23.

Table V.15. Ingestion of Homegrown Fruits

$$\text{Chemical:}\quad CI = \frac{\left[(C_w \times TSCF_w) + (C_s) \times TSCF_s)\right] \times IR \times FI \times EF \times ED}{BW \times AT}$$

$$TSCF_w = 0.784\exp - ((\log(K_{ow}) - 1.78)^2/2.44)$$

$$TSCF_s\ (K_{oc} \bullet OC) = 0.784\exp - ((\log(K_{ow}) - 1.78)^2/2.44)$$

$$\text{Radionuclide:}\quad RI = R_s \times PUF \times IR \times FI \times EF \times ED$$

Where:

CI = Chemical intake (mg/kg/day)
RI = Radionuclide intake (pCi)
C_w = Chemical concentration in groundwater (mg/L)
C_s = Chemical concentration in soil (mg/kg)
R_s = Radionuclide concentration in soil (pCi/kg)
PUF = Plant uptake factor (unitless)
$TSCF_w$ = Transpiration stream concentration factor for water (unitless)
$TSCF_s$ = Transpiration stream concentration factor for soil (unitless)
IR = Ingestion rate of fruit (kg/day)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (day/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days)
K_{ow} = octanol-water partition coefficient (unitless)
K_{oc} = organic carbon partition coefficient (unitless)
OC = organic carbon content of the soil (unitless)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
PUF	Radionuclide specific (See Appendix N)					
K_{ow}	Chemical specific (See Appendix N)					
K_{oc}	Chemical specific (See Appendix N)					
OC	0.2	0.2	NA	0.2	0.2	NA
IR	0.14 kg/day	0.14 kg/day	NA	0.14 kg/day	0.14 kg/day	NA
FI	0.3	0.3	NA	0.2	0.2	NA
EF	350 days/yr	350 days/yr	NA	73 days/yr	73 days/yr	NA
ED	6 years	24 years	NA	3 years	9 years	NA
BW	15 kg	70 kg	NA	15 kg	70 kg	NA
AT - Cancer	25,550 days	25,550 days	NA	25,550 days	25,550 days	NA
AT - Noncancer	2,190 days	8,760 days	NA	1,095 days	3,285 days	NA

NA - not applicable
References:
EPA 1991
EPA 1989a
EPA 1989b
EPA 1989e
EPA 1986b

Table V.16. Ingestion of Homegrown Vegetables

Chemical: $$CI = \frac{\left[((C_W \times RCF_W) + (C_S \times RCF_S)) \times IR_R + ((C_W \times TSCF_W) + (C_S \times TSCF_S)) \times IR_L\right] \times FI \times EF \times ED}{BW \times AT}$$

$$\text{Log } (RCF_w - 0.82) = 0.77 * \text{Log } (K_{ow}) - 1.52$$
$$\text{Log } (RCF_s (K_{oc} * OC) - 0.82) = 0.77 * \text{Log } (K_{ow}) - 1.52$$
$$TSCF_w = 0.784\exp - ((\log (K_{ow}) - 1.78)^2/2.44)$$
$$TSCF_s (K_{oc} * OC) = 0.784 \exp - ((\log (K_{ow}) - 1.78)^2/2.44$$

Radionuclide: $$RI = R_S \times PUF \times (IR_R + IR_L) \times FI \times EF \times ED$$

Where:

CI = Chemical intake (mg/kg/day)
RI = Radionuclide intake (pCi)
C_W = Chemical concentration in water (mg/L)
C_S = Chemical concentration in soil (mg/kg)
R_S = Radionuclide concentration in soil (pCi/kg)
PUF = Plant uptake factor (unitless)
$TSCF_W$ = Transpiration stream concentration factor for water (unitless)
$TSCF_S$ = Transpiration stream concentration factor for soil (unitless)
RCF_W = Root concentration factor for uptake from water (unitless)
RCF_S = Root concentration factor for uptake from soil (unitless)
IR_R = Ingestion rate of root vegetables (kg/day)
IR_L = Ingestion rate of leafy vegetables (kg/day)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (day/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days)
K_{ow} = octanol-water parition coefficient (unitless)
K_{oc} = organic carbon partition coefficient (unitless)
OC = organic carbon content of the soil (unitless)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
PUF	Radionuclide Specific (See Appendix N)					
K_{ow}	Chemical Specific (See Appendix N)					
K_{oc}	Chemical Specific (See Appendix N)					
OC	0.2	0.2	NA	0.2	0.2	NA
IR_R	0.1 kg/day	0.1 kg/day	NA	0.1 kg/day	0.1 kg/day	NA
IR_L	0.1 kg/day	0.1 kg/day	NA	0.1 kg/day	0.1 kg/day	NA
FI	0.4	0.4	NA	0.25	0.25	NA
EF	350 days/yr	350 days/yr	NA	73 days/yr	73 days/yr	NA
ED	6 years	24 years	NA	3 years	9 years	NA
BW	15 kg	70 kg	NA	15 kg	70 kg	NA
AT - Cancer	25,550 days	25,550 days	NA	25,550 days	25,550 days	NA
AT - Noncancer	2,190 days	8,760 days	NA	1,095 days	3,285 days	NA

NA - Not Applicable

References:

EPA 1991
EPA 1989a
EPA 1989b
EPA 1989e
EPA 1986b

Table V.17. Ingestion of Homegrown Meat Products

Chemical: $$CI = \frac{C_W \times BCF \times F \times IR \times FC \times EF \times ED}{BW \times AT}$$

$$BCF = 0;\ Log\ (K_{ow}) < 3.5$$
$$Log\ (BCF) = 3.457 + 0.5 \cdot Log\ (K_{ow});\ Log\ (K_{ow}) > 3.5$$

Radionuclide: $$RI = \left[(R_S \times PUF \times IR_F) + (R_S \times IR_S) + (R_W \times IR_W)\right] \times BIR \times IR \times FC \times EF \times ED$$

Where:

CI = Chemical intake (mg/kg/day)
RI = Radionuclide intake (pCi)
C_W = Chemical concentration in water (mg/L)
R_W = Radionuclide concentration in water (pCi/L)
R_S = Radionuclide concentration in soil (pCi/kg)
IR_F = Cattle ingestion rate of feed (kg/day)
IR_S = Cattle ingestion rate of soil (kg/day)
IR_W = Cattle ingestion rate of water (L/day)
IR = Ingestion rate of beef (kg/day)
BIR = Beef/livestock-intake ratio (pCi/kg/pCi/day)
PUF = Plant uptake factor (unitless)
F = Fat content in cattle tissue (%)
FC = Fraction of homegrown beef that is contaminated (unitless)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days)
K_{ow} = octanol-water partition coefficient (unitless)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
IR_F	0.031 kg/day	0.075 kg/day	NA	0.031 kg/day	0.075 kg/day	NA
IR_S	0.5 kg/day	0.5 kg/day	NA	0.5 kg/day	0.5 kg/day	NA
IR_W	50 L/day	50 L/day	NA	50 L/day	50 L/day	NA
IR	0.1 kg/day	0.1 kg/day	NA	0.1 kg/day	0.1 kg/day	NA
BIR	Radionuclide Specific (See Appendix N)					
PUF	Radionuclide Specific (See Appendix N)					
K_{ow}	Chemical Specific (See Appendix N)					
F	14%	14%	NA	14%	14%	NA
FC	0.75	0.75	NA	0.4	0.4	NA
EF	350 days/yr	350 days/yr	NA	350 days/yr	350 days/yr	NA
ED	6 years	24 years	NA	3 years	9 years	NA
BW	15 kg	70 kg	NA	15 kg	70 kg	NA
AT - Cancer	25,550 days	25,550 days	NA	25,550 days	25,550 days	NA
AT - Noncancer	2,190 days	8,760 days	NA	1,095 days	3,285 days	NA

References:
EPA 1991
EPA 1989a
EPA 1989b
EPA 1989e
EPA 1986b

Table V.18. Ingestion of Homegrown Dairy Products

Chemical: $$CI = \frac{C_W \times BCF \times F \times IR \times FC \times EF \times ED}{BW \times AT}$$

$$BCF = 0;\ \text{Log}(K_{ow}) < 3.5$$
$$\text{Log}(BCF) = 3.457 + 0.5 \bullet \text{Log}(K_{ow});\ \text{Log}(K_{ow}) > 3.5$$

Radionuclide: $$RI = \left[(R_S \times PUF \times IR_F) + (R_S \times IR_S) + (R_W \times IR_W)\right] \times BIR \times IR \times FC \times EF \times ED$$

Where:

- CI = Chemical intake (mg/kg/day)
- RI = Radionuclide intake (pCi)
- C_W = Chemical concentration in water (mg/L)
- R_W = Radionuclide concentration in water (pCi/L)
- R_S = Radionuclide concentration in soil (pCi/kg)
- IR_F = Cattle ingestion rate of feed (kg/day)
- IR_S = Cattle ingestion rate of soil (kg/day)
- IR_W = Cattle ingestion rate of water (L/day)
- IR = Ingestion rate of dairy products (kg/day)
- BIR = Beef/livestock-intake ratio (pCi/kg/pCi/day)
- PUF = Plant uptake factor (unitless)
- BCF = Bioconcentration factor for tissue fat in cattle (unitless)
- F = Fat content of the milk or milk product (%)
- FC = Fraction of dairy products that is contaminated (unitless)
- EF = Exposure frequency (days/yr)
- ED = Exposure duration (yr)
- BW = Body weight (kg)
- AT = Averaging time (days)
- K_{ow} = Octanol-water partition coefficient (unitless)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
IR_F	0.374 kg/day	0.300 kg/day	NA	0.374 kg/day	0.300 kg/day	NA
IR_S	0.5 kg/day	0.5 kg/day	NA	0.5 kg/day	0.5 kg/day	NA
IR_W	50 L/day	50 L/day	NA	50 L/day	50 L/day	NA
IR	0.4 kg/day	0.4 kg/day	NA	0.4 kg/day	0.4 kg/day	NA
BIR	Radionuclide Specific (See Appendix N)					
PUF	Radionuclide Specific (See Appendix N)					
K_{ow}	Chemical Specific (See Appendix N)					
F	4%	4%	NA	4%	4%	NA
FC	0.75	0.75	NA	0.4	0.4	NA
EF	350 days/yr	350 days/yr	NA	350 days/yr	350 days/yr	NA
ED	6 years	24 years	NA	3 years	9 years	NA
BW	15 kg	70 kg	NA	15 kg	70 kg	NA
AT - Cancer	25,550 days	25,550 days	NA	25,550 days	25,550 days	NA
AT - Noncancer	2,190 days	8,760 days	NA	1,095 days	3,285 days	NA

References:
EPA 1991
EPA 1989a
EPA 1989b
EPA 1989e
EPA 1986b

Table V.19. Ingestion of Chemicals/Radionuclides in Surface Water While Swimming

$$\text{Chemical:} \quad CI = \frac{C_w \times IR \times EF \times ET \times ED}{BW \times AT}$$

$$\text{Radionuclide:} \quad RI = R_w \times IR \times ET \times EF \times ED$$

Where:

RI = Radionuclide intake from water ingestion while swimming (pCi)
CI = Chemical intake from water ingestion while swimming (mg/kg/day)
R_w = Radionuclide concentration in water (pCi/L)
C_w = Chemical concentration in water (mg/L)
IR = Ingestion rate (L/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days)

Exposure Assumption:

	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
Parameter	Child	Adult		Child	Adult	
IR	0.05 L/hr	0.05 L/hr	NA	0.05 L/hr	0.05 L/hr	NA
ET	2.7 hr/day	2.7 hr/day	NA	2.7 hr/day	2.7 hr/day	NA
EF	7 days/yr	7 days/yr	NA	7 days/yr	7 days/yr	NA
ED	6 years	24 years	NA	3 years	9 years	NA
BW	15 kg	70 kg	NA	15 kg	70 kg	NA
AT - Cancer	25,550 days	25,550 days	NA	25,550 days	25,550 days	NA
AT - Noncancer	2,190 days	8,760 days	NA	1,095 days	3,285 days	NA

NA - not applicable

References:
EPA 1991
EPA 1989a
EPA 1989b

Table V.20. Inhalation of Particulates Inside/Outside the Residence

Chemical: $C = D \times RF \times PCD \times C_S \times CF_1$

For Cancer Risk: $C_{ADJ} = C \times \frac{BW}{70} \times \frac{IR}{0.833} \times \frac{ED}{70} \times \frac{t}{24}$

Radionuclide: $R = D \times RF \times PCD \times R_S \times IR \times t \times EF \times ED \times CF_2$

Where:

C = Inhaled concentration of chemical ($\mu g/m^3$)
C_{ADJ} = Inhaled concentration of chemical adjusted for cancer risk ($\mu g/m^3$)
R = Inhaled intake of radionuclides (pCi)
D = Dust concentration ($\mu g/m^3$)
RF = Respirable fraction of dust (unitless)
PCD = Proportion of contaminated dust (unitless)
C_S = Chemical concentration in soil ($\mu g/kg$)
R_S = Radionuclide concentration in soil (pCi/g)
t = Exposure time (hr/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
IR = Inhalation rate (m^3/hr)
BW = Body weight (kg)
CF_1 = Conversion factor = 1E-06 kg/mg
CF_2 = Conversion factor = 1E-06 g/μg

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
D (Outside)	0.075 mg/m³	0.075 mg/m³	0.075 mg/m³	0.075 mg/m³	0.075 mg/m³	0.75 mg/m³
D (Inside)	0.056 mg/m³	0.056 mg/m³	0.056 mg/m³	0.056 mg/m³	0.056 mg/m³	0.056 mg/m³
RF	0.73	0.73	0.73	0.73	0.73	0.73
PCD (Outside)	1.0	1.0	1.0	1.0	1.0	1.0
PCD (Inside)	0.80	0.80	0.80	0.80	0.80	0.80
t (Outside)	3 hr/day	3 hr/day	8 hr/day	0.44 hr/day	0.44 hr/day	8 hr/day
t (Inside)	21 hr/day	21 hr/day	8 hr/day	16.4 hr/day	16.4 hr/day	8 hr/day
EF	350 days/yr	350 days/yr	250 days/yr	350 days/yr	350 days/yr	250 days/yr
ED	6 years	24 years	25 years	3 years	9 years	9 years
IR (Outside)	0.42 m³/hr	1.25 m³/hr	1.25 m³/hr	0.21 m³/hr	0.83 m³/hr	1.25 m³/hr
IR (Inside)	0.42 m³/hr	0.71 m³/hr	1.25 m³/hr	0.21 m³/hr	0.63 m³/hr	0.83 m³/hr
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg

References:
EPA 1991
EPA 1989a
EPA 1989b
Hawkley 1985
Wark 1981

Table V.21. Inhalation of Vapors Inside the Residence

$$C = \frac{C_W \times FL \times f}{V \times K \times ER}$$

$$\text{For Cancer Risk: } C_{ADJ} = C \times \frac{t}{24} \times \frac{ED}{70} \times \frac{BW}{70} \times \frac{IR}{0.833}$$

Where:

C = Exposure concentration ($\mu g/m^3$)
C_{ADJ} = Exposure concentration adjusted for less than continuous lifetime exposure ($\mu g/m^3$)
C_W = Chemical concentration in water ($\mu g/L$)
FL = Water flow through house (L/day)
f = Fraction of contaminant volatilized (unitless)
V = House volume (m^3)
K = Mixing coefficient (unitless)
ER = Air exchange rate (1/day)
t = Average time spent in-house per day (hr/day)
ED = Exposure duration (yr)
BW = Body weight (kg)
IR = Inhalation rate (m^3/hr)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor Industrial Worker	Future Resident Farmer		Indoor Industrial Worker
	Child	Adult		Child	Adult	
FL	723 L/day	723 L/day	723 L/day	723 L/day	723 L/day	723 L/day
f	0.5	0.5	0.5	0.5	0.5	0.5
V	177.7 m^3	177.7 m^3	177.7 m^3	177.7 m^3	177.7 m^3	177.7 m^3
K	0.15	0.15	0.15	0.15	0.15	0.15
ER	13.7/day	13.7/day	13.7/day	13.7/day	13.7/day	13.7/day
t	21 hr/day	21 hr/day	8 hr/day	16.4 hr/day	16.4 hr/day	8 hr/day
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
IR	0.42 m^3/hr	0.71 m^3/hr	1.25 m^3/hr	0.21 m^3/hr	0.63 m^3/hr	0.83 m^3/hr

References:
EPA 1991
EPA 1989a
EPA 1989b

Table V.22. Inhalation of Vapors Outside the Residence

$$C = \left(\frac{2}{\Pi}\right)^{1/2} \times \left[\frac{X^{(1-b)}}{a \times (1-b)}\right] \times \left[\frac{C_W \times f \times FL}{X_2 \times C_1 \times u}\right]$$

$$\text{For Cancer Risk: } C_{ADJ} = C \times \frac{t}{24} \times \frac{BW}{70} \times \frac{IR}{0.833} \times \frac{ED}{70}$$

Where:

C = Exposure concentration ($\mu g/m^3$)
C_{ADJ} = Exposure concentration adjusted for less that continuous lifetime exposure ($\mu g/m^3$)
C_W = Chemical concentration in water ($\mu g/m^3$)
FL = Flow of irrigation water (L/day)
f = Fraction of contaminant volatilized (unitless)
X = Length or width of the approximate square irrigated area (m)
π = 3.14159265359
a,b = Constants that relate vertical dispersion to atmosphere stability
u = Near surface wind speed (m/s)
C_1 = Conversion factor = 1,000 $\mu g/mg$
t = Average time spent per day in irrigation activities (hr/day)
ED = Exposure duration (yr)
BW = Body Weight (kg)
IR = Inhalation rate (m^3/hr)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Outdoor Industrial Worker	Future Resident Farmer		Outdoor Industrial Worker
	Child	Adult		Child	Adult	
FL	600 L/day	600 L/day	600 L/day	600 L/day	600 L/day	600 L/day
f	0.5	0.5	0.5	0.5	0.5	0.5
X	10 m	10 m	10 m	10 m	10 m	10 m
a	0.15	0.15	0.15	0.15	0.15	0.15
b	0.75	0.75	0.75	0.75	0.75	0.75
u	2 m/s	2 m/s	2 m/s	2 m/s	2 m/s	2 m/s
t	3 hr/day	3 hr/day	8 hr/day	0.44 hr/day	0.44 hr/day	8 hr/day
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
IR	0.42 m^3/hr	1.25 m^3/hr	1.25 m^3/hr	0.21 m^3/hr	0.83 m^3/hr	0.83 m^3/hr

References:
EPA 1991
EPA 1989a
EPA 1989b

Table V.23. Inhalation of Vapors While Showering

$$\text{Chemical:} \quad C = \frac{C_W \times f \times F_W \times t_1}{V}$$

$$\text{For Cancer Risk:} \quad C_{ADJ} = \frac{[\,(C \times t_1 \times 0.5) + (C \times t_2)\,]}{24} \times \frac{ED}{70} \times \frac{BW}{70} \times \frac{IR}{0.833}$$

Where:

C = Average air concentration in the bathroom ($\mu g/m^3$)
C_{ADJ} = Average air concentration in the bathroom adjusted for less than continuous lifetime exposure ($\mu g/m^3$)
C_W = Chemical concentration in water ($\mu g/m^3$)
f = Fraction of contaminant volatilized (unitless)
F_W = Water flow rate in the shower ((L/hr)
t_1 = Shower duration (hr)
t_2 = Post-shower duration (hr)
V = Bathroom volume (m^3)
ED = Exposure duration (yr)
BW = Body weight (kg)
IR = Inhalation rate (m^3/hr)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
f	0.75	0.75	0.75	0.75	0.75	0.75
F_W	600 L/hr	600 L/hr	600 L/hr	600 L/hr	600 L/hr	600 L/hr
t_1	0.2 hr	0.2 hr	0.2 hr	0.12 hr	0.12 hr	0.12 hr
t_2	0.2 hr	0.2 hr	0.2 hr	0.2 hr	0.2 hr	0.2 hr
V	$9m^3$	$9m^3$	$9m^3$	$9m^3$	$9m^3$	$9m^3$
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
IR	0.42 m^3/hr	0.6 m^3/hr	0.6 m^3/hr	0.21 m^3/hr	0.6 m^3/hr	0.6 m^3/hr

References:
EPA 1991
EPA 1989a
EPA 1989b

Dermal Exposure

The models and assumptions used to estimate a dose from dermal contact with water are shown in Tables V.24a. V.24b, and V.25 for the shower and swimming pathways. Dermal absorption of chemicals from contact with soil is represented by the model and assumptions in Table V.26.

External Radiation Exposure

Exposure to radiation from radionuclides in soils was calculated using the model and assumptions presented in Table V.27. Unlike inhalation, ingestion, and dermal exposure, the external radiation exposure term is defined as an equivalent radionuclide concentration in soil that an onsite receptor would be exposed to for a particular exposure duration period. This exposure term is adjusted for exposure time and shielding.

For the Operable Unit 1 risk assessment, it was assumed that there is no shielding to external radiation. In addition, the future onsite farmer resident is assumed to be exposed to external radiation at every moment during the exposure duration period. These assumptions provide for a more conservative estimate of external radiation exposure and risk.

5.3.3.2. Summary of Chemical Intakes

The chemical and radionuclide intakes for the future resident farmer and future indoor/outdoor worker scenarios and their associated pathways are presented in Appendix I. Organic and inorganic intakes were computed using the RISK ASSISTANT™ computer program (HRI 1993), while radionuclide intakes were generated using a computer spreadsheet program.

5.4. TOXICITY ASSESSMENT

The purposes of the toxicity assessment are to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects (EPA 1989a). This includes the preparation of fate and toxicity profiles for each of the chemicals and identification of human health criteria. The sources of toxicity data include the IRIS (EPA 1993c), the Health Effects Summary Tables (HEAST) (EPA 1993d), the EPA Environmental Criteria and Assessment Office (ECAO), and EPA Region III (EPA 1993e). The toxicity profiles for the COPCs are presented in Appendix J.

Table V.24a. Dermal Absorption of Water While Showering

$$\text{Dermal Absorption of Water While Showering (mg/kg/day)} = \frac{DA(t) \times SA \times EF \times ED}{BW \times AT}$$

Where:

DA(t) = Dose absorbed per unit area per day as a function of t ($mg/cm^2/day$)
SA = Skin surface area available for contact (cm^2)
t = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
SA	7,300 cm^2/day	23,000 cm^2/day	23,000 cm^2/day	7,000 cm^2/day	20,000 cm^2/day	20,000 cm^2/day
DA(t)	Chemical Specific (See Table V.25)					
t	0.2 hr/day	0.2 hr/day	0.2 hr/day	0.12 hr/day	0.12 hr/day	0.12 hr/day
EF	350 days/yr	350 days/yr	250 days/yr	350 days/yr	350 days/yr	250 days/yr
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
AT - Cancer	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days
AT - Noncancer	2,190 days	8,760 days	9,125 days	1,095 days	3,285 days	3,285 days

References:
EPA 1992b
EPA 1991
EPA 1989a
EPA 1989b

Table V.24b. Dermal Absorption of Water While Swimming

$$\text{Dermal Absorption of Water While Swimming (mg/kg/day)} = \frac{DA(t) \times SA \times EF \times ED}{BW \times AT}$$

Where:

DA(t) = Dose absorbed per unit area per day as a function of t ($mg/cm^2/day$)
SA = Skin surface area available for contact (cm^2)
t = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Exposure Assumption:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
	Child	Adult		Child	Adult	
SA	7,300 cm^2/day	23,000 cm^2/day	NA	7,000 cm^2/day	20,000 cm^2/day	NA
DA(t)	Chemical Specific (See Table V.25)					
t	2.7 hr/day	2.7 hr/day	NA	2.7 hr/day	2.7 hr/day	NA
EF	7 days/yr	7 days/yr	NA	7 days/yr	7 days/yr	NA
ED	6 years	24 years	NA	3 years	9 years	NA
BW	15 kg	70 kg	NA	15 kg	70 kg	NA
AT - Cancer	25,550 days	25,550 days	NA	25,550 days	25,550 days	NA
AT - Noncancer	2,190 days	8,760 days	NA	1,095 days	3,285 days	NA

NA - not applicable

References:
EPA 1992b
EPA 1991
EPA 1989a
EPA 1989b

Table V.25. Parameter Equations for Dermal Absorption of Water While Showering or Swimming

For Inorganic Chemicals - DA(t)

$$DA(t) = Kp \times Cw \times t \times CF_1$$

For Organic Chemicals - DA(t)

$$DA(t) = 2 \times Kp \times Cw \times \left[\frac{6 \times \tau \times t}{\pi}\right]^{0.5};\ t, < t_A$$

$$DA(t) = Kp \times Cw \times \left[\frac{t}{1 + B}\right] + \left[2 \times \tau \times \left(\frac{1 + 3B}{1 + B}\right)\right];\ t > t_A$$

Parameter Equations

$$\log (Kp) = -2.72 + [0.71 \times \log (K_{ow})] - [0.0061 \times MW]$$

$$\tau = \frac{L}{6 \times 10^{\wedge} (-2.72 - 0.0061 \times MW)}$$

$$B = \frac{K_{ow}}{10000}$$

$$t_2 = 2.4\ \tau;\ B \leq 0.1$$

$$t_2 = (8.4 + 6 \log B)\ \tau;\ 0.1 \leq B \leq 1.17$$

$$t_2 = 6\ (y - (y^2 - z^2)^{0.5} \times \tau;\ B \leq 1.17$$

$$y = \frac{2\ (1 + B)^2 - z}{\pi}$$

$$z = \frac{1 + 3B}{3}$$

Where:

DA(t) = Dose absorbed per unit area per day ($mg/cm^2/day$)
Kp = Dermal permeability coefficient of the chemical from water (cm/hr) [inorganic default = 0.001]
Cw = Chemical concentration in water (mg/m^3) (to convert mg/L to mg/m^3, multiply by 1,000)
t = Exposure duration (hr/day)
CF_1 = Conversion factor (m^3/cm^3)
t_A = Time required for the transport of organic compounds to reach steady-state; a function of lag time and lipophilicity (hr)
B = Relative contribution of permeability coefficients for the chemical in the stratum corneum and the viable epidermus (unitless)
K_{ow} = Octanol-water partition coefficient (unitless) [see Appendix N for chemical-specific K_{ow}]
MW = Molecular weight of the chemical (see Appendix N for chemical-specific MW)
L = Path length through the skin = 10u

Reference: EPA 1992b

Table V.26. Dermal Contact with Chemicals in Soil

$$\text{Dermal Absorption of Chemicals in Soil:} = \frac{CS \times CF_1 \times CF_2 \times SA \times AF \times ABS \times ET \times EF \times ED}{BW \times AT}$$

Where:

CS = Chemical concentration in soil (mg/kg)
CF_1 = Conversion factor (kg/mg)
CF_2 = Conversion factor (day/hr)
SA = Skin surface area available for contact (cm^2/day)
AF = Absorption factor (unitless)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Exposure Assumptions:

Parameter	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Outdoor Industrial Worker	Future Resident Farmer		Outdoor Industrial Worker
	Child	Adult		Child	Adult	
SA[a]	3910 cm^2/day	8620 cm^2/day	8620 cm^2/day	3910 cm^2/day	8620 cm^2/day	8620 cm^2/day
AF	1 mg/cm^2	1 mg/cm^2	1 mg/cm^2	0.2 mg/cm^2	0.2 mg/cm^2	0.2 mg/cm^2
ABS[b]	0.25 for VOCs; 0.10 for SVOCs; 0.01 for Inorganics					
ET	3 hr/day	3 hr/day	8 hr/day	0.44 hr/day	0.44 hr/day	8 hr/day
EF	350 days/yr	350 days/yr	250 days/yr	350 days/yr	350 days/yr	250 days/yr
ED	6 years	24 years	25 years	3 years	9 years	9 years
BW	15 kg	70 kg	70 kg	15 kg	70 kg	70 kg
AT-Cancer	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days	25,550 days
AT-Noncancer	2,190 days	8,760 days	9,125 days	1,095 days	3,285 days	3,285 days

[a]Combined surface areas of the arms, legs, and hands (EPA 1989a).
[b]Ohio EPA default absoption factors.

References:

EPA 1989a
EPA 1989b
EPA 1991
EPA 1992b

Table V.27. Exposure to External Radiation

$$R_{EXP} = R_S \times \frac{ET}{24} \times \frac{EF}{365} \times ED \times (1-SH)$$

Where:

R_{EXP} = External radiation exposure term (pCi-yr/g)
R_s = Radionuclide concentration in soil (pCi/g)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SH = Shielding factor (unitless)

Exposure Assumption:

	Reasonable Maximum Exposure			Central Tendency Exposure		
	Future Resident Farmer		Indoor/ Outdoor Industrial Worker	Future Resident Farmer		Indoor/ Outdoor Industrial Worker
Parameter	Child	Adult		Child	Adult	
ET	24 hr/day	24 hr/day	8 hr/day	24 hr/day	24 hr/day	8 hr/day
EF	365 days/yr	365 days/yr	250 days/yr	365 days/yr	365 days/yr	250 days/yr
ED	6 years	24 years	25 years	3 years	9 years	9 years
SH	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]

[a]Assumed there are no shielding effects

References:
EPA 1991a
EPA 1989a
EPA 1989b
DOE 1989c

5.4.1. Toxicity for Noncarcinogenic Effects

The EPA Office of Research and Development has calculated acceptable intake values, denoted as reference doses (RfDs) or reference concentrations (RfCs), for long-term (chronic) exposure to noncarcinogens. These values are estimates of route-specific exposure levels that would not be expected to cause adverse effects when exposure occurs for a significant portion of a lifespan. The RfDs and RfCs include adjustment factors to account for uncertainties associated with limitations of the toxicological database, including extrapolating animal studies to humans and sensitive individuals. These values are annually updated and published in HEAST and provided through IRIS. Provisional values of RfDs and RfCs provided by the EPA ECAO and EPA Region III are used when RfDs/RfCs are not available from IRIS or HEAST. The most recent oral RfDs and inhalation RfCs of the COC and the associated sources are summarized in Table V.28.

5.4.2. Toxicity for Carcinogenic Effects

For chemical carcinogens, the EPA Office of Research and Development has calculated estimates of the carcinogenic potential. These estimates, or slope factors, correlate intake of a carcinogen with an increased risk of cancer. The most recent oral and inhalation slope factors from IRIS, HEAST, EPA, and ECAO, along with weight of evidence and slope factor source for COPCs, are summarized in Table V.29.

The EPA currently classifies all radionuclides as Group A, known human carcinogens, based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancer in humans. Mutagenic and teratogenic effects are considered to be less significant, and acute toxic effects would be manifest only at radiation doses well above those considered in this assessment. The ingestion, inhalation, and ground exposure slope factors for the various radionuclides of concern at Mound Plant are summarized in Table V.30.

Certain radionuclides have daughter products that could be more hazardous than the parent radionuclide. For example, strontium-90 decays into yttrium-90, which emits beta particles at much higher energies than those emitted by strontium-90. As a result, the risks posed by the intake of yttrium-90 are much higher than those for strontium-90. To take into account the potential carcinogenic effects of the daughter products, radionuclide slope factors with a +D designation were used for the risk assessment where available. Slope factors with a +D designation accounts for the carcinogenicity of both the parent radionuclides and their decay products.

Table V.28. Toxicity Values - Potential Noncarcinogenic Effects

Chemical	Chronic Inhalation RfC (mg/m^3)	RfC Source	Chronic Ingestion RfD (mg/kg/day)	RfD Source
Organic Chemicals				
1,1,1-Trichloroethane	1.0E+00	HEAST	9.0E-02	HEAST
1,2-*cis*-Dichloroethene	--	--	1.0E-02	HEAST
1,2-*trans*-Dichloroethene	--	--	2.0E-02	IRIS
1,2-Dichloroethane	1.0E-02	ECAO	--	--
1,2-Dichloroethene	--	--	9.0E-03	HEAST
2,3,7,8-TCDD (Dioxins)	--	--	--	--
4-Methylphenol	--	--	5.0E-03	HEAST
Archlor-1248 (PCB)	--	--	--	--
Benzo(a)anthracene	--	--	--	--
Benzo(a)pyrene	--	--	--	--
Benzo(b)fluoranthene	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--
Benzoic acid	--	--	4.0E+00	IRIS
Bis(2-ethylhexyl)phthalate	--	--	2.0E-02	IRIS
Chlordane (alpha)	--	--	6.0E-05	IRIS
Chrysene	--	--	--	--
Dichloromethane	3.0E+00	HEAST	6.0E-02	IRIS
Diethyl phthalate	--	--	8.0E-01	IRIS
Endosulfan	--	--	6.0E-03	HEAST
Fluoranthene	--	--	4.0E-02	IRIS
Indeno(1,2,3-cd)pyrene	--	--	--	--
Phenol	--	--	6.0E-03	IRIS
Pyrene	--	--	3.0E-02	IRIS
Tetrachloroethene	--	--	1.0E-02	IRIS
Tetrachloromethane	2.0E-03	ECAO	7.0E-04	IRIS

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Chemical	Chronic Inhalation RfC (mg/m^3)	RfC Source	Chronic Ingestion RfD (mg/kg/day)	RfD Source
Toluene	4.0E-01	IRIS	2.0E-01	IRIS
Trichloroethene	--	--	6.0E-03	ECAO
Trichlorofluoromethane	7.0E-01	HEAST	3.0E-01	IRIS
Trichlormethane	--	--	1.0E-02	IRIS
Vinyl chloride	--	--	--	--
Inorganic Chemicals				
Fluoride	--	--	6.0E-02	IRIS
Nitrate	--	--	1.6E+00	IRIS
Silver	--	--	5.0E-03	IRIS

ECAO - U.S. EPA Environmental Criteria and Assessment Office
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables

Table V.29. Toxicity Values - Potential Carcinogenic Effects

Chemical	EPA Weight of Evidence[a]	Inhalation Slope Factor (1/μg/m^3)	Inhalation Slope Factor Source	Ingestion Slope Factor (1/mg/kg-day)	Ingestion Slope Factor Source
Organic Chemicals					
1,1,1-Trichloroethane	D	--	--	--	--
1,2-*cis*-Dichloroethene	D	--	--	--	--
1,2-*trans*-Dichloroethene	NA	--	--	--	--
1,2-Dichloroethane	B2	2.6E-05	IRIS	9.1E-02	IRIS
1,2-Dichloroethene	NA	--	--	--	--
2,3,7,8-TCDD (Dioxins)	B2	3.3E-11	HEAST	1.5E+05	HEAST
4-Methyphenol	NA	--	--	--	--
Aroclor-1248 (PCB)	B2	--	--	7.7E+00	IRIS
Benzo(a)anthracene	B2	1.7E-04[b]	ECAO	7.3E-01[b]	ECAO
Benzo(a)pyrene	B2	1.7E-03	HEAST	7.3E+00	IRIS
Benzo(b)fluoranthene	B2	1.7E-04[b]	ECAO	7.3E-01[b]	ECAO
Benzo(k)fluoranthene	B2	1.7E-05	ECAO	7.3E-01[b]	ECAO
Benzoic acid	D	--	--	--	--
Bis(2-ethylhexyl)phthalate	B2	--	--	1.4E-02	IRIS
Chlordane (alpha)	B2	3.7E-04	IRIS	1.3E+00	IRIS
Chrysene	B2	1.7E-05[c]	ECAO	7.3E-02[c]	ECAO
Dichloromethane	B2	4.7E-07	IRIS	7.5E-03	IRIS
Diethyl phthalate	D	--	--	--	--
Endosulfan	NA	--	--	--	--
Fluoranthene	D	--	--	--	--
Indeno(1,2,3-cd)pyrene	B2	1.7E-04[b]	ECAO	7.3E-01[b]	ECAO
Phenol	NA	--	--	--	--
Pyrene	D	--	--	--	--
Tetrachloroethene	NA	5.8E-07	ECAO	5.2E-02	ECAO
Tetrachloromethane	B2	1.5E-05	IRIS	1.3E-01	IRIS
Toluene	D	--	--	--	--
Trichloroethene	NA	1.7E-06	ECAO	1.1E-02	ECAO

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Chemical	EPA Weight of Evidence[a]	Inhalation Slope Factor ($1/\mu g/m^3$)	Inhalation Slope Factor Source	Ingestion Slope Factor (1/mg/kg-day)	Ingestion Slope Factor Source
Trichlorofluoromethane	NA	--	--	--	--
Trichloromethane	B2	2.3E-05	IRIS	6.1E-03	IRIS
Vinyl chloride	A	8.4E-05	HEAST	1.9E+00	HEAST
Inorganic Chemicals					
Fluoride	NA	--	--	--	--
Nitrate	NA	--	--	--	--
Silver	D	--	--	--	--

[a]A = Known human carcinogen
B1 = Probable human carcinogen, limited human data
B2 = Probable human carcinogen, inadequate or no human data
C = Possible human carcinogen
D = Not classifiable as human carcinogen
[b]Benzo(a)pyrene toxicity value adjusted by a toxicity equivalency factor of 0.1 (EPA 1993)
[c]Benzo(a)pyrene toxicity value adjusted by a toxicity equivalency factor or 0.01 (EPA 1993)
E = Evidence that not carcinogenic in humans
ECAO - U.S. EPA Environmental Criteria and Assessment Office
HEAST - Health Effects Assessment Summary Tables
IRIS - Integrated Risk Information System
NA - Weight of evidence information not available

Table V.30. Slope Factors for Radionuclides of Concern at Mound Plant

Radionuclide[a]	Ingestion (Risk/pCi)	Inhalation (Risk/pCi)	Ground Surface (Risk/yr per pCi/g)
Actinium-227 + D	3.5E-10	8.8E-08	8.5E-07
Plutonium-238	2.2E-10	3.9E-08	2.8E-11
Plutonium-239	2.3E-10	3.8E-08	1.7E-11
Plutonium-240	2.3E-10	3.8E-08	2.7E-11
Radium-226 + D	1.2E-10	3.0E-09	6.0E-06
Strontium-90 + D	3.6E-11	6.2E-11	0.0E+00
Thorium-228 + D	5.5E-11	7.8E-08	5.6E-06
Thorium-230	1.3E-11	2.9E-08	5.4E-11
Thorium-232	1.2E-11	2.8E-08	2.6E-11
Tritium	5.4E-14	7.8E-14	0.0E+00
Uranium-234	1.6E-11	2.6E-08	3.0E-11
Uranium-235 + D	1.6E-11	2.5E-08	2.4E-07
Uranium-236	1.5E-11	2.5E-08	2.4E-11
Uranium-238 + D	2.8E-11	5.2E-08	3.6E-08

[a]All radionuclides have an A (known human carcinogen) weight of evidence classification.
D - daughters
REF: EPA 1993d

Fifteen dioxins were detected in Area B soils and retained as COPCs. Of these, only 2, 3, 7, 8-TCDD has EPA toxicity factors. To assess the risks of the other dioxins, toxicity equivalent factors were used to convert dioxin 95 percent UCL concentrations into 2,3,7,8-TCDD equivalent concentrations (EPA 1989e). The converted dioxin concentrations were then summed with the 2,3,7,8-TCDD reference concentration value to obtain an overall dioxin concentration. This overall concentration was then used in the risk assessment to assess the combined carcinogenic effects of 2,3,7,8-TCDD and 14 dioxins. The conversions of dioxin concentrations into 2,3,7,8-TCDD equivalent concentrations are presented in Table V.31.

5.5. RISK CHARACTERIZATION

In this section, toxicity and exposure assessment are summarized and integrated into quantitative expressions of risk. Both noncarcinogenic and carcinogenic effects are evaluated.

Radionuclide risks were assessed separately for radionuclides that exceed background and radionuclides that were detected within background levels. The radionuclides detected within background levels are the daughter products of the radionuclides that were found to exceed background.

5.5.1. Carcinogenic Risk Characterization - Future Resident Scenario

For potential carcinogenic risks, the probability that an individual will develop cancer over a lifetime of exposure is estimated from daily intakes and dose response information (carcinogen potency factors). Carcinogenic risk depends on three factors: the dose, the carcinogenic potency of the chemical or radionuclide, and the exposure duration. To calculate carcinogenic risk, the products of the individual chemical exposures and carcinogenic slope factors were taken and then summed to provide the estimated risk to the future resident. The RME and CTE carcinogenic risks to the future resident from all pathways are presented in Appendix I.

Tables V.32a and V.32b summarize the potential risks to the future resident from the ingestion, inhalation, dermal contact, and external radiation exposure pathways for the future farmer RME and CTE (does not include daughter product radionuclides). RME carcinogenic risks to the child and adult from all chemicals, radionuclides, and pathways are two excess cancers per 10,000 persons exposed and five excess cancers per 10,000 persons exposed. The overall CTE carcinogenic risks to the child and adult are four excess cancers per 100,000 persons exposed and one excess cancer per 10,000 persons exposed, respectively.

Table V.31. Adjustment of Dioxin Concentrations

Chemical	Reference Concentration (µg/kg)	Toxicity Equivalent Factor[a]	TEF Adjusted Concentration (µg/kg)
1,2,3,4,6,7,8-HpCDF	6.30E-03	1E-02	6.30E-05
1,2,3,4,6,7,8-HpCDD	3.03E-02	1E-02	3.03E-04
1,2,3,4,7,8,9-HpCDF	6.20E-04	1E-02	6.20E-06
1,2,3,4,7,8-HxCDD	6.50E-04	1E-01	6.50E-05
1,2,3,4,7,8-HxCDF	2.20E-03	1E-01	2.20E-04
1,2,3,5,7,8-HxCDF	1.20E-03	1E-01	1.20E-04
1,2,3,6,7,8-HxCDD	1.70E-03	1E-01	1.70E-04
1,2,3,7,8-PeCDD	1.80E-03	5E-01	9.00E-04
1,2,3,7,8-PeCDF	1.10E-03	5E-02	5.50E-05
2,3,4,6,7,8-HxCDF	1.00E-03	1E-01	1.00E-04
2,3,4,7,8-PeCDF	1.60E-03	5E-01	8.00E-04
2,3,7,8-TCDD	9.60E-03	1E+00	9.60E-03
2,3,7,8-TCDF	2.80E-03	1E-01	2.80E-04
OCDD	2.73E-01	1E-03	2.73E-04
OCDF	1.03E-02	1E-03	1.03E-05
2,3,7,8-TCDD Equivalent Concentration			1.30E-02

[a]Ref: EPA 1989f

Table V.32a. Future Resident Farmer Scenario - Reasonable Maximum Exposure - Overall Carcinogenic Risks - All Pathways

Chemical	Ingestion Risk		Dermal Contact Risk		Inhalation Risk		External Radiation Risk		Total Risk	Relative Risk
	Child	Adult	Child	Adult	Child	Adult	Child	Adult		
1,1,1-Trichloroethane	------	------	------	------	------	------	------	------	0E+00	0.0%
1,2-*cis*-Dichloroethene	------	------	------	------	------	------	------	------	0E+00	0.0%
1,2-*trans*-Dichloroethene	------	------	------	------	------	------	------	------	0E+00	0.0%
1,2-Dichloroethane	2E-07	3E-07	6E-09	2E-08	8E-08	3E-06	------	------	3E-06	0.5%
1,2-Dichloroethene	------	------	------	------	------	------	------	------	0E+00	0.0%
2,3,7,8-TCDD	4E-06	3E-06	5E-07	1E-06	1E-22	5E-21	------	------	8E-06	1.2%
4-MethylPhenol	------	------	------	------	------	------	------	------	0E+00	0.0%
Aroclor-1248 (PCB)	3E-06	2E-06	2E-07	3E-07	------	------	------	------	5E-06	0.8%
Benzo(a)anthracene	3E-07	2E-07	4E-08	8E-08	1E-11	4E-10	------	------	6E-07	0.1%
Benzo(a)Pyrene	7E-06	5E-06	4E-07	8E-07	1E-10	4E-09	------	------	1E-05	2.1%
Benzo(b)Fluoranthene	1E-06	1E-06	4E-08	8E-08	1E-11	4E-10	------	------	2E-06	0.4%
Benzo(k)Fluoranthene	3E-07	2E-07	3E-08	5E-08	8E-12	3E-10	------	------	5E-07	0.1%
Benzoic Acid	------	------	------	------	------	------	------	------	0E+00	0.0%
Bis(2-ethylhexyl)phthalate	6E-07	5E-07	7E-08	2E-07	------	------	------	------	1E-06	0.2%
Chlordane (alpha)	7E-06	6E-06	7E-07	2E-06	1E-07	4E-06	------	------	2E-05	3.0%
Chrysene	6E-08	4E-08	4E-09	8E-09	1E-12	4E-11	------	------	1E-07	0.0%
Dichloromethane	7E-09	6E-09	4E-11	7E-11	1E-15	4E-14	------	------	1E-08	0.0%
Diethyl Phthalate	------	------	------	------	------	------	------	------	0E+00	0.0%
Endosulfan (sulfate)	------	------	------	------	------	------	------	------	0E+00	0.0%
Fluoranthene	------	------	------	------	------	------	------	------	0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	2E-07	1E-07	3E-08	5E-08	7E-12	3E-10	------	------	4E-07	0.1%
Phenol	------	------	------	------	------	------	------	------	0E+00	0.0%
Pyrene	------	------	------	------	------	------	------	------	0E+00	0.0%
Tetrachloroethene	7E-05	1E-04	2E-05	5E-05	8E-07	2E-05	------	------	3E-04	41.6%
Tetrachloromethane	3E-06	4E-06	4E-07	1E-06	4E-07	1E-05	------	------	2E-05	3.0%
Toluene	------	------	------	------	------	------	------	------	0E+00	0.0%
Trichloroethene	4E-06	6E-06	4E-07	1E-06	8E-07	3E-05	------	------	4E-05	6.0%
Trichlorofluoromethane	------	------	------	------	------	------	------	------	0E+00	0.0%
Trichloromethane	8E-07	1E-06	4E-08	1E-07	4E-06	1E-04	------	------	1E-04	21.4%
Vinyl Chloride	2E-05	3E-05	5E-07	1E-06	1E-06	3E-05	------	------	8E-05	11.5%
Fluoride	------	------	------	------	------	------	------	------	0E+00	0.0%
Nitrate	------	------	------	------	------	------	------	------	0E+00	0.0%
Silver	------	------	------	------	------	------	------	------	0E+00	0.0%
Actinium-227+D	2E-06	1E-05	------	------	------	------	------	------	2E-05	2.3%
Plutonium-238	1E-06	5E-06	------	------	1E-07	9E-07	7E-10	3E-09	7E-06	1.0%
Plutonium-239/240	1E-06	1E-05	------	------	3E-09	3E-08	2E-11	8E-11	1E-05	1.7%
Strontium-90+D	2E-06	8E-06	------	------	3E-11	2E-10	------	------	1E-05	1.5%
Tritium	1E-06	9E-06	------	------	1E-13	1E-12	------	------	1E-05	1.6%
Uranium-235/236+D	4E-09	3E-08	------	------	------	------	------	------	4E-08	0.0%
Uranium-238+D	8E-08	7E-07	------	------	------	------	------	------	8E-07	0.1%
Total Pathway Risk	**1E-04**	**2E-04**	**2E-05**	**6E-05**	**8E-06**	**2E-04**	**7E-10**	**3E-09**		
Relative Pathway Risk	**19.4%**	**30.8%**	**3.5%**	**9.3%**	**1.1%**	**35.8%**	**0.0%**	**0.0%**		

Overall Child Risk = 2E-04
Overall Adult Risk = 5E-04
Overall Risk (Adult+Child) = 7E-04

Table V.32b. Future Resident Farmer Scenario - Central Tendency Exposure - Overall Carcinogenic Risks - All Pathways

Chemical	Ingestion Risk		Dermal Contact Risk		Inhalation Risk		External Radiation Risk		Total Risk	Relative Risk
	Child	Adult	Child	Adult	Child	Adult	Child	Adult		
1,1,1-Trichloroethane	------	------	------	------	------	------	------	------	0E+00	0.0%
1,2-*cis*-Dichloroethene	------	------	------	------	------	------	------	------	0E+00	0.0%
1,2-*trans*-Dichloroethene	------	------	------	------	------	------	------	------	0E+00	0.0%
1,2-Dichloroethane	5E-08	6E-08	2E-09	4E-09	2E-08	7E-07	------	------	8E-07	0.5%
1,2-Dichloroethene	------	------	------	------	------	------	------	------	0E+00	0.0%
2,3,7,8-TCDD	1E-06	3E-07	8E-09	1E-08	2E-23	9E-22	------	------	2E-06	1.1%
4-MethylPhenol	------	------	------	------	------	------	------	------	0E+00	0.0%
Aroclor-1248 (PCB)	5E-07	2E-07	3E-09	4E-09	------	------	------	------	7E-07	0.5%
Benzo(a)anthracene	9E-08	3E-08	6E-10	8E-10	2E-12	8E-11	------	------	1E-07	0.1%
Benzo(a)Pyrene	1E-06	4E-07	6E-09	8E-09	2E-11	8E-10	------	------	2E-06	1.1%
Benzo(b)Fluoranthene	2E-07	7E-08	7E-10	9E-10	2E-12	9E-11	------	------	2E-07	0.2%
Benzo(k)Fluoranthene	7E-08	2E-08	4E-10	6E-10	1E-12	5E-11	------	------	9E-08	0.1%
Benzoic Acid	------	------	------	------	------	------	------	------	0E+00	0.0%
Bis(2-ethylhexyl)phthalate	5E-08	4E-08	3E-08	5E-08	------	------	------	------	2E-07	0.1%
Chlordane (alpha)	5E-07	4E-07	3E-07	5E-07	2E-08	1E-06	------	------	3E-06	1.9%
Chrysene	1E-08	4E-09	6E-11	8E-11	2E-13	8E-12	------	------	1E-08	0.0%
Dichloromethane	5E-10	3E-10	5E-13	8E-13	2E-16	7E-15	------	------	8E-10	0.0%
Diethyl Phthalate	------	------	------	------	------	------	------	------	0E+00	0.0%
Endosulfan (sulfate)	------	------	------	------	------	------	------	------	0E+00	0.0%
Fluoranthene	------	------	------	------	------	------	------	------	0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	6E-08	2E-08	4E-10	5E-10	1E-12	5E-11	------	------	8E-08	0.1%
Phenol	------	------	------	------	------	------	------	------	0E+00	0.0%
Pyrene	------	------	------	------	------	------	------	------	0E+00	0.0%
Tetrachloroethene	1E-05	2E-05	8E-06	1E-05	2E-07	6E-06	------	------	6E-05	40.0%
Tetrachloromethane	6E-07	7E-07	1E-07	3E-07	7E-08	3E-06	------	------	5E-06	3.1%
Toluene	------	------	------	------	------	------	------	------	0E+00	0.0%
Trichloroethene	9E-07	1E-06	2E-07	3E-07	2E-07	7E-06	------	------	9E-06	6.3%
Trichlorofluoromethane	------	------	------	------	------	------	------	------	0E+00	0.0%
Trichloromethane	2E-07	2E-07	2E-08	3E-08	8E-07	3E-05	------	------	4E-05	24.9%
Vinyl Chloride	4E-06	5E-06	2E-07	3E-07	2E-07	8E-06	------	------	2E-05	12.0%
Fluoride	------	------	------	------	------	------	------	------	0E+00	0.0%
Nitrate	------	------	------	------	------	------	------	------	0E+00	0.0%
Silver	------	------	------	------	------	------	------	------	0E+00	0.0%
Actinium-227+D	4E-07	3E-06	------	------	------	------	------	------	3E-06	2.1%
Plutonium-238	3E-07	1E-06	------	------	2E-08	2E-07	3E-10	1E-09	2E-06	1.1%
Plutonium-239/240	3E-07	2E-06	------	------	5E-10	5E-09	9E-12	3E-11	2E-06	1.6%
Strontium-90+D	6E-07	2E-06	------	------	5E-12	4E-11	------	------	2E-06	1.7%
Tritium	4E-07	2E-06	------	------	2E-14	2E-13	------	------	2E-06	1.5%
Uranium-235/236+D	1E-09	6E-09	------	------	------	------	------	------	7E-09	0.0%
Uranium-238+D	2E-08	1E-07	------	------	------	------	------	------	2E-07	0.1%
Total Pathway Risk	**3E-05**	**3E-05**	**8E-06**	**2E-05**	**1E-06**	**6E-05**	**3E-10**	**1E-09**		
Relative Pathway Risk	**17.4%**	**23.9%**	**5.8%**	**10.6%**	**1.0%**	**41.4%**	**0.0%**	**0.0%**		

Overall Child Risk = 4E-05
Overall Adult Risk = 1E-04
Overall Risk (Adult+Child) = 1E-04

For the future resident farmer scenario, the ingestion and inhalation pathways contribute more than 80 percent of the carcinogenic risk. The remainder of the carcinogenic risk is attributable to dermal contact. The overall carcinogenic risk due to external radiation exposure is less than $1x10^{-7}$.

The following COPCs contribute approximately 80 percent of the overall RME carcinogenic risk: PCE, TCE, trichloromethane, and vinyl chloride. The COPCs that significantly contribute to the remainder of the carcinogenic risk are the following: 1,2-dichloroethane, 2,3,7,8-TCDD, aroclor-1248, benzo(a)pyrene, benzo(b)fluoranthene, chlordane (alpha), tetrachloromethane, actinium-227, plutonium-238, plutonium-239/240, strontium-90, and tritium. Tetrachloroethene had the highest overall RME risk of $3x10^{-4}$, which exceeds the EPA target risk range. Tetrachloroethene also had the highest overall CTE risk of $6x10^{-5}$. The RME and CTE carcinogenic risks for each COPC are presented in Tables V.32a and V.32b.

Figure 5.3 displays the overall carcinogenic risks posed by each medium of concern. The overall groundwater carcinogenic risks were $6x10^{-4}$ and $1x10^{-4}$ for the RME and CTE, respectively. The overall risks (RME and CTE) posed by soil COPCs were more than one order of magnitude less than those for groundwater.

Daughter product carcinogenic risks are presented in Tables V.33a and V.33b for the RME and CTE, respectively. Thorium-228 was found to pose the highest carcinogenic risks of $1x10^{-4}$ and $5x10^{-5}$ for the RME and CTE, respectively. Radium-226 was the only other daughter product COPC with an RME carcinogenic risk exceeding $1x10^{-6}$.

5.5.2. Carcinogenic Risk Characterization - Future Indoor Industrial Park Worker Scenario

For the future onsite indoor worker, the overall RME and CTE risks were found to be $2x10^{-4}$ and $5x10^{-5}$, respectively (does not include daughter product radionuclides). PCE had the highest RME risk of $8x10^{-5}$. Other COPCs with RME risk levels exceeding $1x10^{-6}$ are 1,2-dichloroethane, chlordane (alpha), tetrachloromethane, TCE, trichloromethane, vinyl chloride, actinium-227, plutonium-238, plutonium-239/240, and tritium. PCE, tetrachloromethane, TCE, trichloromethane, and vinyl chloride are the only COPCs with CTE carcinogenic risks exceeding $1x10^{-6}$. The future indoor worker RME and CTE risks are presented in Tables V.34a and V.34b, respectively.

The carcinogenic risks posed by each medium of concern to the future indoor industrial worker are shown in Figure 5.4 (does not include daughter product radionuclides). Groundwater COPCs contribute virtually all of the carcinogenic risk (greater than 99 percent). The soil RME and CTE risk levels are less than the lowerbound value of the EPA target risk range.

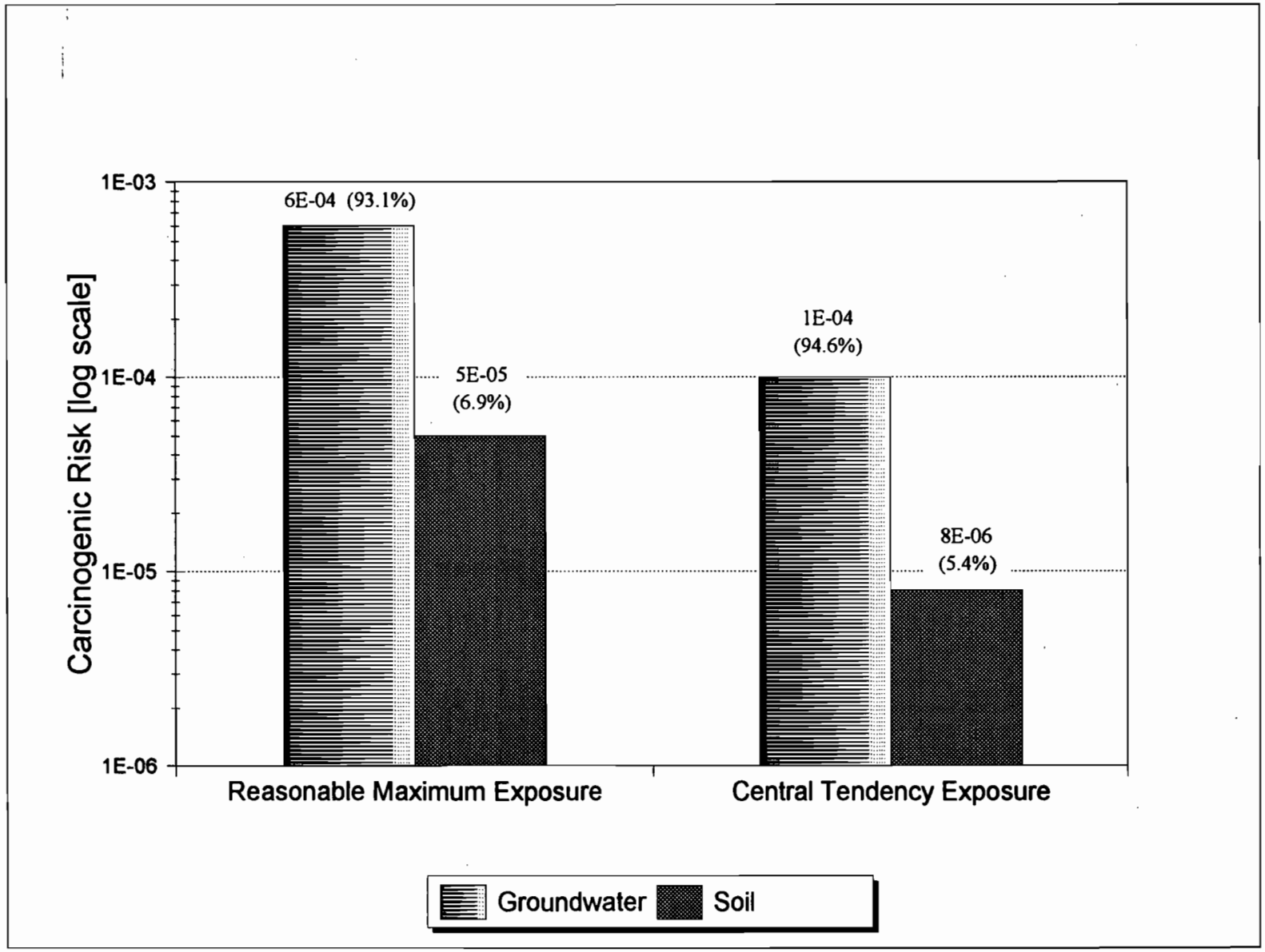

Figure 5.3. Carcinogenic risks by medium - future farmer resident scenario (adult + child).

Table V.33a. Daughter Product Carcinogenic Risks - Future Resident Farmer Scenario - Reasonable Maximum Exposure

Radionuclide	Ingestion Risk		Inhalation Risk		External Radiation		Total Radionuclide Risk
	Adult	Child	Adult	Child	Adult	Child	
Radium-226	2E-06	2E-07	------	------	------	------	2E-06
Thorium-228	3E-07	5E-08	3E-07	4E-08	1E-04	3E-05	1E-04
Thorium-230	3E-07	3E-08	------	------	------	------	3E-07
Thorium-232	4E-08	9E-09	1E-07	1E-08	4E-10	1E-10	2E-07
Uranium-234	2E-07	3E-08	------	------	------	------	3E-07
Uranium-235/236	4E-09	1E-09	1E-08	1E-09	4E-07	1E-07	5E-07
Total Pathway Risk	**3E-06**	**4E-07**	**5E-07**	**6E-08**	**1E-04**	**3E-05**	

Table V.33b. Daughter Product Carcinogenic Risks - Future Resident Farmer Scenario - Central Tendency Exposure

Radionuclide	Ingestion Risk		Inhalation Risk		External Radiation		Total Radionuclide Risk
	Adult	Child	Adult	Child	Adult	Child	
Radium-226	5E-07	8E-08	------	------	------	------	6E-07
Thorium-228	7E-08	2E-08	7E-08	7E-09	4E-05	1E-05	5E-05
Thorium-230	7E-08	1E-08	------	------	------	------	9E-08
Thorium-232	1E-08	3E-09	2E-08	2E-09	1E-10	5E-11	4E-08
Uranium-234	6E-08	1E-08	------	------	------	------	8E-08
Uranium-235/236	1E-09	4E-10	2E-09	2E-10	1E-07	5E-08	2E-07
Total Pathway Risk	**7E-07**	**1E-07**	**9E-08**	**1E-08**	**4E-05**	**1E-05**	

Table V.34a. Future Indoor Industrial Park Worker Scenario - Reasonable Maximum Exposure - Carcinogenic Risks

Chemical	Ingestion	Dermal Contact	Inhalation	External Radiation	Total Risk	Relative Risk
1,1,1-Trichloroethane	------	------	------	------	0E+00	0.0%
1,2-*cis*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-*trans*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-Dichloroethane	1E-07	1E-08	1E-06	------	2E-06	0.7%
1,2-Dichloroethene	------	------	------	------	0E+00	0.0%
2,3,7,8-TCDD	------	------	2E-21	------	2E-21	0.0%
4-MethylPhenol	------	------	------	------	0E+00	0.0%
Aroclor-1248 (PCB)	------	------	------	------	0E+00	0.0%
Benzo(a)anthracene	------	------	1E-10	------	1E-10	0.0%
Benzo(a)Pyrene	------	------	1E-09	------	1E-09	0.0%
Benzo(b)Fluoranthene	------	------	2E-10	------	2E-10	0.0%
Benzo(k)Fluoranthene	------	------	1E-10	------	1E-10	0.0%
Benzoic Acid	------	------	------	------	0E+00	0.0%
Bis(2-ethylhexyl)phthalate	3E-08	1E-07	------	------	2E-07	0.1%
Chlordane (alpha)	2E-07	1E-06	2E-06	------	4E-06	1.7%
Chrysene	------	------	1E-11	------	1E-11	0.0%
Dichloromethane	------	------	1E-14	------	1E-14	0.0%
Diethyl Phthalate	------	------	------	------	0E+00	0.0%
Endosulfan (sulfate)	------	------	------	------	0E+00	0.0%
Fluoranthene	------	------	------	------	0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	9E-11	------	9E-11	0.0%
Phenol	------	------	------	------	0E+00	0.0%
Pyrene	------	------	------	------	0E+00	0.0%
Tetrachloroethene	3E-05	4E-05	1E-05	------	8E-05	35.7%
Tetrachloromethane	1E-06	7E-07	6E-06	------	8E-06	3.6%
Toluene	------	------	------	------	0E+00	0.0%
Trichloroethene	2E-06	7E-07	1E-05	------	2E-05	7.6%
Trichlorofluoromethane	------	------	------	------	0E+00	0.0%
Trichloromethane	5E-07	8E-08	7E-05	------	7E-05	32.5%
Vinyl Chloride	9E-06	9E-07	2E-05	------	3E-05	11.7%
Fluoride	------	------	------	------	0E+00	0.0%
Nitrate	------	------	------	------	0E+00	0.0%
Silver	------	------	------	------	0E+00	0.0%
Actinium-227+D	5E-06	------	------	------	5E-06	2.3%
Plutonium-238	1E-06	2E-09	9E-07	5E-10	2E-06	1.0%
Plutonium-239/240	4E-06	5E-11	3E-08	1E-11	4E-06	1.7%
Strontium-90+D	2E-07	4E-11	2E-10	------	2E-07	0.1%
Tritium	3E-06	2E-13	1E-12	------	3E-06	1.3%
Uranium-235/236+D	1E-08	------	------	------	1E-08	0.0%
Uranium-238+D	2E-07	------	------	------	2E-07	0.1%
Total Pathway Risk	**5E-05**	**4E-05**	**1E-04**	**5E-10**		
Relative Pathway Risk	**24.7%**	**18.8%**	**56.5%**	**0.0%**		

Overall Indoor Worker Risk = 2E-04

Table V.34b. Future Indoor Industrial Park Worker Scenario - Central Tendency Exposure - Carcinogenic Risks

Chemical	Ingestion	Dermal Contact	Inhalation	External Radiation	Total Risk	Relative Risk
1,1,1-Trichloroethane	------	------	------	------	0E+00	0.0%
1,2-*cis*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-*trans*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-Dichloroethane	2E-08	3E-09	3E-07	------	3E-07	0.7%
1,2-Dichloroethene	------	------	------	------	0E+00	0.0%
2,3,7,8-TCDD	------	------	4E-22	------	4E-22	0.0%
4-MethylPhenol	------	------	------	------	0E+00	0.0%
Aroclor-1248 (PCB)	------	------	------	------	0E+00	0.0%
Benzo(a)anthracene	------	------	3E-11	------	3E-11	0.0%
Benzo(a)Pyrene	------	------	3E-10	------	3E-10	0.0%
Benzo(b)Fluoranthene	------	------	4E-11	------	4E-11	0.0%
Benzo(k)Fluoranthene	------	------	2E-11	------	2E-11	0.0%
Benzoic Acid	------	------	------	------	0E+00	0.0%
Bis(2-ethylhexyl)phthalate	6E-09	3E-08	------	------	4E-08	0.1%
Chlordane (alpha)	3E-08	3E-07	5E-07	------	9E-07	1.8%
Chrysene	------	------	3E-12	------	3E-12	0.0%
Dichloromethane	------	------	3E-15	------	3E-15	0.0%
Diethyl Phthalate	------	------	------	------	0E+00	0.0%
Endosulfan (sulfate)	------	------	------	------	0E+00	0.0%
Fluoranthene	------	------	------	------	0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	2E-11	------	2E-11	0.0%
Phenol	------	------	------	------	0E+00	0.0%
Pyrene	------	------	------	------	0E+00	0.0%
Tetrachloroethene	5E-06	9E-06	3E-06	------	2E-05	35.1%
Tetrachloromethane	2E-07	2E-07	1E-06	------	2E-06	3.6%
Toluene	------	------	------	------	0E+00	0.0%
Trichloroethene	4E-07	2E-07	3E-06	------	4E-06	7.6%
Trichlorofluoromethane	------	------	------	------	0E+00	0.0%
Trichloromethane	9E-08	2E-08	2E-05	------	2E-05	33.6%
Vinyl Chloride	2E-06	2E-07	4E-06	------	6E-06	11.8%
Fluoride	------	------	------	------	0E+00	0.0%
Nitrate	------	------	------	------	0E+00	0.0%
Silver	------	------	------	------	0E+00	0.0%
Actinium-227+D	9E-07	------	------	------	9E-07	1.9%
Plutonium-238	2E-07	4E-10	3E-07	2E-10	5E-07	1.1%
Plutonium-239/240	7E-07	1E-11	9E-09	5E-12	7E-07	1.4%
Strontium-90+D	4E-08	1E-11	7E-11	------	4E-08	0.1%
Tritium	5E-07	6E-14	3E-13	------	5E-07	1.1%
Uranium-235/236+D	2E-09	------	------	------	2E-09	0.0%
Uranium-238+D	5E-08	------	------	------	5E-08	0.1%
Total Pathway Risk	**1E-05**	**1E-05**	**3E-05**	**2E-10**		
Relative Pathway Risk	**21.3%**	**19.7%**	**59.0%**	**0.0%**		

Overall Indoor Worker Risk = 5E-05

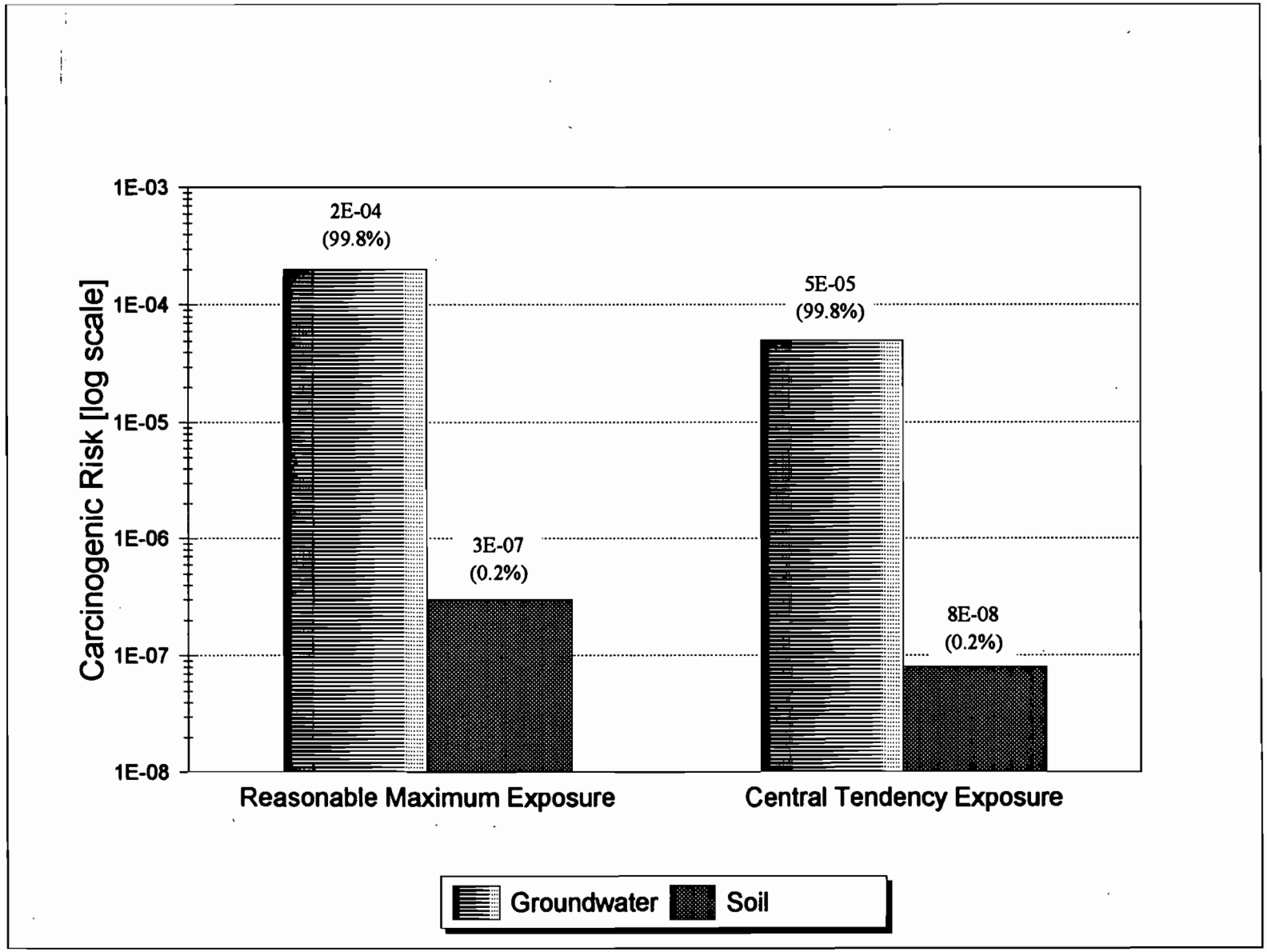

Figure 5.4. Carcinogenic risks by medium - future industrial worker scenario (indoor).

Daughter product carcinogenic risks are presented in Tables V.35a and V.35b for the RME and CTE, respectively. Thorium-228 was found to pose the highest carcinogenic risks of $2x10^{-5}$ and $6x10^{-6}$ for the RME and CTE, respectively. Thorium-228 was the only daughter product COPC with RME and CTE carcinogenic risks exceeding $1x10^{-6}$.

5.5.3. Carcinogenic Risk Characterization - Future Outdoor Industrial Park Worker Scenario

For the future onsite outdoor worker, the overall RME and CTE risks were found to be $1x10^{-4}$ and $2x10^{-5}$, respectively (does not include daughter product radionuclides). The ingestion and dermal contact pathways contribute approximately 83 percent of the carcinogenic risk. PCE had the highest RME risk of $7x10^{-5}$. Other chemicals with RME risks exceeding $1x10^{-6}$ are 2,3,7,8-TCDD, benzo(a)pyrene, chlordane (alpha), tetrachloromethane, TCE, trichloromethane, vinyl chloride, actinium-227, plutonium-238, plutonium-239/240, and tritium. PCE, trichloromethane, and vinyl chloride are the only COPCs with CTE carcinogenic risks exceeding $1x10^{-6}$. The future outdoor worker RME and CTE risks are presented in Tables V.36a and V.36b, respectively.

The carcinogenic risks posed by each medium of concern to the future outdoor industrial worker are shown in Figure 5.5 (does not include daughter product radionuclides). Groundwater COPCs contribute to the majority (approximately 95 percent) of the overall RME and CTE carcinogenic risks.

Daughter product carcinogenic risks are presented in Tables V.37a and V.37b for the RME and CTE, respectively. Thorium-228 was found to pose the highest carcinogenic risks of $2x10^{-5}$ and $6x10^{-6}$ for the RME and CTE, respectively. Thorium-228 was the only daughter product COPC with RME and CTE carcinogenic risks exceeding $1x10^{-6}$.

5.5.4. Noncarcinogenic Risk Characterization - Future Resident Farmer Scenario

Noncarcinogenic risk was evaluated by calculating the hazard quotient (HQ), which is the ratio of the estimated daily exposure of each contaminant to the applicable chronic RfC or RfD for that contaminant. The HQs were then summed to derive a hazard index (HI) for each exposure route and for all exposures combined. All RME and CTE noncarcinogenic HQs and HIs from all pathways are presented in Appendix I.

An HI of greater than 1.0 at any time during an individual's lifetime indicates that there may be a potential for noncarcinogenic effects. Tables V.38 and V.39 provide the RME and CTE chronic HIs from all pathways for the future resident. The overall RME HIs for the child and adult in the future farmer scenario are 21 and 18, respectively. For the future farmer CTE, the overall HIs are 12 for the child and 11 for the adult.

Table V.35a. Daughter Product Carcinogenic Risks - Future Indoor Industrial Worker Scenario - Reasonable Maximum Exposure

Radionuclide	Ingestion Risk	Inhalation Risk	External Radiation	Total Radionuclide Risk
Radium-226	7E-07	------	------	7E-07
Thorium-228	6E-08	1E-07	2E-05	2E-05
Thorium-230	1E-07	------	------	1E-07
Thorium-232	1E-08	4E-08	7E-11	5E-08
Uranium-234	9E-08	------	------	9E-08
Uranium-235/236	------	4E-09	7E-08	7E-08
Total Pathway Risk	**1E-06**	**2E-07**	**2E-05**	

Table V.35b. Daughter Product Carcinogenic Risks - Future Indoor Industrial Worker Scenario - Central Tendency Exposure

Radionuclide	Ingestion Risk	Inhalation Risk	External Radiation	Total Radionuclide Risk
Radium-226	2E-07	------	------	2E-07
Thorium-228	2E-08	3E-08	6E-06	6E-06
Thorium-230	3E-08	------	------	3E-08
Thorium-232	3E-09	9E-09	2E-11	1E-08
Uranium-234	2E-08	------	------	2E-08
Uranium-235/236	------	8E-10	2E-08	3E-08
Total Pathway Risk	**2E-07**	**4E-08**	**6E-06**	

Table V.36a. Future Outdoor Industrial Park Worker Scenario - Reasonable Maximum Exposure - Carcinogenic Risks

Chemical	Ingestion	Dermal Contact	Inhalation	External Radiation	Total Risk	Relative Risk
1,1,1-Trichloroethane	------	------	------	------	0E+00	0.0%
1,2-*cis*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-*trans*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-Dichloroethane	1E-07	1E-08	2E-07	------	4E-07	0.3%
1,2-Dichloroethene	------	------	------	------	0E+00	0.0%
2,3,7,8-TCDD	3E-07	2E-06	3E-21	------	2E-06	1.9%
4-MethylPhenol	------	------	------	------	0E+00	0.0%
Aroclor-1248 (PCB)	1E-07	7E-07	------	------	8E-07	0.6%
Benzo(a)anthracene	3E-08	2E-07	2E-10	------	2E-07	0.1%
Benzo(a)Pyrene	3E-07	2E-06	2E-09	------	2E-06	1.5%
Benzo(b)Fluoranthene	3E-08	2E-07	3E-10	------	2E-07	0.2%
Benzo(k)Fluoranthene	2E-08	1E-07	2E-10	------	1E-07	0.1%
Benzoic Acid	------	------	------	------	0E+00	0.0%
Bis(2-ethylhexyl)phthalate	3E-08	1E-07	------	------	2E-07	0.1%
Chlordane (alpha)	2E-07	1E-06	4E-07	------	2E-06	1.6%
Chrysene	3E-09	1E-08	2E-11	------	2E-08	0.0%
Dichloromethane	1E-11	1E-10	2E-14	------	1E-10	0.0%
Diethyl Phthalate	------	------	------	------	0E+00	0.0%
Endosulfan (sulfate)	------	------	------	------	0E+00	0.0%
Fluoranthene	------	------	------	------	0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	2E-08	1E-07	2E-10	------	1E-07	0.1%
Phenol	------	------	------	------	0E+00	0.0%
Pyrene	------	------	------	------	0E+00	0.0%
Tetrachloroethene	3E-05	4E-05	2E-06	------	7E-05	55.1%
Tetrachloromethane	1E-06	7E-07	1E-06	------	3E-06	2.4%
Toluene	------	------	------	------	0E+00	0.0%
Trichloroethene	2E-06	7E-07	2E-06	------	5E-06	4.2%
Trichlorofluoromethane	------	------	------	------	0E+00	0.0%
Trichloromethane	5E-07	8E-08	1E-05	------	1E-05	10.1%
Vinyl Chloride	9E-06	9E-07	3E-06	------	1E-05	10.2%
Fluoride	------	------	------	------	0E+00	0.0%
Nitrate	------	------	------	------	0E+00	0.0%
Silver	------	------	------	------	0E+00	0.0%
Actinium-227+D	5E-06	------	------	------	5E-06	4.1%
Plutonium-238	1E-06	3E-09	5E-07	5E-10	2E-06	1.6%
Plutonium-239/240	4E-06	9E-11	2E-08	1E-11	4E-06	3.0%
Strontium-90+D	2E-07	7E-11	1E-10	------	2E-07	0.2%
Tritium	3E-06	4E-13	6E-13	------	3E-06	2.3%
Uranium-235/236+D	1E-08	------	------	------	1E-08	0.0%
Uranium-238+D	2E-07	------	------	------	2E-07	0.2%
Total Pathway Risk	**6E-05**	**5E-05**	**2E-05**	**5E-10**		
Relative Pathway Risk	**45.2%**	**37.6%**	**17.3%**	**0.0%**		

Overall Outdoor Worker Risk = 1E-04

Table V.36b. Future Outdoor Industrial Park Worker Scenario - Central Tendency Exposure - Carcinogenic Risks

Chemical	Ingestion	Dermal Contact	Inhalation	External Radiation	Total Risk	Relative Risk
1,1,1-Trichloroethane	------	------	------	------	0E+00	0.0%
1,2-*cis*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-*trans*-Dichloroethene	------	------	------	------	0E+00	0.0%
1,2-Dichloroethane	2E-08	3E-09	4E-08	------	7E-08	0.3%
1,2-Dichloroethene	------	------	------	------	0E+00	0.0%
2,3,7,8-TCDD	1E-07	1E-07	7E-22	------	3E-07	1.1%
4-MethylPhenol	------	------	------	------	0E+00	0.0%
Aroclor-1248 (PCB)	4E-08	5E-08	------	------	9E-08	0.4%
Benzo(a)anthracene	9E-09	1E-08	6E-11	------	2E-08	0.1%
Benzo(a)Pyrene	9E-08	1E-07	6E-10	------	2E-07	0.8%
Benzo(b)Fluoranthene	1E-08	1E-08	6E-11	------	2E-08	0.1%
Benzo(k)Fluoranthene	6E-09	7E-09	4E-11	------	1E-08	0.1%
Benzoic Acid	------	------	------	------	0E+00	0.0%
Bis(2-ethylhexyl)phthalate	6E-09	3E-08	------	------	4E-08	0.1%
Chlordane (alpha)	3E-08	3E-07	7E-08	------	4E-07	1.7%
Chrysene	9E-10	1E-09	5E-12	------	2E-09	0.0%
Dichloromethane	3E-12	1E-11	6E-15	------	1E-11	0.0%
Diethyl Phthalate	------	------	------	------	0E+00	0.0%
Endosulfan (sulfate)	------	------	------	------	0E+00	0.0%
Fluoranthene	------	------	------	------	0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	6E-09	7E-09	4E-11	------	1E-08	0.1%
Phenol	------	------	------	------	0E+00	0.0%
Pyrene	------	------	------	------	0E+00	0.0%
Tetrachloroethene	5E-06	9E-06	4E-07	------	1E-05	58.5%
Tetrachloromethane	2E-07	2E-07	2E-07	------	6E-07	2.4%
Toluene	------	------	------	------	0E+00	0.0%
Trichloroethene	4E-07	2E-07	4E-07	------	1E-06	4.1%
Trichlorofluoromethane	------	------	------	------	0E+00	0.0%
Trichloromethane	9E-08	2E-08	2E-06	------	2E-06	9.5%
Vinyl Chloride	2E-06	2E-07	5E-07	------	2E-06	9.8%
Fluoride	------	------	------	------	0E+00	0.0%
Nitrate	------	------	------	------	0E+00	0.0%
Silver	------	------	------	------	0E+00	0.0%
Actinium-227+D	9E-07	------	------	------	9E-07	3.8%
Plutonium-238	3E-07	7E-10	1E-07	2E-10	5E-07	1.8%
Plutonium-239/240	7E-07	2E-10	4E-08	5E-12	7E-07	2.9%
Strontium-90+D	4E-08	2E-11	3E-11	------	4E-08	0.2%
Tritium	5E-07	1E-13	1E-13	------	5E-07	2.1%
Uranium-235/236+D	2E-09	------	------	------	2E-09	0.0%
Uranium-238+D	5E-08	------	------	------	5E-08	0.2%
Total Pathway Risk	**1E-05**	**1E-05**	**4E-06**	**2E-10**		
Relative Pathway Risk	**43.4%**	**40.1%**	**16.5%**	**0.0%**		

Overall Outdoor Worker Risk = 2E-05

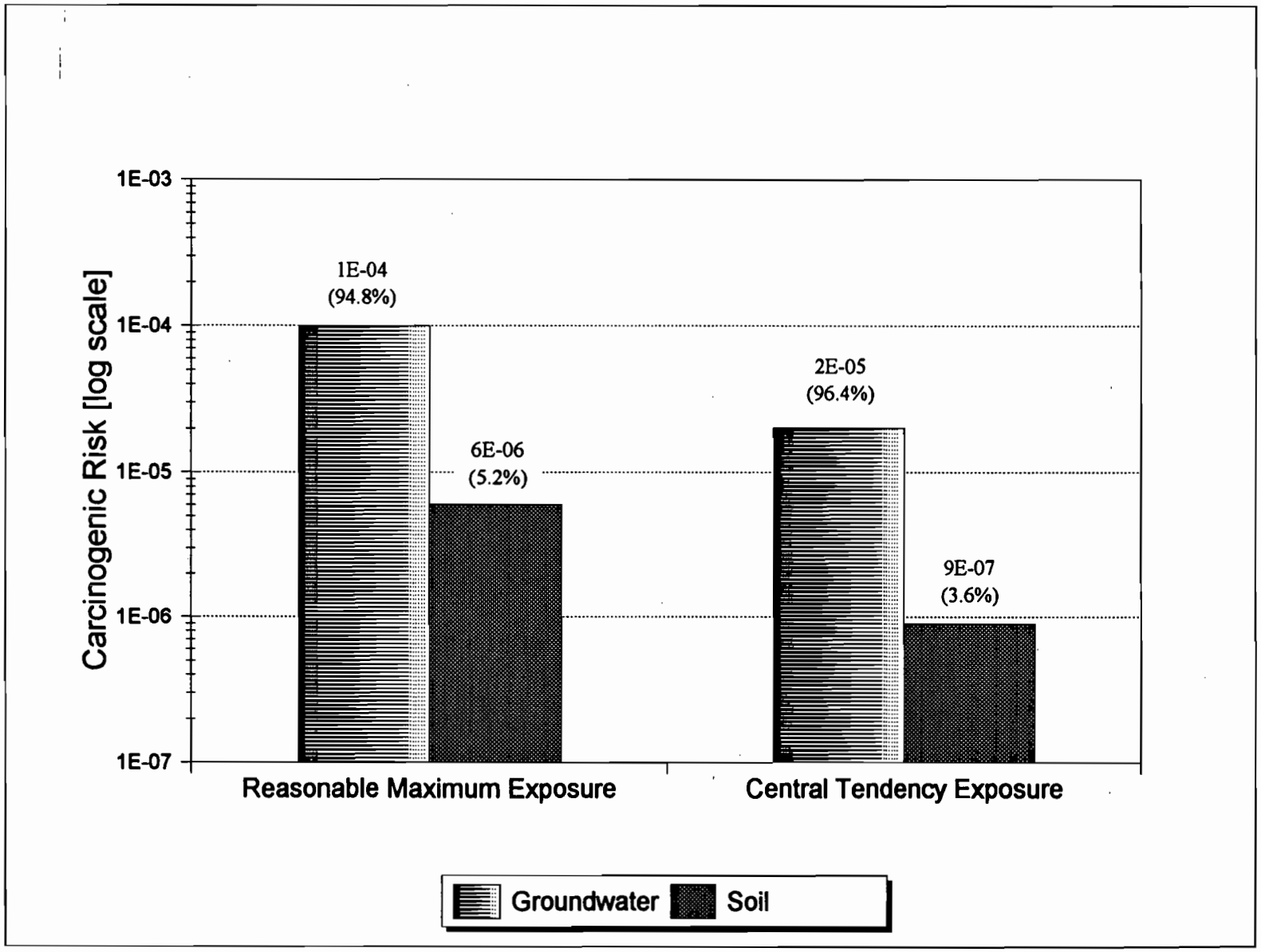

Figure 5.5. Carcinogenic risks by medium - future industrial worker scenario (outdoor).

Table V.37a. Daughter Product Carcinogenic Risks - Future Outdoor Industrial Worker Scenario - Reasonable Maximum Exposure

Radionuclide	Ingestion Risk	Inhalation Risk	External Radiation	Total Radionuclide Risk
Radium-226	7E-07	------	------	7E-07
Thorium-228	8E-08	2E-07	2E-05	2E-05
Thorium-230	1E-07	------	------	1E-07
Thorium-232	1E-08	6E-08	7E-11	7E-08
Uranium-234	9E-08	------	------	9E-08
Uranium-235/236	3E-10	6E-09	7E-08	7E-08
Total Pathway Risk	**1E-06**	**3E-07**	**2E-05**	

Table V.37b. Daughter Product Carcinogenic Risks - Future Outdoor Industrial Worker Scenario - Central Tendency Exposure

Radionuclide	Ingestion Risk	Inhalation Risk	External Radiation	Total Radionuclide Risk
Radium-226	2E-07	------	------	2E-07
Thorium-228	2E-08	5E-08	6E-06	6E-06
Thorium-230	3E-08	------	------	3E-08
Thorium-232	4E-09	1E-08	2E-11	2E-08
Uranium-234	2E-08	------	------	2E-08
Uranium-235/236	1E-10	1E-09	2E-08	3E-08
Total Pathway Risk	**2E-07**	**6E-08**	**6E-06**	

Table V.38. Future Resident Farmer Scenario - Reasonable Maximum Exposure - Overall Noncarcinogenic Hazard Indices - All Pathways

Chemical	Ingestion Hazard Index		Dermal Contact Hazard Index		Inhalation Hazard Index		Total Hazard Index	Relative Hazard Index
	Child	Adult	Child	Adult	Child	Adult		
1,1,1-Trichloroethane	5.2E-04	2.0E-04	5.2E-05	3.6E-05	6.5E-03	6.5E-03	1.4E-02	0.0%
1,2-*cis*-Dichloroethene	7.6E-01	3.0E-01	1.2E-02	8.3E-03	------	------	1.1E+00	2.8%
1,2-*trans*-Dichloroethene	3.1E-03	1.2E-03	2.2E-04	1.5E-04	------	------	4.7E-03	0.0%
1,2-Dichloroethane	------	------	------	------	4.1E-01	4.1E-01	8.2E-01	2.1%
1,2-Dichloroethene	1.4E-03	2.9E-04	7.8E-06	3.7E-06	------	------	1.7E-03	0.0%
2,3,7,8-TCDD	------	------	------	------	------	------	0.0E+00	0.0%
4-MethylPhenol	4.2E-02	9.3E-03	1.3E-04	6.2E-05	------	------	5.2E-02	0.1%
Aroclor-1248 (PCB)	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(a)anthracene	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(a)Pyrene	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(b)Fluoranthene	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(k)Fluoranthene	------	------	------	------	------	------	0.0E+00	0.0%
Benzoic Acid	7.4E-05	1.6E-05	8.5E-07	4.0E-07	------	------	9.1E-05	0.0%
Bis(2-ethylhexyl)phthalate	2.3E-02	5.4E-03	2.8E-03	1.9E-03	------	------	3.3E-02	0.1%
Chlordane (alpha)	1.0E+00	2.2E-01	1.1E-01	7.5E-02	------	------	1.4E+00	3.6%
Chrysene	------	------	------	------	------	------	0.0E+00	0.0%
Dichloromethane	1.8E-04	3.8E-05	9.7E-07	4.5E-07	2.1E-10	2.1E-10	2.2E-04	0.0%
Diethyl Phthalate	8.8E-05	3.5E-05	4.7E-06	3.2E-06	------	------	1.3E-04	0.0%
Endosulfan (sulfate)	5.1E-05	1.0E-05	2.8E-06	1.3E-06	------	------	6.6E-05	0.0%
Fluoranthene	6.0E-04	1.2E-04	1.7E-05	7.8E-06	------	------	7.4E-04	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	------	------	------	------	0.0E+00	0.0%
Phenol	4.9E-04	1.0E-04	5.7E-07	2.7E-07	------	------	6.0E-04	0.0%
Pyrene	1.7E-02	4.0E-03	7.9E-03	5.4E-03	------	------	3.5E-02	0.1%
Tetrachloroethene	1.6E+00	5.7E-01	4.4E-01	3.0E-01	------	------	3.0E+00	7.6%
Tetrachloromethane	3.4E-01	1.3E-01	4.6E-02	3.2E-02	1.5E+01	1.5E+01	3.1E+01	79.9%
Toluene	1.9E-05	4.1E-06	1.6E-07	7.5E-08	8.8E-10	8.8E-10	2.4E-05	0.0%
Trichloroethene	7.3E-01	2.8E-01	6.9E-02	4.7E-02	------	------	1.1E+00	2.9%
Trichlorofluoromethane	7.4E-04	2.9E-04	7.6E-05	5.1E-05	4.4E-02	4.4E-02	8.9E-02	0.2%
Trichloromethane	1.6E-01	6.4E-02	8.0E-03	5.5E-03	------	------	2.4E-01	0.6%
Vinyl Chloride	------	------	------	------	------	------	0.0E+00	0.0%
Fluoride	9.3E-04	1.0E-04	2.3E-05	1.1E-05	------	------	1.1E-03	0.0%
Nitrate	5.1E-05	5.4E-06	1.3E-06	5.9E-07	------	------	5.8E-05	0.0%
Silver	1.1E-02	1.2E-03	2.6E-04	1.2E-04	------	------	1.2E-02	0.0%
Hazard Index	**4.7E+00**	**1.6E+00**	**7.0E-01**	**4.8E-01**	**1.6E+01**	**1.6E+01**		
Relative Hazard Index	**12.1%**	**4.0%**	**1.8%**	**1.2%**	**40.4%**	**40.4%**		

Overall Child HI = 2.1E+01
Overall Adult HI = 1.8E+01
Overall HI (Adult+Child) = 3.9E+01

Table V.39. Future Resident Farmer Scenario - Central Tendency Exposure - Overall Noncarcinogenic Hazard Indices - All Pathways

Chemical	Ingestion Hazard Index		Dermal Contact Hazard Index		Inhalation Hazard Index		Total Hazard Index	Relative Hazard Index
	Child	Adult	Child	Adult	Child	Adult		
1,1,1-Trichloroethane	2.4E-04	9.7E-05	4.0E-05	2.5E-05	4.2E-03	4.2E-03	8.8E-03	0.0%
1,2-*cis*-Dichloroethene	3.6E-01	1.5E-01	8.0E-03	4.9E-03	------	------	5.3E-01	2.3%
1,2-*trans*-Dichloroethene	1.5E-03	6.1E-04	1.7E-04	1.1E-04	------	------	2.4E-03	0.0%
1,2-Dichloroethane	------	------	------	------	2.6E-01	2.6E-01	5.2E-01	2.2%
1,2-Dichloroethene	1.9E-04	3.9E-05	2.3E-07	1.1E-07	------	------	2.3E-04	0.0%
2,3,7,8-TCDD	------	------	------	------	------	------	0.0E+00	0.0%
4-MethylPhenol	6.2E-03	1.2E-03	4.0E-06	1.8E-06	------	------	7.4E-03	0.0%
Aroclor-1248 (PCB)	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(a)anthracene	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(a)Pyrene	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(b)Fluoranthene	------	------	------	------	------	------	0.0E+00	0.0%
Benzo(k)Fluoranthene	------	------	------	------	------	------	0.0E+00	0.0%
Benzoic Acid	1.3E-05	2.3E-06	2.5E-08	1.2E-08	------	------	1.5E-05	0.0%
Bis(2-ethylhexyl)phthalate	4.0E-03	1.0E-03	2.1E-03	1.3E-03	------	------	8.5E-03	0.0%
Chlordane (alpha)	1.5E-01	3.6E-02	8.6E-02	5.3E-02	------	------	3.2E-01	1.4%
Chrysene	------	------	------	------	------	------	0.0E+00	0.0%
Dichloromethane	2.6E-05	5.3E-06	2.8E-08	1.3E-08	2.1E-10	2.1E-10	3.1E-05	0.0%
Diethyl Phthalate	4.0E-05	1.7E-05	3.6E-06	2.2E-06	------	------	6.2E-05	0.0%
Endosulfan (sulfate)	1.1E-05	1.7E-06	8.3E-08	3.8E-08	------	------	1.3E-05	0.0%
Fluoranthene	1.4E-04	2.0E-05	5.0E-07	2.3E-07	------	------	1.6E-04	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	------	------	------	------	0.0E+00	0.0%
Phenol	6.7E-05	1.4E-05	1.7E-08	8.0E-09	------	------	8.1E-05	0.0%
Pyrene	2.9E-03	7.9E-04	6.2E-03	3.7E-03	------	------	1.4E-02	0.1%
Tetrachloroethene	6.2E-01	2.5E-01	3.4E-01	2.1E-01	------	------	1.4E+00	6.0%
Tetrachloromethane	1.4E-01	6.0E-02	3.6E-02	2.2E-02	9.9E+00	9.9E+00	2.0E+01	84.9%
Toluene	2.8E-06	5.6E-07	4.7E-09	2.2E-09	8.8E-10	8.8E-10	3.3E-06	0.0%
Trichloroethene	3.3E-01	1.4E-01	5.3E-02	3.2E-02	------	------	5.6E-01	2.4%
Trichlorofluoromethane	3.3E-04	1.4E-04	5.9E-05	3.6E-05	2.8E-02	2.8E-02	5.7E-02	0.2%
Trichloromethane	7.5E-02	3.2E-02	6.2E-03	3.8E-03	------	------	1.2E-01	0.5%
Vinyl Chloride	------	------	------	------	------	------	0.0E+00	0.0%
Fluoride	9.3E-04	7.8E-05	6.7E-07	3.2E-07	------	------	1.0E-03	0.0%
Nitrate	5.1E-05	4.3E-06	3.6E-08	1.8E-08	------	------	5.5E-05	0.0%
Silver	1.1E-02	9.0E-04	7.6E-06	3.6E-06	------	------	1.2E-02	0.0%
Hazard Index	**1.7E+00**	**6.7E-01**	**5.4E-01**	**3.3E-01**	**1.0E+01**	**1.0E+01**		
Relative Hazard Index	**7.3%**	**2.9%**	**2.3%**	**1.4%**	**43.1%**	**43.1%**		

Overall Child HI = 1.2E+01
Overall Adult HI = 1.1E+01
Overall HI (Adult+Child) = 2.4E+01

For the future farmer scenario, the inhalation pathway contributes to approximately 80 percent of the overall noncarcinogenic risk. Tetrachloromethane trichloroethene, and PCE were the only COPCs with overall RME HIs exceeding unity and contributed to approximately 90 percent of the overall noncarcinogenic risk. Tetrachloromethane had the highest overall RME and CTE HI of 31 and 20, respectively. The RME and CTE HIs for each of the COPCs are presented in Table V.38 and V.39, respectively.

The noncarcinogenic HIs for each medium of concern are presented in Figure 5.6. Groundwater COPCs contribute virtually all of the noncarcinogenic risk (greater than 99 percent). The soil RME and CTE HIs are 2 orders of magnitude less than unity.

5.5.5. Noncarcinogenic Risk Characterization - Future Indoor Industrial Park Worker Scenario

For the future indoor industrial park worker scenario, the overall RME and CTE HIs were 17 and 11, respectively. The inhalation pathway contributes approximately 96 percent of the overall noncarcinogenic risk. Tetrachloromethane had the highest RME and CTE HIs of approximately 15 and 10, respectively. The RME and CTE HIs for the future indoor worker scenario are presented in Tables V.40 and V.41, respectively.

Tetrachloromethane was the only COPC with RME and CTE HIs that exceeded unity. The overall RME and CTE HIs, with the exception of tetrachloromethane, were found to be below unity.

Figure 5.7 presents the overall noncarcinogenic HIs for each medium of concern. The groundwater COPC HIs contribute almost 100 percent of the noncarcinogenic risk. The soil COPC HIs were approximately 10 orders of magnitude less than unity.

5.5.6. Noncarcinogenic Risk Characterization - Future Outdoor Industrial Park Worker Scenario

For the future outdoor industrial park worker scenario, the overall RME and CTE HIs were 15 and 9, respectively. The inhalation pathway contributes approximately 95 percent of the overall noncarcinogenic risk. Tetrachloromethane had the highest RME and CTE HIs of approximately 14 and 9, respectively. The RME and CTE HIs for the future outdoor worker scenario are presented in Tables V.42 and V.43.

Tetrachloromethane was the only COPC with RME and CTE HIs that exceeded unity. The overall RME and CTE HIs, with the exception of tetrachloromethane, were found to be below unity.

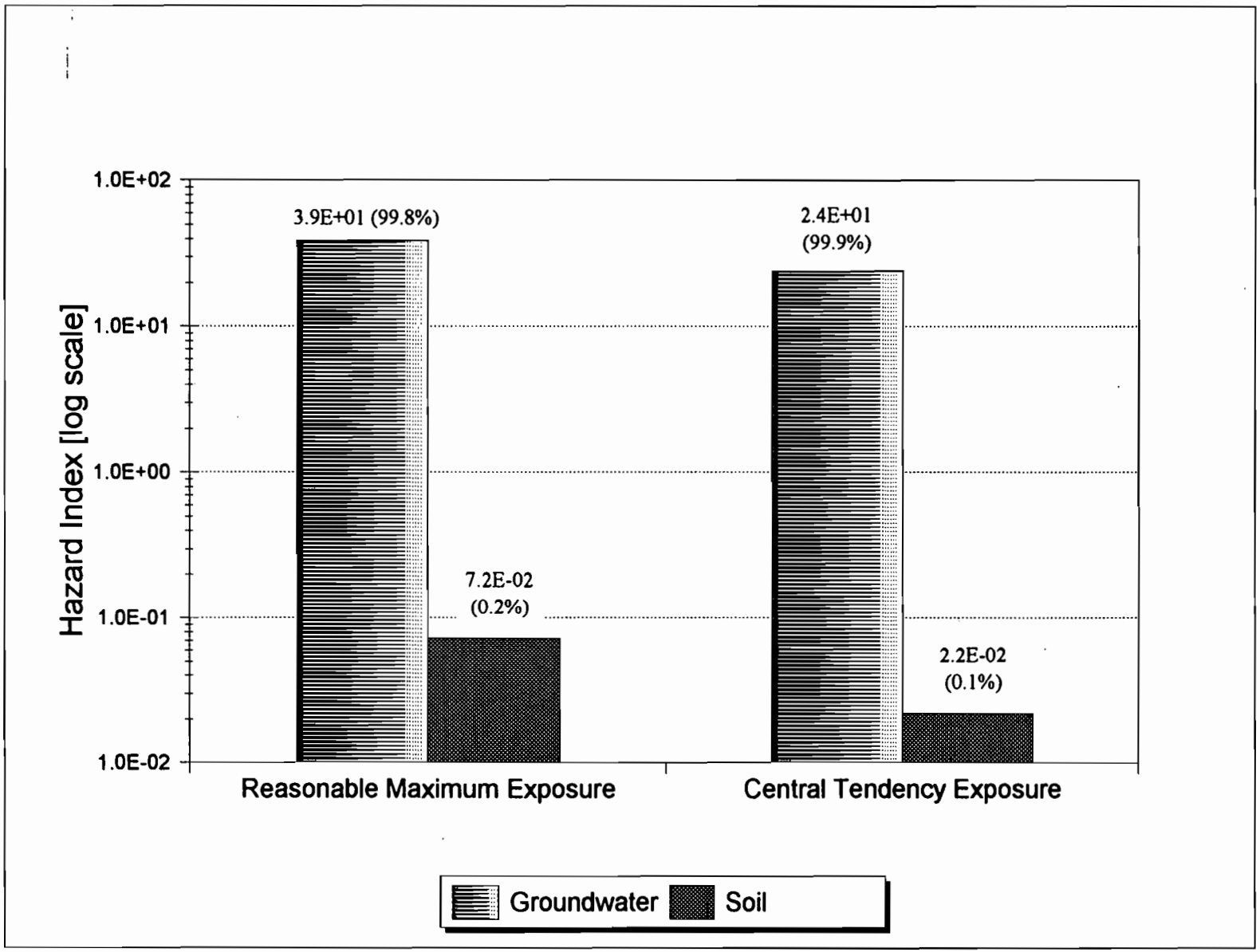

Figure 5.6. Hazard indices by medium - future farmer resident scenario (adult + child).

Table V.40. Future Indoor Industrial Park Worker Scenario - Reasonable Maximum Exposure - Noncarcinogenic Hazard Indices

Chemical	Ingestion	Dermal Contact	Inhalation	Total Hazard Quotient	Relative Hazard Quotient
1,1,1-Trichloroethane	6.4E-05	2.3E-05	6.5E-03	6.6E-03	0.0%
1,2-*cis*-Dichloroethene	1.0E-01	4.6E-03	------	1.0E-01	0.6%
1,2-*trans*-Dichloroethene	4.1E-04	1.0E-04	------	5.1E-04	0.0%
1,2-Dichloroethane	------	------	4.1E-01	4.1E-01	2.5%
1,2-Dichloroethene	------	------	------	0.0E+00	0.0%
2,3,7,8-TCDD	------	------	------	0.0E+00	0.0%
4-MethylPhenol	------	------	------	0.0E+00	0.0%
Aroclor-1248 (PCB)	------	------	------	0.0E+00	0.0%
Benzo(a)anthracene	------	------	------	0.0E+00	0.0%
Benzo(a)Pyrene	------	------	------	0.0E+00	0.0%
Benzo(b)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzo(k)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzoic Acid	------	------	------	0.0E+00	0.0%
Bis(2-ethylhexyl)phthalate	3.0E-04	1.3E-03	------	1.5E-03	0.0%
Chlordane (alpha)	6.5E-03	5.0E-02	------	5.7E-02	0.3%
Chrysene	------	------	------	0.0E+00	0.0%
Dichloromethane	------	------	8.0E-11	8.0E-11	0.0%
Diethyl Phthalate	1.1E-05	2.1E-06	------	1.3E-05	0.0%
Endosulfan (sulfate)	------	------	------	0.0E+00	0.0%
Fluoranthene	------	------	------	0.0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	------	0.0E+00	0.0%
Phenol	------	------	------	0.0E+00	0.0%
Pyrene	2.3E-04	3.7E-03	------	3.9E-03	0.0%
Tetrachloroethene	1.5E-01	2.0E-01	------	3.5E-01	2.1%
Tetrachloromethane	3.9E-02	2.1E-02	1.5E+01	1.5E+01	93.2%
Toluene	------	------	3.3E-10	3.3E-10	0.0%
Trichloroethene	9.2E-02	3.2E-02	------	1.2E-01	0.7%
Trichlorofluoromethane	9.0E-05	3.3E-05	4.4E-02	4.4E-02	0.3%
Trichloromethane	2.1E-02	3.6E-03	------	2.5E-02	0.1%
Vinyl Chloride	------	------	------	0.0E+00	0.0%
Fluoride	------	------	------	0.0E+00	0.0%
Nitrate	------	------	------	0.0E+00	0.0%
Silver	------	------	------	0.0E+00	0.0%
Hazard Index	**4.1E-01**	**3.2E-01**	**1.6E+01**		
Relative Hazard Index	**2.5%**	**1.9%**	**95.6%**		

Overall Indoor Worker HI = 1.7E+01

Table V.41. Future Indoor Industrial Park Worker Scenario - Central Tendency Exposure - Noncarcinogenic Hazard Indices

Chemical	Ingestion	Dermal Contact	Inhalation	Total Hazard Quotient	Relative Hazard Quotient
1,1,1-Trichloroethane	3.3E-05	1.6E-05	4.2E-03	4.2E-03	0.0%
1,2-*cis*-Dichloroethene	5.3E-02	2.4E-03	------	5.5E-02	0.5%
1,2-*trans*-Dichloroethene	2.1E-04	6.5E-05	------	2.8E-04	0.0%
1,2-Dichloroethane	------	------	2.6E-01	2.6E-01	2.4%
1,2-Dichloroethene	------	------	------	0.0E+00	0.0%
2,3,7,8-TCDD	------	------	------	0.0E+00	0.0%
4-MethylPhenol	------	------	------	0.0E+00	0.0%
Aroclor-1248 (PCB)	------	------	------	0.0E+00	0.0%
Benzo(a)anthracene	------	------	------	0.0E+00	0.0%
Benzo(a)Pyrene	------	------	------	0.0E+00	0.0%
Benzo(b)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzo(k)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzoic Acid	------	------	------	0.0E+00	0.0%
Bis(2-ethylhexyl)phthalate	1.6E-04	8.5E-04	------	1.0E-03	0.0%
Chlordane (alpha)	3.3E-03	3.3E-02	------	3.7E-02	0.3%
Chrysene	------	------	------	0.0E+00	0.0%
Dichloromethane	------	------	8.0E-11	8.0E-11	0.0%
Diethyl Phthalate	5.8E-06	1.4E-06	------	7.1E-06	0.0%
Endosulfan (sulfate)	------	------	------	0.0E+00	0.0%
Fluoranthene	------	------	------	0.0E+00	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	------	0.0E+00	0.0%
Phenol	------	------	------	0.0E+00	0.0%
Pyrene	1.2E-04	2.4E-03	------	2.6E-03	0.0%
Tetrachloroethene	8.1E-02	1.3E-01	------	2.1E-01	2.0%
Tetrachloromethane	2.0E-02	1.4E-02	9.9E+00	9.9E+00	93.6%
Toluene	------	------	3.3E-10	3.3E-10	0.0%
Trichloroethene	4.8E-02	2.0E-02	------	6.8E-02	0.6%
Trichlorofluoromethane	4.7E-05	2.3E-05	2.8E-02	2.8E-02	0.3%
Trichloromethane	1.1E-02	2.4E-03	------	1.3E-02	0.1%
Vinyl Chloride	------	------	------	0.0E+00	0.0%
Fluoride	------	------	------	0.0E+00	0.0%
Nitrate	------	------	------	0.0E+00	0.0%
Silver	------	------	------	0.0E+00	0.0%
Hazard Index	**2.2E-01**	**2.1E-01**	**1.0E+01**		
Relative Hazard Index	**2.1%**	**1.9%**	**96.0%**		

Overall Indoor Worker HI = 1.1E+01

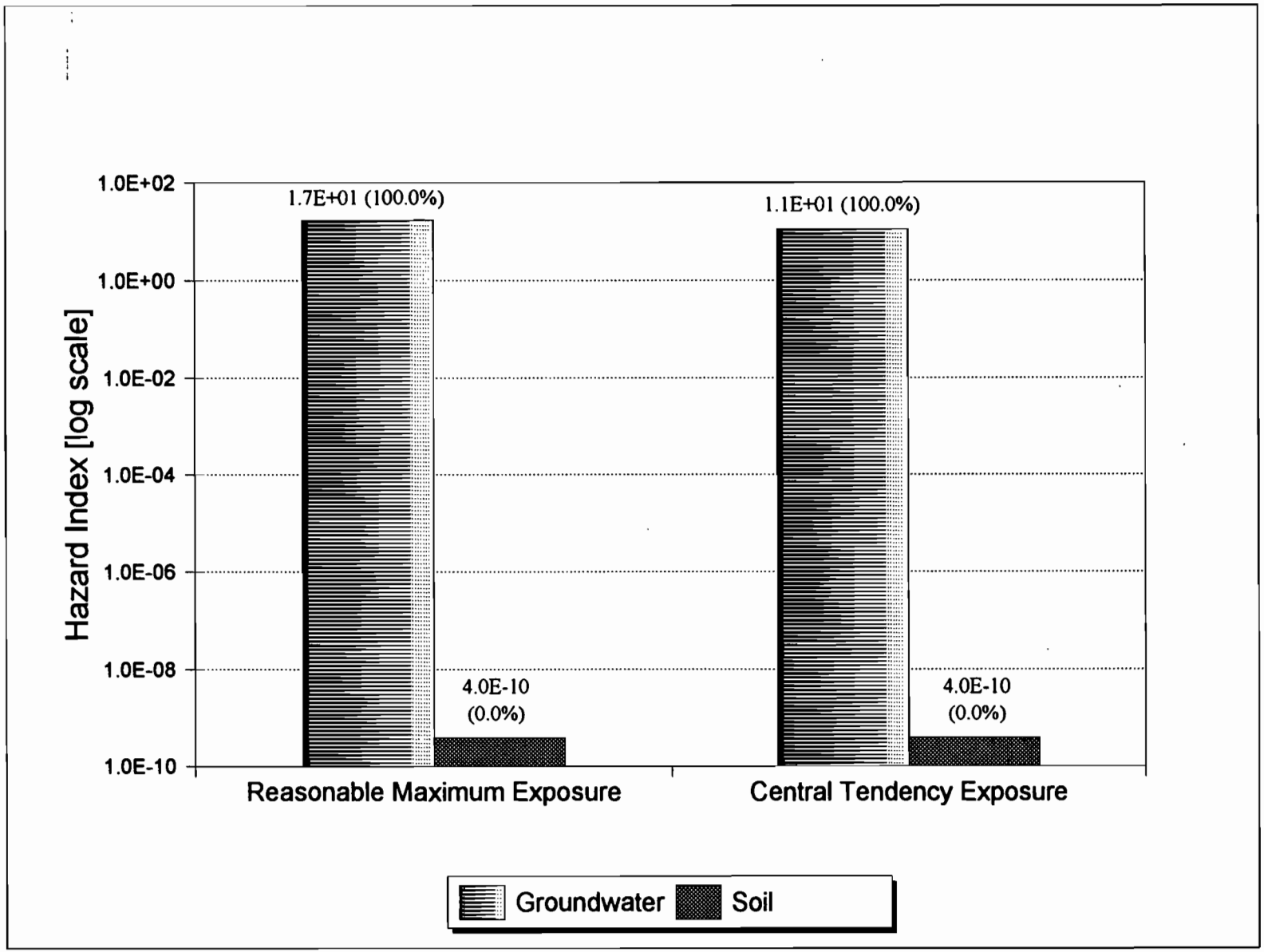

Figure 5.7. Hazard indices by medium - future industrial worker scenario (indoor).

Table V.42. Future Outdoor Industrial Park Worker Scenario - Reasonable Maximum Exposure - Noncarcinogenic Risks

Chemical	Ingestion	Dermal Contact	Inhalation	Total Hazard Quotient	Relative Hazard Quotient
1,1,1-Trichloroethane	6.4E-05	2.3E-05	5.9E-03	6.0E-03	0.0%
1,2-*cis*-Dichloroethene	1.0E-01	4.6E-03	------	1.0E-01	0.7%
1,2-*trans*-Dichloroethene	4.1E-04	1.0E-04	------	5.1E-04	0.0%
1,2-Dichloroethane	------	------	3.7E-01	3.7E-01	2.4%
1,2-Dichloroethene	4.9E-07	7.0E-06	------	7.5E-06	0.0%
2,3,7,8-TCDD	------	------	------	0.0E+00	0.0%
4-MethylPhenol	2.0E-05	1.2E-04	------	1.4E-04	0.0%
Aroclor-1248 (PCB)	------	------	------	0.0E+00	0.0%
Benzo(a)anthracene	------	------	------	0.0E+00	0.0%
Benzo(a)Pyrene	------	------	------	0.0E+00	0.0%
Benzo(b)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzo(k)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzoic Acid	1.4E-07	7.8E-07	------	9.1E-07	0.0%
Bis(2-ethylhexyl)phthalate	3.0E-04	1.3E-03	------	1.6E-03	0.0%
Chlordane (alpha)	6.5E-03	5.0E-02	------	5.7E-02	0.4%
Chrysene	------	------	------	0.0E+00	0.0%
Dichloromethane	6.0E-08	8.7E-07	1.3E-10	9.3E-07	0.0%
Diethyl Phthalate	1.1E-05	2.1E-06	------	1.3E-05	0.0%
Endosulfan (sulfate)	1.8E-07	2.5E-06	------	2.7E-06	0.0%
Fluoranthene	2.5E-06	1.5E-05	------	1.8E-05	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	------	0.0E+00	0.0%
Phenol	9.0E-08	5.2E-07	------	6.1E-07	0.0%
Pyrene	2.3E-04	3.7E-03	------	3.9E-03	0.0%
Tetrachloroethene	1.5E-01	2.0E-01	------	3.5E-01	2.3%
Tetrachloromethane	3.9E-02	2.1E-02	1.4E+01	1.4E+01	92.9%
Toluene	1.0E-08	1.5E-07	5.5E-10	1.6E-07	0.0%
Trichloroethene	9.2E-02	3.2E-02	------	1.2E-01	0.8%
Trichlorofluoromethane	9.0E-05	3.3E-05	4.0E-02	4.0E-02	0.3%
Trichloromethane	2.1E-02	3.6E-03	------	2.5E-02	0.2%
Vinyl Chloride	------	------	------	0.0E+00	0.0%
Fluoride	3.5E-05	2.0E-05	------	5.5E-05	0.0%
Nitrate	1.9E-06	1.1E-06	------	3.1E-06	0.0%
Silver	4.2E-04	2.4E-04	------	6.6E-04	0.0%
Hazard Index	**4.1E-01**	**3.2E-01**	**1.4E+01**		
Relative Hazard Index	**2.7%**	**2.1%**	**95.2%**		

Overall Outdoor Worker HI = 1.5E+01

Table V.43. Future Outdoor Industrial Park Worker Scenario - Central Tendency Exposure - Noncarcinogenic Risks

Chemical	Ingestion	Dermal Contact	Inhalation	Total Hazard Quotient	Relative Hazard Quotient
1,1,1-Trichloroethane	3.3E-05	1.6E-05	3.6E-03	3.7E-03	0.0%
1,2-*cis*-Dichloroethene	5.3E-02	2.4E-03	------	5.5E-02	0.6%
1,2-*trans*-Dichloroethene	2.1E-04	6.5E-05	------	2.8E-04	0.0%
1,2-Dichloroethane	------	------	2.2E-01	2.2E-01	2.4%
1,2-Dichloroethene	4.9E-07	1.4E-06	------	1.9E-06	0.0%
2,3,7,8-TCDD	------	------	------	0.0E+00	0.0%
4-MethylPhenol	2.0E-05	2.4E-05	------	4.4E-05	0.0%
Aroclor-1248 (PCB)	------	------	------	0.0E+00	0.0%
Benzo(a)anthracene	------	------	------	0.0E+00	0.0%
Benzo(a)Pyrene	------	------	------	0.0E+00	0.0%
Benzo(b)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzo(k)Fluoranthene	------	------	------	0.0E+00	0.0%
Benzoic Acid	1.4E-07	1.6E-07	------	2.9E-07	0.0%
Bis(2-ethylhexyl)phthalate	1.6E-04	8.6E-04	------	1.0E-03	0.0%
Chlordane (alpha)	3.3E-03	3.3E-02	------	3.7E-02	0.4%
Chrysene	------	------	------	0.0E+00	0.0%
Dichloromethane	6.0E-08	1.7E-07	1.3E-10	2.3E-07	0.0%
Diethyl Phthalate	5.8E-06	1.4E-06	------	7.1E-06	0.0%
Endosulfan (sulfate)	1.8E-07	5.2E-07	------	7.0E-07	0.0%
Fluoranthene	2.5E-06	3.0E-06	------	5.5E-06	0.0%
Indeno(1,2,3-cd)Pyrene	------	------	------	0.0E+00	0.0%
Phenol	9.0E-08	1.0E-07	------	1.9E-07	0.0%
Pyrene	1.2E-04	2.4E-03	------	2.6E-03	0.0%
Tetrachloroethene	8.1E-02	1.3E-01	------	2.1E-01	2.3%
Tetrachloromethane	2.0E-02	1.4E-02	8.5E+00	8.6E+00	93.1%
Toluene	1.0E-08	2.9E-08	5.5E-10	3.9E-08	0.0%
Trichloroethene	4.8E-02	2.0E-02	------	6.8E-02	0.7%
Trichlorofluoromethane	4.7E-05	2.3E-05	2.4E-02	2.4E-02	0.3%
Trichloromethane	1.1E-02	2.4E-03	------	1.3E-02	0.1%
Vinyl Chloride	------	------	------	0.0E+00	0.0%
Fluoride	3.5E-05	4.2E-06	------	3.9E-05	0.0%
Nitrate	1.9E-06	2.3E-07	------	2.2E-06	0.0%
Silver	4.2E-04	4.8E-05	------	4.7E-04	0.0%
Hazard Index	**2.2E-01**	**2.1E-01**	**8.8E+00**		
Relative Hazard Index	**2.4%**	**2.2%**	**95.4%**		

Overall Outdoor Worker HI = 9.2E+00

Figure 5.8 presents the overall noncarcinogenic HIs for each medium of concern. The groundwater COPC HIs contribute almost 100 percent of the noncarcinogenic risk. The soil COPC HIs were approximately 3 to 4 orders of magnitude less than unity.

5.6. UNCERTAINTY ANALYSIS

The primary objective of this risk assessment is to determine potential current and future risks to human health posed by soil and groundwater contamination resulting from previous operations at the Site. In assessing risk, as outlined by EPA guidelines, a number of conservative assumptions are made such that the relative risks calculated are likely to overstate the true (absolute) risk. Erring on the conservative side provides most effectively for safeguarding the public health and for emphasizing the most prominent sources of health risk that will influence the remedial process.

5.6.1. Chemicals of Potential Concern

A number of potential sources of error may arise in the data evaluation for COPCs. The sources of data uncertainty stem from the following:

- Uncertainties that stem from contaminants that were not detected in groundwater or soils. Replacing nondetect contaminant concentrations with a proxy concentration of one-half the quantitation limit can lead to overestimation or underestimation of the representative site concentrations (i.e., average contaminant concentration values). The actual concentration of an undetected contaminant could range anywhere from 0 to the sample detection limit.

- Uncertainties that stem from the blank contamination analyses. Contaminants that were qualified as nondetects as a result of blank contamination could either be present in the sample at significant concentrations or are nonexistent. The use of one-half the quantitation limit to characterize a contaminant concentration that was qualified as a nondetect (a result of the contaminant being detected in an associated blank) may lead to overestimation or underestimation of the representative site concentrations.

- Uncertainties associated with "J" or "UJ" qualified data. A concentration value qualified as "J" or "UJ" is an estimated value that results from either analytical QC aspects of the analysis and/or matrix interferences. Use of "J" and "UJ" qualified data in the risk assessment may lead to underestimation or overestimation of the representative site concentrations.

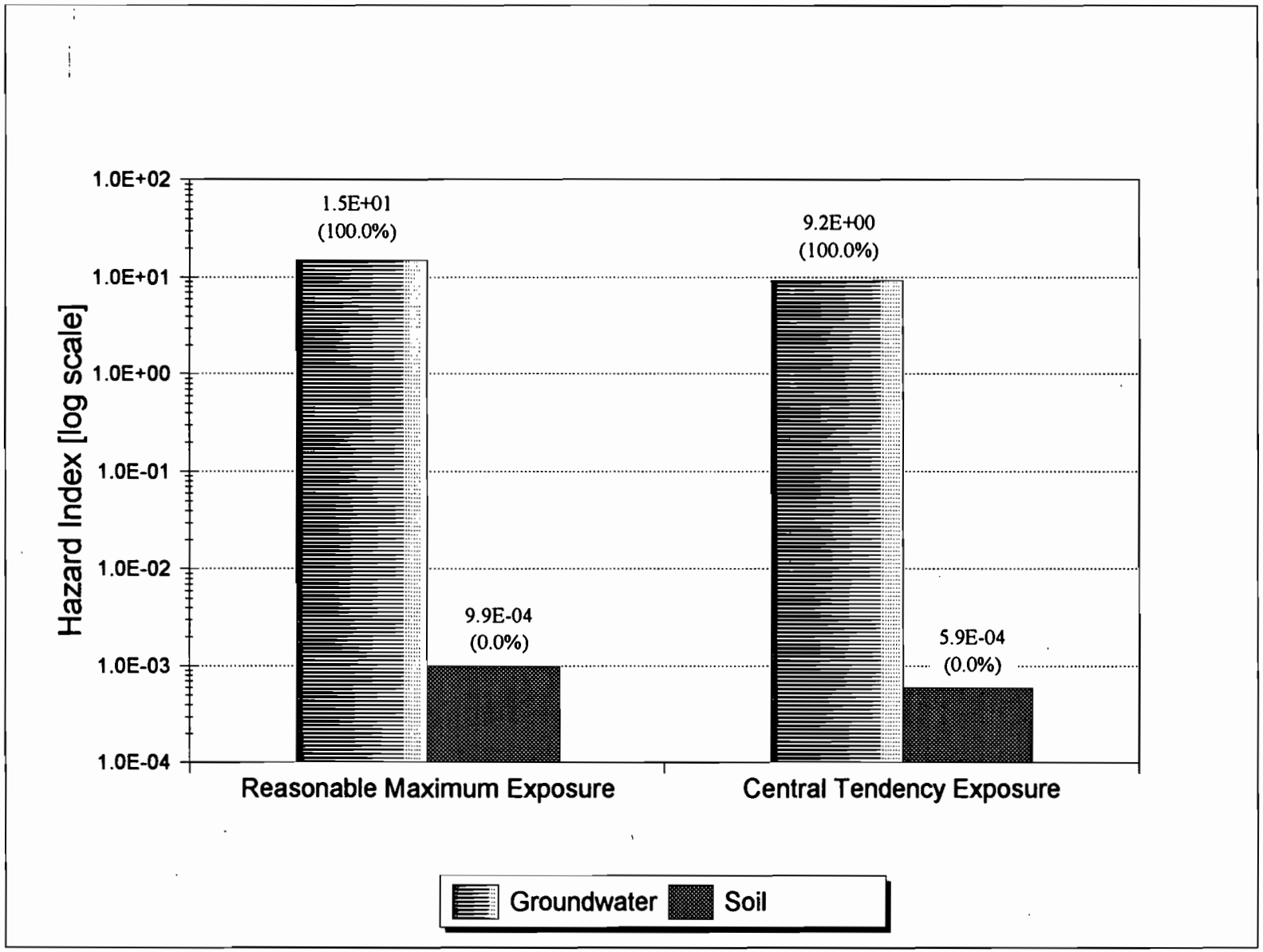

Figure 5.8. Hazard indices by medium - future industrial worker scenario (outdoor).

5.6.2. Exposure Assessment

A number of potential sources of error may arise in all phases of the exposure assessment. This section discusses some of the more significant uncertainty factors affecting the estimates of contaminant exposures. The following sources of uncertainty are:

- Uncertainties that stem from environmental sampling data. The uncertainties associated with sampling data may lead to either overestimation or underestimation of exposure.

- Uncertainties that arise in the estimation of exposure parameters. A number of the exposure parameters used to calculate intakes were intentionally overestimated to obtain an exposure estimate likely to be protective of health.

- Uncertainties that stem from assuming that the contaminant concentrations are normally distributed across the operable unit. Use of the 95 percent UCL of the arithmetic mean is likely to yield an overestimation of exposure.

- Use of groundwater concentrations for surface water characterization. The assumption that surface water areas within Area B are filled with groundwater could yield either overestimation or underestimation of exposure.

- Uncertainties associated with exposure parameters. Conservative parameters were used to obtain the RME in which at least 90 percent of actual exposures are expected to be lower. Average parameters were used to obtain the CTE in which at least 50 percent of actual exposures are expected to be lower. The RME overestimates exposure, while the CTE may overestimate or underestimate exposure.

- Uncertainties associated with fate and transport modeling assumptions. Soil-water partition coefficients, beef intake ratios, milk intake ratios, plant uptake factors, etc., can be highly variable due to the multiple factors affecting their characteristics in the natural environment. Uncertainties in these parameters could affect the exposures attributed to locally grown foodstuffs by a factor greater than 100.

- Use of present data to assess future exposures that could lead to overestimation or underestimation of exposure. Future exposures could be overestimated because some hazardous contaminants degrade to nonhazardous states. However, continued releases from contaminant sources could lead to higher exposures, which could result in underestimation of exposure. In addition, certain contaminants transform into more hazardous materials, which could increase the amount of exposure.

- Errors associated with radiological analyses of environmental samples could yield either overestimation or underestimation of exposure.

- Use of the maximum detected concentration in cases where the 95 percent UCL was higher may result in a bias toward higher or lower measured concentrations than is actually existing.

5.6.3. Toxicity Assessment

There are several uncertainties involved with the use of toxicity factors for defining site risks. The sources of toxicity uncertainty include;

- The extrapolation methods used in the development of the RfC and RfD by the EPA (extrapolation of high dose to low dose; extrapolation of animal data to humans) require uncertainty factors of up to 1,000 or greater to be incorporated into the calculation. A large margin of safety is thus built into the development of the RfD and RfC.

- The EPA model (linear, multistage) for developing carcinogenic slope factors overestimates cancer risk because the statistical 95 percent UCL for cancer risk produced by a lifetime exposure is used. Because of the difficulty in determining whether carcinogens have threshold doses, it is conservatively assumed that there are no thresholds, and that even a single molecule of a carcinogen can induce cancer.

- For dermal exposures, the calculated dermally absorbed dose is used in combination with the oral slope factor, which may lead to some underestimation of dermal risk.

5.6.4. Risk Characterization

Tables V.44 and V.45 present the range of potential carcinogenic and noncarcinogenic risks associated with Area B, respectively. The lower bound values represent CTE values, while the upperbound values represent RME values. These ranges provide an idea of the uncertainties associated with Area B risks and provide information on the sensitivity of each exposure scenario to the values of its numerical parameters.

5.7. SUMMARY

The risk assessment performed for Operable Unit 1, Area B has provided estimates of potential relative risk for the future farmer resident and for future worker exposure to groundwater and soils. The scenarios that were developed are conservative and hypothetical, and relative risks determined for these can be interpreted more accurately by considering the assumptions in the calculations.

For the future farmer resident RME, the total RME carcinogenic risks to the child and adult from all chemicals, radionuclides, and pathways are two and five excess cancers in 10,000 persons exposed, respectively. The combined overall RME adult and child risk may be of potential concern because it lies outside the upperbound value of the EPA target carcinogenic risk range of $1x10^{-6}$ to $1x10^{-4}$ (EPA 1988a). The majority of carcinogenic risk contribution is from PCE and trichloromethane.

Table V.44. Carcinogenic Risk Characterization Summary Table

Chemical	Carcinogenic Risk Range (Lowerbound Value = CTE; Upperbound Value = RME)		
	Future Farmer Resident (Adult + Child)	Future Indoor Industrial Park Worker	Future Outdoor Industrial Park Worker
Organic Chemicals			
1,2-dichloroethane	8E-07 - 3E-06	3E-07 - 2E-06	7E-08 - 4E-07
2,3,7,8-TCDD (Dioxins)	2E-06 - 8E-06	4E-22 - 2E-21	3E-07 - 2E-06
Aroclor-1248 (PCB)	7E-07 - 5E-06	------	9E-08 - 8E-07
Benzo(a)anthracene	1E-07 - 6E-07	3E-11 - 1E-10	2E-08 - 2E-07
Benzo(a)pyrene	2E-06 - 1E-05	3E-10 - 1E-09	2E-07 - 2E-06
Benzo(b)fluoranthene	2E-07 - 2E-06	4E-11 - 2E-10	2E-08 - 2E-07
Benzo(k)fluoranthene	9E-08 - 5E-07	2E-11 - 1E-10	1E-08 - 1E-07
Bis(2-ethylhexyl)phthalate	2E-07 - 1E-06	4E-08 - 2E-07	4E-08 - 2E-07
Chlordane (alpha)	3E-06 - 2E-05	9E-07 - 4E-06	4E-07 - 2E-06
Chrysene	1E-08 - 1E-07	3E-12 - 1E-11	2E-09 - 2E-08
Dichloromethane	8E-10 - 1E-08	3E-15 - 1E-14	1E-11 - 1E-10
Indeno(1,2,3-cd)pyrene	8E-08 - 4E-07	2E-11 - 9E-11	1E-08 - 1E-07
Tetrachloroethene ✓	6E-05 - 3E-04	2E-05 - 8E-05	1E-05 - 7E-05
Tetrachloromethane	5E-06 - 2E-05	2E-06 - 8E-06	6E-07 - 3E-06
Trichloroethene ✓	9E-06 - 4E-05	4E-06 - 2E-05	1E-06 - 5E-06
Trichloromethane ✓	4E-05 - 1E-04	2E-05 - 7E-05	2E-06 - 1E-05
Vinyl Chloride	2E-05 - 8E-05	6E-06 - 3E-05	2E-06 - 1E-05
Radionuclides			
Actinium-227	3E-06 - 2E-05	9E-07 - 5E-06	9E-07 - 5E-06
Plutonium-238	2E-06 - 7E-06	5E-07 - 2E-06	5E-07 - 2E-06
Plutonium-239/240	2E-06 - 1E-05	7E-07 - 4E-06	7E-07 - 4E-06
Strontium-90	2E-06 - 1E-05	4E-08 - 2E-07	4E-08 - 2E-07
Tritium	2E-06 - 1E-05	5E-07 - 3E-06	5E-07 - 3E-06
Uranium-235/236	7E-09 - 4E-08	2E-09 - 1E-08	2E-09 - 1E-08
Uranium-238	2E-07 - 8E-07	5E-08 - 2E-07	5E-08 - 2E-07

Table V.45. Noncarcinogenic Risk Characterization Summary Table

Chemical	Noncarcinogenic Hazard Index Range (Lowerbound Value = CTE, Upperbound Value = RME)		
	Future Farmer Resident (Adult + Child)	Future Indoor Industrial Park Worker	Future Outdoor Industrial Park Worker
Organic Chemicals			
1,1,1-Trichloroethane	8.8E-03 - 1.4E-02	4.2E-03 - 6.6E-03	3.7E-03 - 6.0E-03
1,2-*cis*-Dichloroethene	5.3E-01 - 1.1E+00	5.5E-02 - 1.0E-01	5.5E-02 - 1.0E-01
1,2-*trans*-Dichloroethene	2.4E-03 - 4.7E-03	2.8E-04 - 5.1E-04	2.8E-04 - 5.1E-04
1,2-Dichloroethane	5.2E-01 - 8.2E-01	2.6E-01 - 4.1E-01	2.2E-01 - 3.7E-01
1,2-Dichloroethene	2.3E-04 - 1.7E-03	------	1.9E-06 - 7.5E-06
4-Methylphenol	7.4E-03 - 5.2E-02	------	4.4E-05 - 1.4E-04
Benzoic Acid	1.5E-05 - 9.1E-05	------	2.9E-07 - 9.1E-07
Bis(2-ethylhexyl)phthalate	8.5E-03 - 3.3E-02	1.0E-03 - 1.5E-03	1.0E-03 - 1.6E-03
Chlordane (alpha)	2.3E-01 - 1.4E+00	3.7E-02 - 5.7E-02	3.7E-02 - 5.7E-02
Dichloromethane	3.1E-05 - 2.2E-04	8.0E-11 - 8.0E-11	2.3E-07 - 9.3E-07
Diethyl Phthalate	6.2E-05 - 1.3E-04	7.1E-06 - 1.3E-05	7.1E-06 - 1.3E-05
Endosulfan (sulfate)	1.3E-05 - 6.6E-05	------	7.0E-07 - 2.7E-06
Fluoranthene	1.6E-04 - 7.4E-04	------	5.5E-06 - 1.8E-05
Phenol	8.1E-05 - 6.0E-04	------	1.9E-07 - 6.1E-07
Pyrene	1.4E-02 - 3.5E-02	2.6E-03 - 3.9E-03	2.6E-03 - 3.9E-03
Tetrachloroethene	1.4E+00 - 3.0E+00	2.1E-01 - 3.5E-01	2.1E-01 - 3.5E-01
Tetrachloromethane	2.0E+01 - 3.1E+01	9.9E+00 - 1.5E+01	8.6E+00 - 1.4E+01
Toluene	3.3E-06 - 2.4E-05	3.3E-10 - 3.3E-10	3.9E-08 - 1.6E-07
Trichloroethene	5.6E-01 - 1.1E+00	6.8E-02 - 1.2E-01	6.8E-02 - 1.2E-01
Trichlorofluoromethane	5.7E-02 - 8.9E-02	2.8E-02 - 4.4E-02	2.4E-02 - 4.0E-02
Trichloromethane	1.2E-01 - 2.4E-01	1.3E-02 - 2.5E-02	1.3E-02 - 2.5E-02
Inorganic Elements/Chemicals			
Fluoride	1.0E-03 - 1.1E-03	------	3.9E-05 - 5.5E-05
Nitrate	5.5E-05 - 5.8E-05	------	2.2E-06 - 3.1E-06
Silver	1.2E-02 - 1.2E-02	------	4.7E-04 - 6.5E-04

Radium-226 and thorium-228 were the only daughter product radionuclides with RME carcinogenic risks that exceed $1x10^{-6}$ for the future farmer resident. The RME carcinogenic risk for thorium-228 was found to be $1x10^{-4}$ in soil, which is higher than the risks for all other chemicals and radionuclides detected in soil. However, thorium-228 was detected at concentration levels equivalent to background.

HIs that exceed unity indicate that the chemical may cause adverse health effects to exposed individuals. As a rule, the greater a chemical HI exceeds unity, the greater the level of potential concern (EPA 1989a). For the future onsite resident scenario, tetrachloromethane and PCE pose the most significant noncarcinogenic risks, with overall RME HIs 3 to 31 times greater than unity. Since the sum of all COPC RME and CTE HIs are 24 to 39 times greater than unity, exposure to all COPCs could produce adverse health effects for the potential future residential farmer.

For the future indoor industrial park worker, the overall probability of cancer occurrence was two excess cancers in 10,000 persons exposed and five excess cancers in 100,000 persons exposed for the RME and CTE, respectively. PCE, chlordane (alpha), 1,2-dichloroethane, tetrachloromethane, trichloromethane, vinyl chloride, TCE, actinium-227, plutonium-238, plutonium-239/240, and tritium had RME risk levels exceeding $1x10^{-6}$. The majority of carcinogenic risk contribution is from PCE and trichloromethane. The overall indoor worker RME risk may be of potential concern because it exceeds the EPA target risk range of $1x10^{-6}$ to $1x10^{-4}$ (EPA 1988a).

For the future outdoor industrial park worker, the overall probability of cancer occurrence was one excess cancer in 10,000 persons exposed and two excess cancers in 100,000 persons exposed for the RME and CTE, respectively. Tetrachloroethene contributes more than half of the carcinogenic risk. The overall outdoor worker RME risk may be of potential concern because it lies at the upperbound limit of the EPA target risk range.

Thorium-228 was the only daughter product radionuclide with RME and CTE carcinogenic risks that exceed $1x10^{-6}$ for both the future indoor and outdoor workers. The future indoor and outdoor worker RME carcinogenic risks for thorium-228 were both found to be $2x10^{-5}$ in soil; these risk levels are significantly higher than the risks for all other chemicals and radionuclides detected in soil. However, thorium-228 was detected at concentration levels equivalent to background.

Tetrachloromethane is the only COPC that had RME and CTE HIs exceeding unity for both the future indoor and outdoor industrial park worker scenarios. Without tetrachloromethane, the overall RME and CTE HIs are approximately equal to or less than unity for the future indoor and outdoor workers. The potential health effects associated with tetrachloromethane are discussed in Appendix J.

The risks to future indoor and outdoor workers are based on chemical and radionuclide concentrations in groundwater and soil within and directly adjacent to the sanitary landfill in Area B. The future worker scenarios assume that exposures take place within Area B and that the drinking and domestic water supply is exclusively from Area B.

This assessment does not apply to current Mound Plant workers. At the present time, Mound Plant workers are not exposed to Area B COPCs for the following reasons:

- Mound Plant workers are being supplied water from production wells that are not within or directly adjacent to Area B. In addition, the production wells that supply water to Mound Plant employees meet all federal and state drinking water standards. Production wells that do not meet these standards are not used by Mound Plant.

- Access to Area B is restricted. In addition, appropriate health and safety measures are adhered to when personnel are at the Area B site. These measures are utilized to assure that potential exposures to Area B COPCs are minimized.

Based on the results presented in Figures 5.3 through 5.8, it is clearly evident that the groundwater COPCs would contribute most of the carcinogenic and noncarcinogenic risks to hypothetical future onsite residents and workers. The differences between groundwater and soil COPC risks approximately equal or exceed an order of magnitude. The highest soil risk was $2x10^{-5}$ for the future farmer resident RME scenario (excluding thorium-228). However, this risk level lies within the EPA target risk range (EPA 1988a) and is an order of magnitude less than the overall groundwater risk. If remediation of Operable Unit 1, Area B is deemed necessary, groundwater would be the focus of the remedial efforts to significantly reduce the overall level of risk to potential future workers and residents.

The COCs to focus remedial action efforts are defined as COPCs that either have risks that exceed the minimum acceptable levels or risks that provide a significant contribution to the overall risk in any one of the exposure scenarios. A COPC is considered to provide a significant contribution to the overall risk if its hazard index exceeds 0.1 or its carcinogenic risk exceeds $1x10^{-6}$. Based on these criteria, the COCs delineated by the Operable Unit 1, Area B risk assessment for the resident scenario are the following.

For groundwater:

- 1,2-dichloroethane
- 1,2-*cis*-DCE
- benzo(b)fluoranthene
- chlordane (alpha)
- PCE

- tetrachloromethane
- TCE
- trichloromethane
- vinyl chloride
- actinium-227
- plutonium-238
- plutonium-239/240, and
- radium-226
- tritium.

For soil:

- 2,3,7,8-TCDD (dioxins)
- aroclor-1248 (PCB)
- benzo(a)pyrene
- plutonium-238, and
- strontium-90.

Thorium-228 was not selected as a COC in soil because it was determined that its presence is not attributable to any actions that took place on the site. Thorium-228 was selected as a COPC because it is a daughter product of plutonium-240. Plutonium-240 has a long half-life (6,569 years) and has only been present on this planet for approximately 70 years (plutonium is an anthropogenic radionuclide). Using standard decay equations, the contribution of thorium-228 from plutonium-240 decay in soil was computed. It was assumed that the plutonium has existed in site soils for 70 years at a concentration of 0.237 pCi/g (maximum detected concentration).

The maximum concentration of thorium-228 in soil from plutonium-240 decay was found to be 6×10^{-16} pCi/g. This is approximately 15 orders of magnitude less than the thorium-228 site concentration mean. This clearly indicates that the plutonium-240 contribution to the thorium-228 levels at the site is insignificant. As a result, thorium-228 was not considered as a site COC.

This baseline risk assessment is considered to be conservative and presents the RME and CTE scenarios in the absence of any remedial action. The general conclusion of the baseline risk assessment is that the contamination measured within Operable Unit 1, Area B may represent a significant risk to future hypothetical workers or residents at the Site.

6. FINDINGS AND CONCLUSIONS

The data presented in the preceding sections can be summarized and simplified to provide succinct descriptions of the site conditions within Operable Unit 1. Further, overall conclusions concerning contaminant occurrence and movement can be made on the basis of the RI data available.

6.1. WASTE OCCURRENCE

The former waste disposal sites within area B (the historic landfill and associated features) are concentrated within, beneath, and immediately adjacent to the current site sanitary landfill. These waste disposal sites are the result of a long history of dumping, burning, moving, reworking, burying, and partial removal and placement into the engineered structure - the site sanitary landfill. At the present time, the area bounded by the overflow pond to the north, the paved roads to the west and south, and the bunker area to the east can be considered as a single entity. It is internally heterogeneous and not all portions are contaminated, but subdividing it does not increase understanding of the transport phenomena that are occurring, nor does it facilitate the development of remedial alternatives for the area.

6.2. SURFACE WATER FEATURES

The northern part of Area B is dominated by the overflow pond, which is part of the stormwater retention and discharge system. Except for the extreme southwestern portion, all surface runoff from Area B is directed through the overflow pond. As discussed in Section 4, while the overflow pond may have been a source of recharge to the Buried Valley aquifer in the past (through the annulus of the casing of well 0055), it is apparently no longer so. The chemical and radiological nature of the overflow pond contents are not well known. The available data suggest that pond contents are not a concentrated contaminant source. The overflow pond will be further studied as part of the site-wide RI, as will any other surface water runoff from Area B.

6.3. GEOLOGIC SETTING

As shown on the fence diagram, Plate B, Area B is partially located on a buried bedrock shelf that drops off to the west, north, and south. The surface of the bedrock is a pre-glacial erosional surface. As described in the borings within Area B that encounter the bedrock, the surface is weathered but grades rapidly into competent material.

The bedrock section subjacent to Area B is dominated by shale, with a significant limestone-bearing portion (truncated by erosion) immediately beneath the site sanitary landfill. As revealed in the log of site-wide RI boring 0352, the next nearest (vertically) significant limestone portion is approximately 30 ft lower in the section and does not intersect the bedrock interface until some distance to the west of Area B.

The bedrock is overlain by glacial outwash materials, glacial till, and artificial fill. The outwash materials that contain the Buried Valley aquifer thin eastward against the margin of the buried valley, which is located beneath the western edge of Area B, adjacent to the waste disposal areas (site sanitary landfill and historic landfill). Only the western portion of the site sanitary landfill overlies the Buried Valley aquifer. The eastern portion overlies the bedrock shelf. To the north, these outwash materials extend up the plant tributary valley, as shown on cross section A-A[7].

The portion of the Buried Valley aquifer immediately adjacent to Area B (to the west) varies from 0 to 40 ft in thickness and is relatively free of fine-grained till layers within the outwash. The aquifer is not composed of an upper and lower unit, as had been supposed in the past. Typical transmissivities are between 30,000 and 50,000 ft^2/day.

6.4. HYDROLOGIC SETTING

Groundwater primarily occurs in the outwash sediments of the Buried Valley aquifer or in its extension up the plant tributary valley. Within the tributary valley, gradients are steep, governed by topography and the thickness of the unconsolidated zone; flow is to the west-southwest, along the axis of the valley. In the main part of the Buried Valley aquifer, to the west of Area B, gradients are nearly flat; flow is to the west and south, governed by the interrelationships among recharge, river stage, and the pumping of the Mound Plant production wells. In the immediate vicinity of Area B, flow is governed by the plant production wells.

The predominant water type, independent of formation of completion, is calcium bicarbonate, reflecting a common groundwater source - the Buried Valley aquifer. Only wells 0309 and 0123 departed from this pattern to display a sodium-potassium chloride water type. Well 0309 may be connected to a bedrock fracture system, as indicated by the high storage coefficient derived from the aquifer test analyses. No explanation is known for the anomalous water type at well 0123.

The direction of migration for surface contamination from Area B is along bedrock and topographic highs from east to west. Within the soils, the direction of migration would first be downward through the vadose zone until groundwater, fractures, bedding planes, or lower permeability units are

encountered. At that time, the migration direction would be in the direction of groundwater flow or laterally along the discontinuity. Within the groundwater system, the direction of movement for dissolved components will be with the groundwater. In Area B, the groundwater flow direction is west from the tributary valley, the area of the overflow pond, the site sanitary landfill, and the SM/PP Hill. Once within the main portion of the Buried Valley aquifer, the direction of movement will be to the south and southwest.

The waste materials and contaminated soils within Area B are partially isolated from the hydrologic environment. Much of the surface is engineered to provide rapid runoff and, therefore, low recharge rates. The materials immediately below the waste disposal area are predominantly fine-grained, retarding groundwater movement. The water table is at or below the bedrock interface in this area, so the unconsolidated materials are also in the vadose zone, decreasing migration potential. However, during periods of high seasonal groundwater (or enhanced recharge through the site), some of the waste materials or contaminated soils are exposed to groundwater.

6.5. CONTAMINANT OCCURRENCE

6.5.1. Soils

Examination of the areal extent of the VOC contamination in the soils in Area B shows that it is restricted to the area of past disposal activity with no discernible source. The majority of the concentration detections occur at a depth of less than 20 ft and are limited in areal extent.

The only discernible pattern in the metals and radionuclide contamination was that all detections are in the area of the site sanitary landfill or along the drainage ditches.

The only discernible pattern for all the compounds detected during the surficial and subsurface soil sampling appear to be directly related to activities in and around the site sanitary landfill. There does not appear to be a major source of any of the contaminants detected, but rather a random pattern of dispersed contamination that occurred from reworking and transport of sediments.

6.5.2. Groundwater

Groundwater quality data indicate the following:

- VOCs present with validated detections include 1,1,1-TCA, 1,1,2,2-tetrachloroethane, 1,1,-DCE, 1,2,-*cis*-DCE, 1,2-*trans*-DCE, 1,2-DCE (total), bromodichloromethane, vinyl chloride (chloroethene), dichloromethane, dibromochloromethane, PCE, tetrachloromethane, total xylenes, trichlorethene, trichloromethane, freon-113, and trichlorofluoromethane.

- For the period December 1991 through March 1993, PCE, TCE, 1,2-*cis*-DCE, vinyl chloride, and trichloromethane were detected above present or proposed regulatory limits.

- Metals present with validated detections include aluminum, antimony, arsenic, barium, cadmium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, vanadium, and zinc.

- For the period December 1991 through March 1993, chromium, and nickel were detected above primary MCLs. Aluminum, iron, and manganese were detected above secondary MCLs.

Only TCE and 1,1,1-TCA show concentrations offsite. These are generally less than 1 μg/L and appear to vary seasonally. There is no consistent trend in concentrations with time in wells in the area. There also appears to be little trend in contamination with depth. Thus, the data do not show a discernible pattern or a particular area where a potential source might exist, although the detections appear to be concentrated in the area of the site sanitary landfill and the assumed location of the historic landfill.

6.5.3. Rate and Direction of Migration

Flow velocities (migration rates) for representative contaminants were calculated for the Buried Valley aquifer in the vicinity of Area B, assuming a uniform aquifer seepage velocity of 200 ft/yr. Contaminants were chosen to illustrate a range of possible effects of retardation. Dichloroethene is retarded the least, with a possible velocity of 50 ft/yr. Dioxins are retarded the most (4.9×10^{-4} ft/yr); trichloromethane and TCE fall between the two (41 and 20 ft/yr, respectively). However, all VOCs tend to remain in the groundwater and not partition appreciably back onto the soil. Thus, once in the groundwater system, they would tend to move with the groundwater and not at the retarded velocities shown here. Tritium is also expected to move at the same velocity as the groundwater; plutonium is not expected to move from contaminated soils.

As described above, once a contaminant reaches the Buried Valley aquifer, it has the potential to move offsite quickly. However, these velocities assume there is no pumping within the Buried Valley aquifer. The pumping at well 0076 for the Mound Plant water supply creates a capture zone for at least a portion of the VOC contamination within the Buried Valley aquifer.

6.6. EXPOSURE POINT

The most immediate point of exposure for contaminants originating in Area B also lies within the confines of Operable Unit 1—the system of plant production wells. Production Well 1 (0071) has been taken off-line because of increasing levels of VOCs in the discharge water. Production well 3 (0076)

is now the primary source of process and potable water for the plant. Well 2 (0271) is pumped, as required, to provide a supplemental source of plant water.

6.7. RISK ASSESSMENT

The baseline risk assessment for Area B, Operable Unit 1, addresses future public health risks that may exist, assuming that no remedial actions will be performed. Therefore, the assessment serves as a baseline case that can be used to compare the relative effectiveness of alternative remedial strategies in reducing public health risks. This baseline risk assessment focuses on exposure of future residents and site workers to soil and groundwater contamination. Any risk associated with a selected remedial action, such as landfill excavation, is not addressed as part of the baseline risk assessment, but will be addressed under adverse impacts in the feasibility study.

Future Resident Farmer

For the future resident farmer RME scenario, carcinogenic risks to the child and adult from all contaminants and pathways are 2×10^{-4} and 5×10^{-4}, respectively. Ingestion and inhalation contribute to most (85 percent) of the carcinogenic risk. Tetrachloroethene had the highest overall RME risk of 3×10^{-4}.

For the future resident farmer CTE scenario, the overall risks to the child and adult are 4×10^{-5} and 1×10^{-4} respectively. Tetrachloroethene had the highest overall CTE risk of 6×10^{-5}.

The overall groundwater carcinogenic risks to the resident farmer were 5×10^{-4} and 1×10^{-4} for the RME and CTE, respectively. The overall risks (RME and CTE) posed by soil COCs were more than an order of magnitude less than those for groundwater.

For the future resident farmer scenario, the noncarcinogenic RME HIs for the child and adult are 21 and 18, respectively. The CTE HIs are 12 for the child and 11 for the adult. Inhalation of COCs contributes approximately 80 percent of the overall noncarcinogenic risk. Groundwater COCs contribute virtually all of the noncarcinogenic risk (greater than 99 percent). The soil RME and CTE HIs are 2 orders of magnitude less than unity.

Future Indoor Industrial Worker

For the future indoor industrial park worker scenario, the overall RME and CTE carcinogenic risks were 2×10^{-4} and 5×10^{-5}, respectively. The inhalation and ingestion pathways contribute approximately

80 percent of the risk. Tetrachloroethene had the highest RME risk of 8×10^{-5} and CTE risk of 2×10^{-5}.

Groundwater COCs contribute virtually all of the carcinogenic risk (greater than 99 percent) to the future indoor industrial worker. The soil RME and CTE risk levels are less than the lower-bound value of the EPA target risk range.

For the future indoor industrial park worker scenario, the overall RME and CTE HIs were 17 and 11, respectively. Inhalation of COCs contributes approximately 96 percent of the overall noncarcinogenic risk. Tetrachloromethane had the highest RME and CTE HIs of approximately 15 and 10, respectively. The groundwater HIs contribute almost 100 percent of the noncarcinogenic risk. The soil HIs were approximately 10 orders of magnitude less than unity.

Future Outdoor Industrial Worker

For the future outdoor industrial park worker, the overall RME and CTE carcinogenic risks were 1×10^{-4} and 2×10^{-5}, respectively. Ingestion and dermal contact contribute approximately 83 percent of the carcinogenic risk. Tetrachloroethene had the highest RME risk of 7×10^{-5}. Tetrachloroethene, trichloromethane, and vinyl chloride are the only contaminants with CTE carcinogenic risks exceeding 1×10^{-6}. Groundwater COCs contribute approximately 95 percent of the overall RME and CTE carcinogenic risks.

For the future outdoor industrial park worker, the overall RME and CTE HIs were 15 and 9, respectively. The inhalation pathway contributes approximately 95 percent of the overall noncarcinogenic risk. Tetrachloromethane had the highest RME and CTE HIs of approximately 14 and 9, respectively. Groundwater contributes almost 100 percent of the overall noncarcinogenic risks.

It is evident that the groundwater COCs would contribute most of the carcinogenic and noncarcinogenic risks to future onsite residents and workers. If remediation of Operable Unit 1, Area B is deemed necessary, groundwater must be the focus of the remedial efforts to significantly reduce the overall level of risk.

The baseline risk assessment is considered conservative and presents the RME and CTE scenarios in the absence of any remedial action. The general conclusion of the baseline risk assessment is that the contamination measured within Operable Unit 1, Area B may represent a significant risk to future hypothetical workers or residents on the site.

7. RECOMMENDATIONS

Recommendations of this RI Report are:

1. The RI data relative to Operable Unit 1 are sufficiently complete to develop a FS and select a remedy. Preparation of the FS, including such additional work as is required to design the remedy, is recommended.

2. Although the data are sufficient, they should be augmented by two sets of data that are currently unavailable and that are in preparation or planned:

   - Validated background soil and groundwater quality data.
   - Validated surface water and sediment quality data for the overflow pond.

   The measured contaminant concentrations in soil and groundwater were evaluated against available data to determine anticipated levels of concern and will be re-evaluated once validated background soil and groundwater data are made available through the site-wide study. It is anticipated that the conclusions so revisited will not change in any great degree. These background data are expected to be available before the FS process is completed. If the data are not available, the Mound Plant FFA includes two ways to re-evaluate conclusions:

   - Section XVII. Five Year Review: In accordance with Section 121(c) of CERCLA, EPA and OEPA will review any remedial action on a 5-year basis. If the regulatory agencies determine that additional action or modification of the remedial action is appropriate in accordance with Section 104 or 106 of CERCLA/Superfund Amendments Reauthorization Act of 1986 (SARA), DOE will be required to implement the action.
   - Section XIII. Additional Work or Modification to Work. If either DOE, EPA or OEPA becomes aware of a need for additional work, the party will notify the others and DOE will propose and implement the additional work.

   An investigation of surface water and sediment is planned as a part of Operable Unit 9 and will include characterization of the Overflow Pond. At such time as the data are available, the environmental and human health effects of the overflow pond and the adjacent portions of the stormwater retention and discharge system (the plant drainage ditch and the retention basins) should be evaluated. This evaluation need not be a part of the Operable Unit 1 study, because the surface water can be considered separately from all contaminant sources within Area B.

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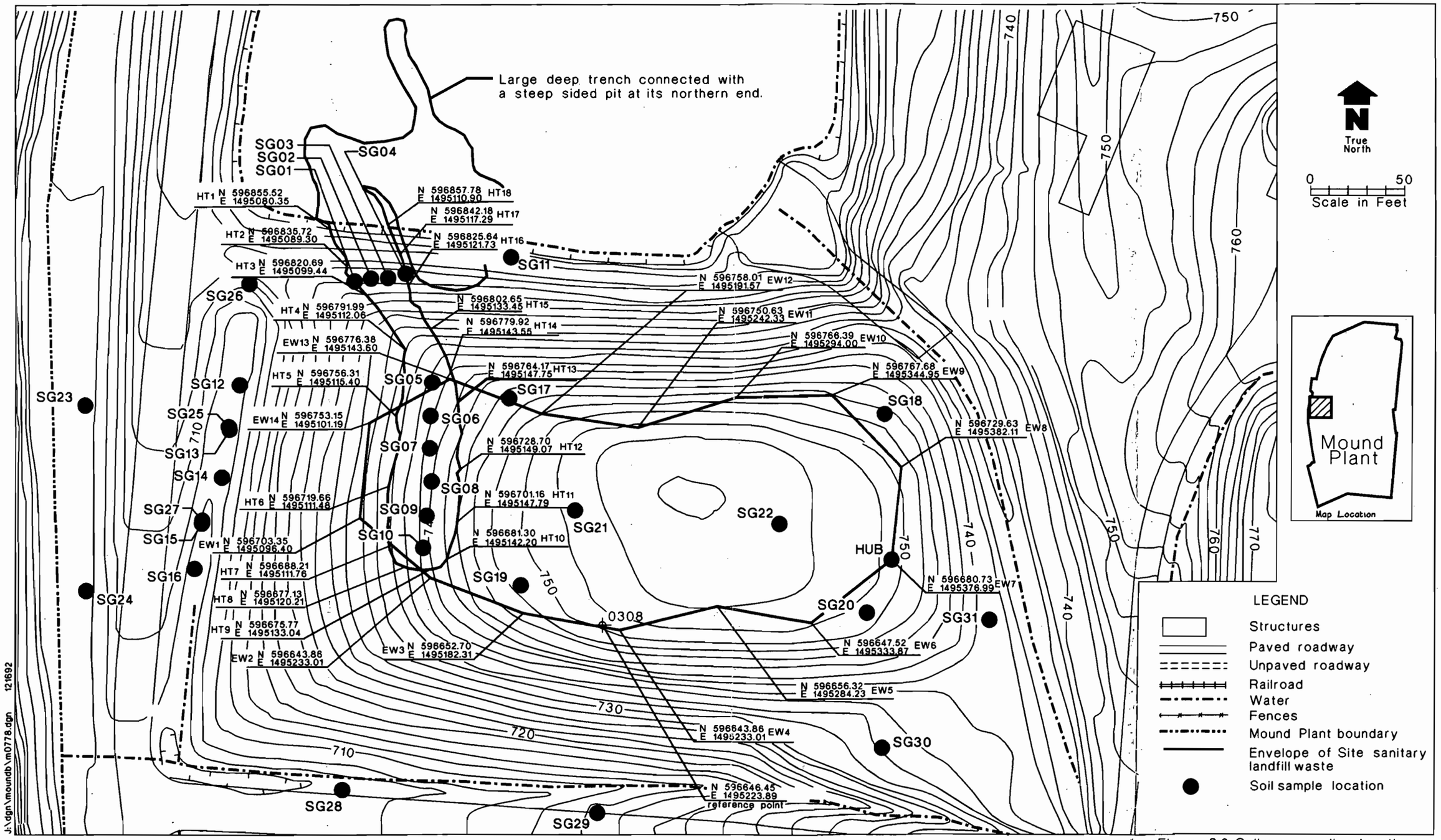

Figure 3.2. Soil gas sampling locations.

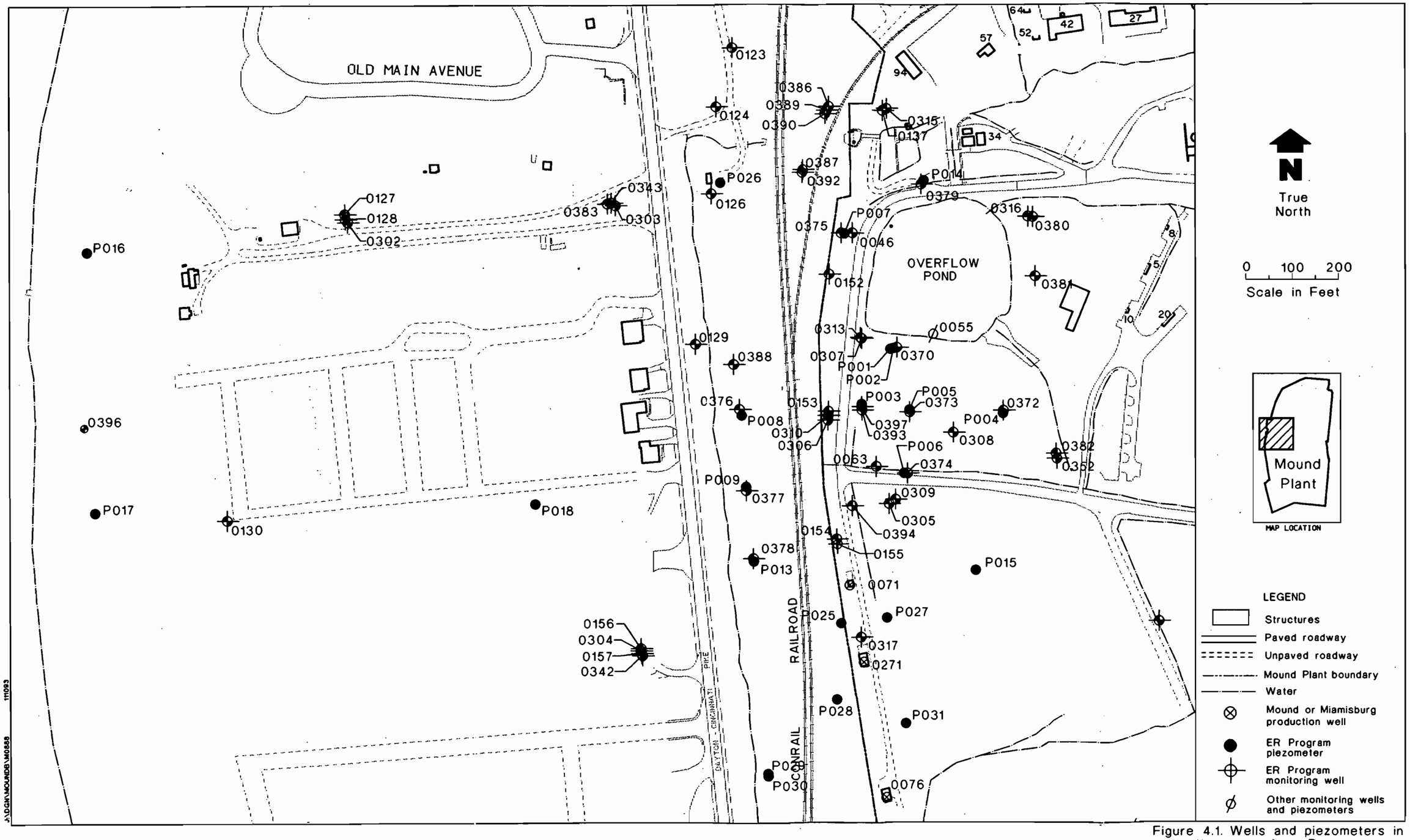

Figure 4.1. Wells and piezometers in and adjacent to Area B.

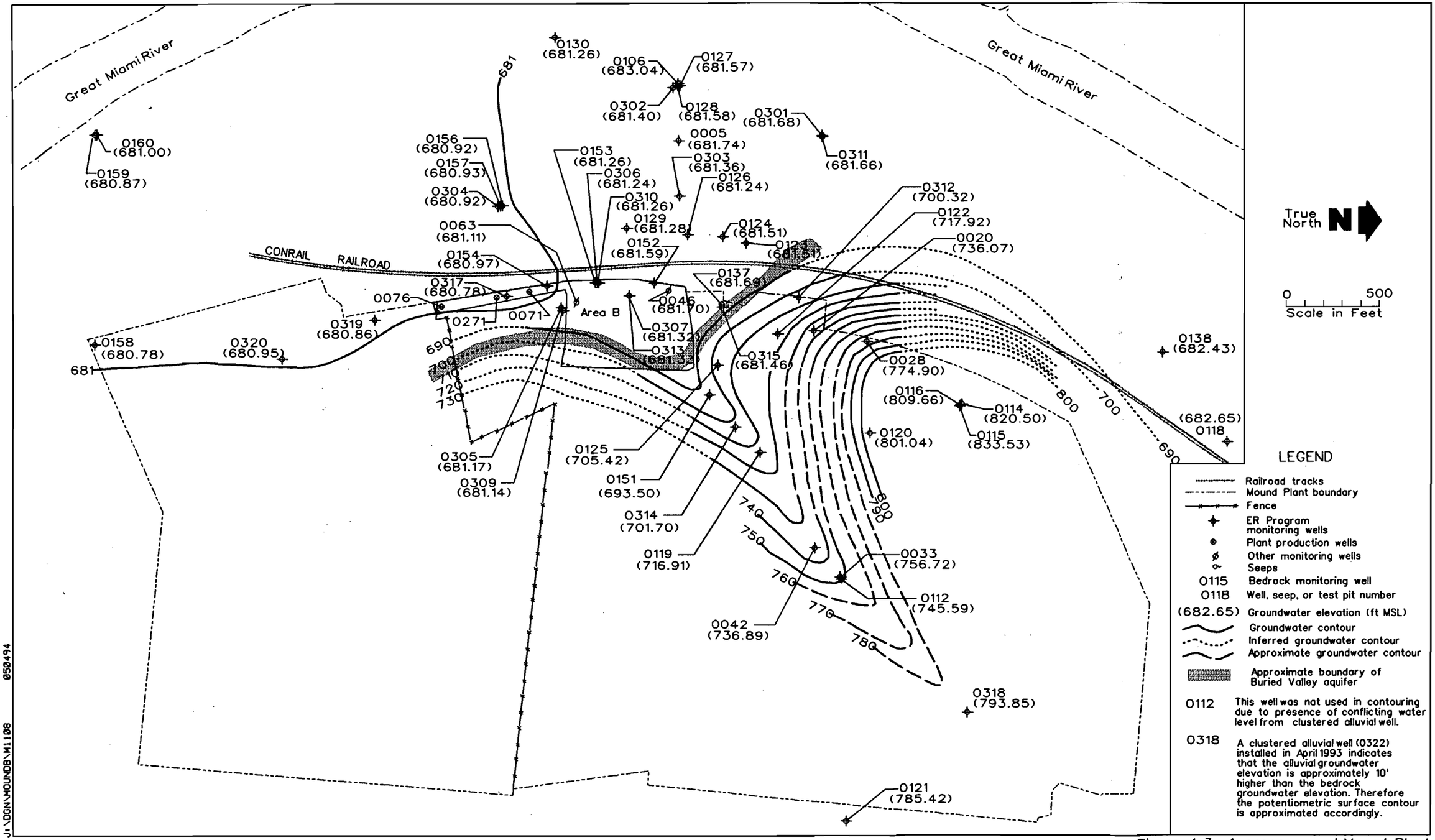

Figure 4.3. Average annual Mound Plant groundwater elevation, June 1992 to March 1993.

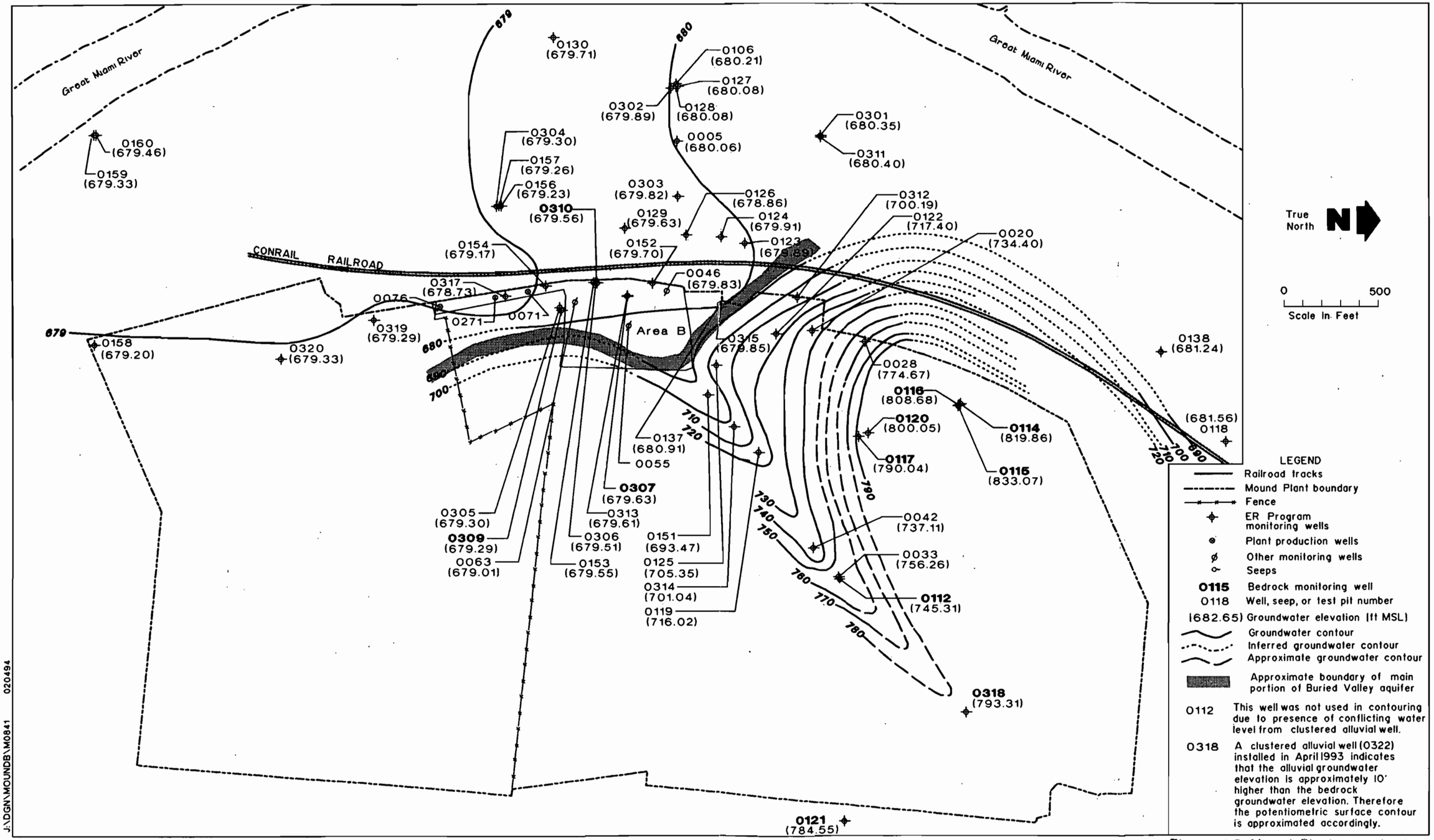

Figure 4.5. Mound Plant groundwater elevation, June 1992.

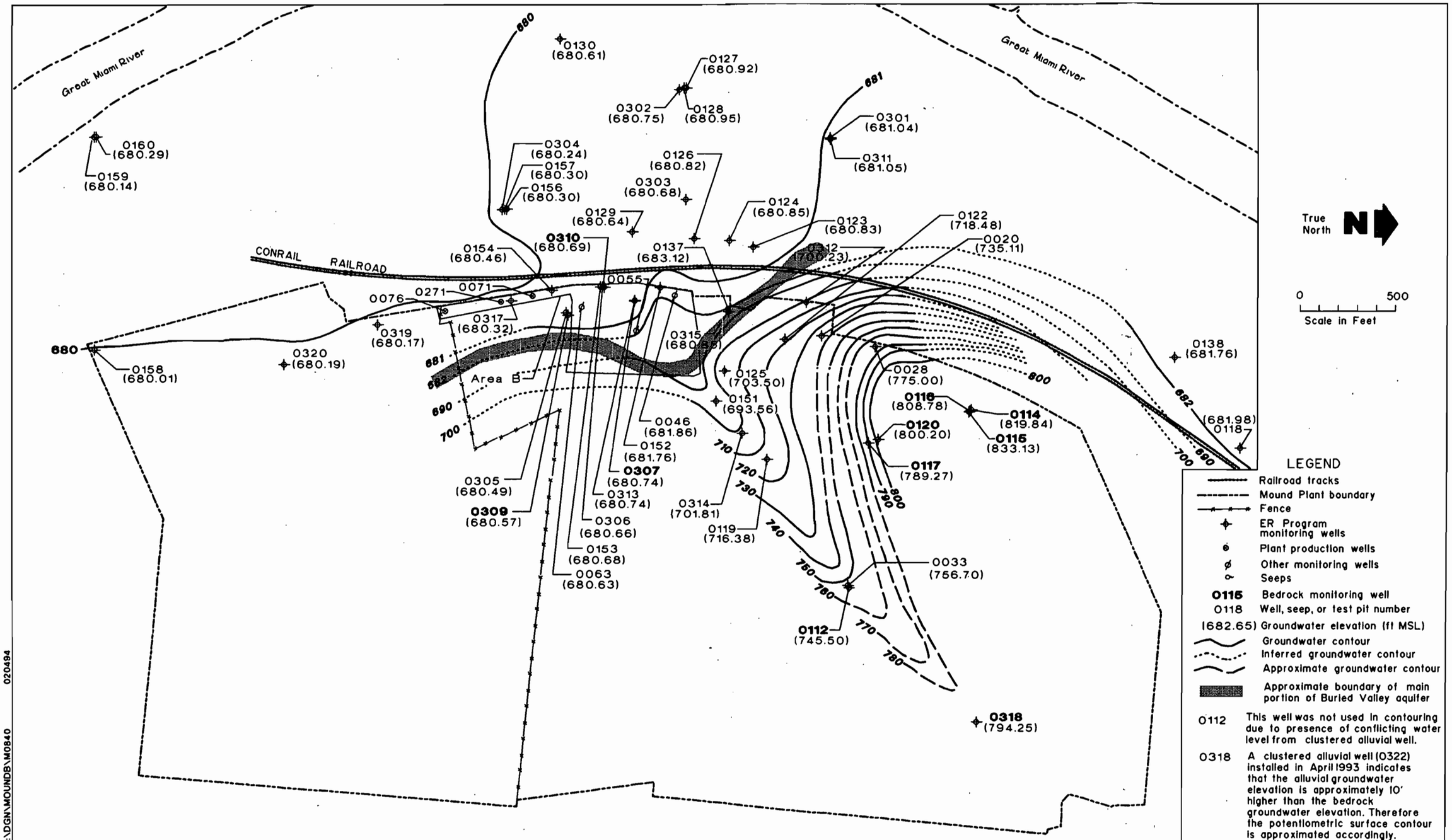

Figure 4.6. Mound Plant groundwater elevation, September 1992.

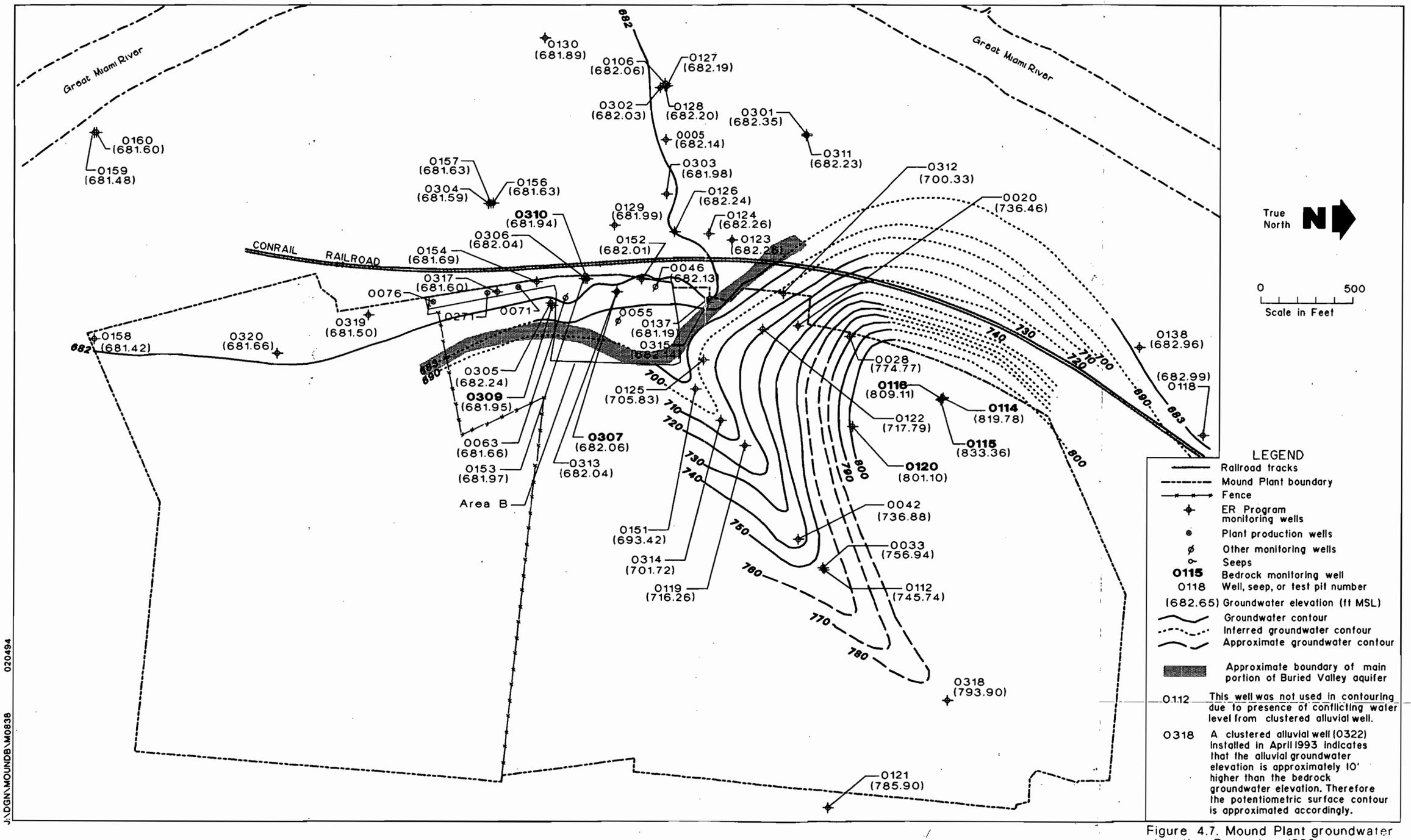

Figure 4.7. Mound Plant groundwater elevation, December 1992.

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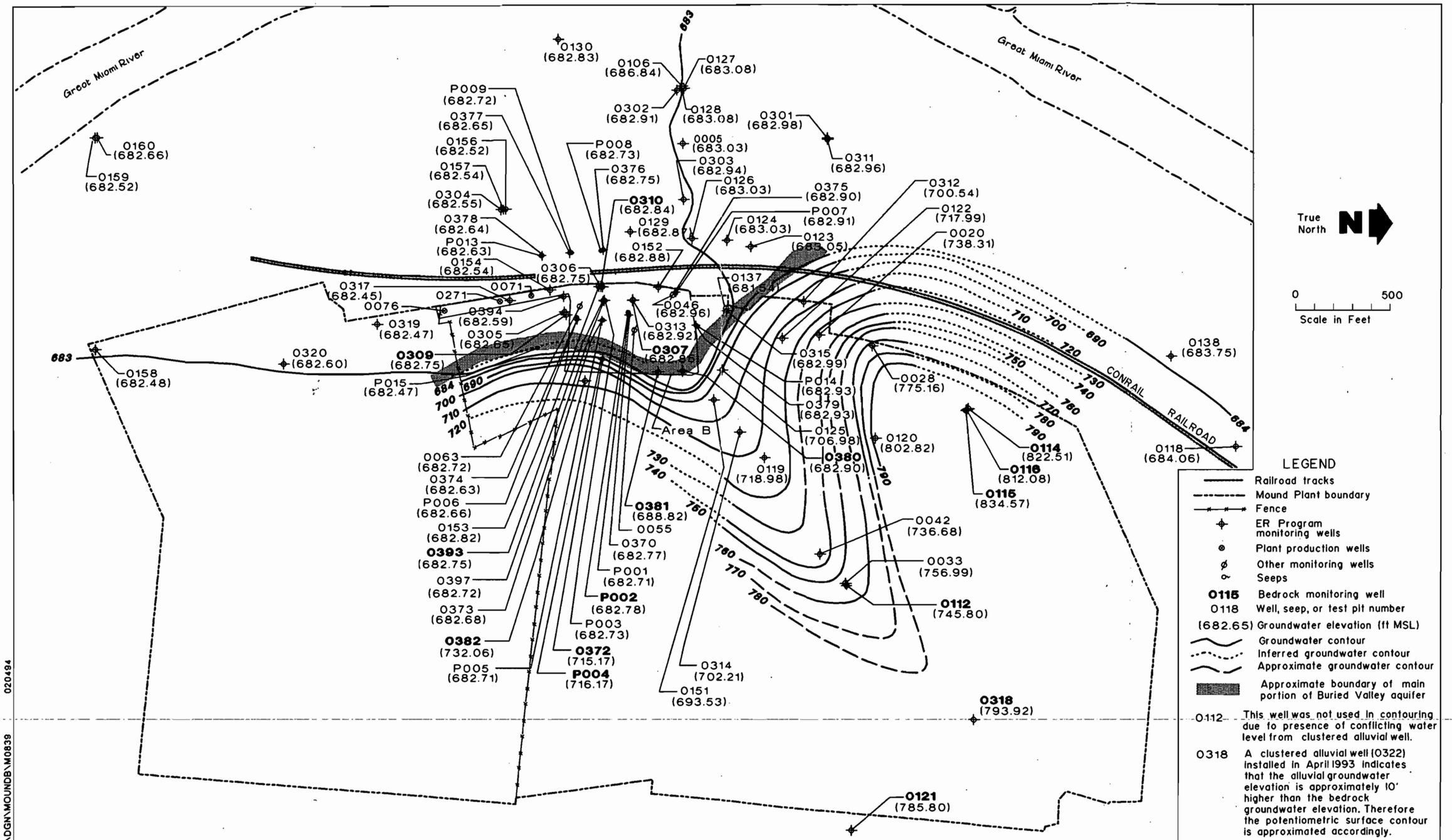


Figure 4.8. Mound Plant groundwater elevation, March 1993.

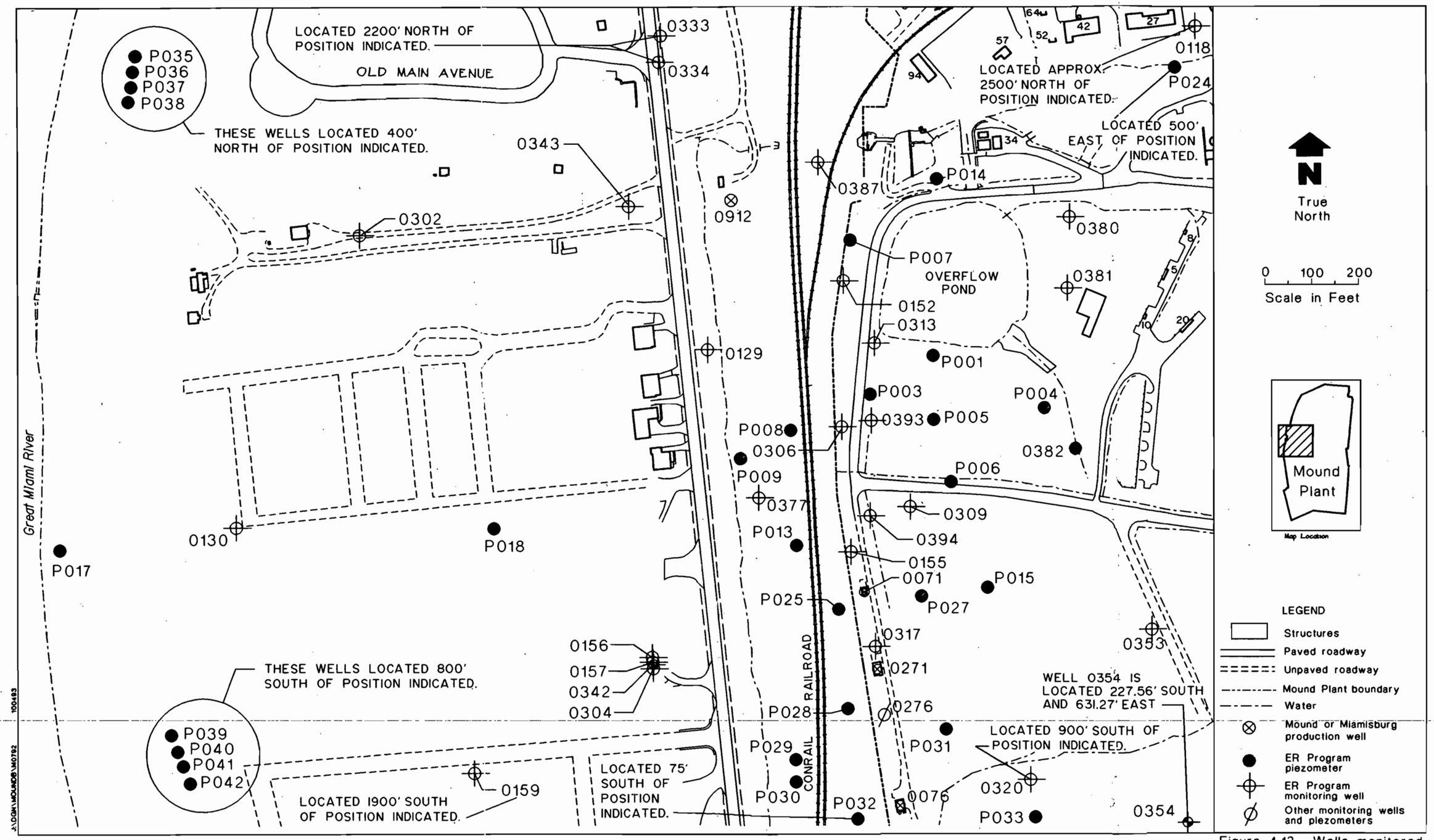


Figure 4.13 Wells monitored during 1993 aquifer test.

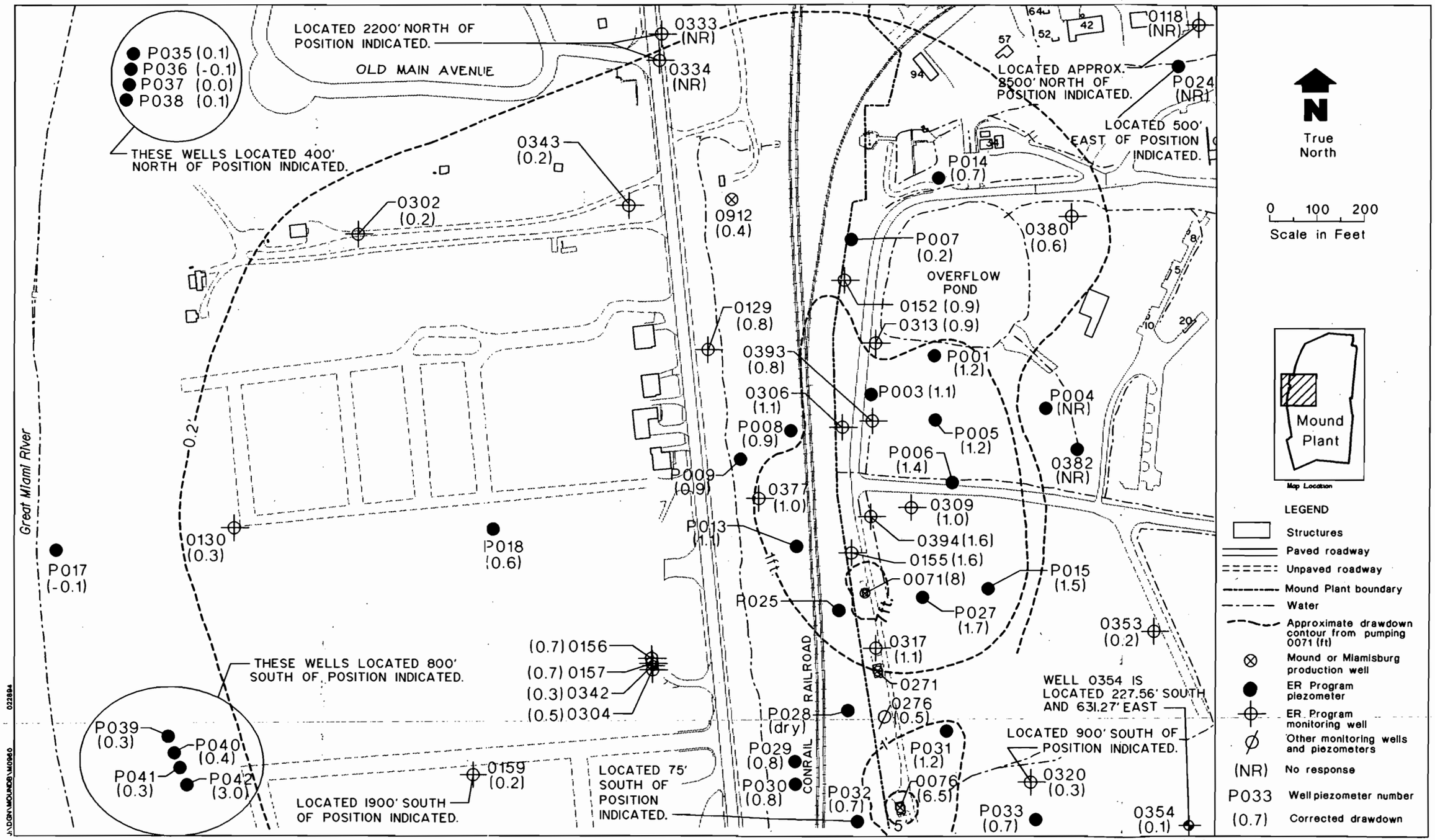


Figure 4.16. Approximate extent of drawdown from pumping 0071 at 14,400 minutes.

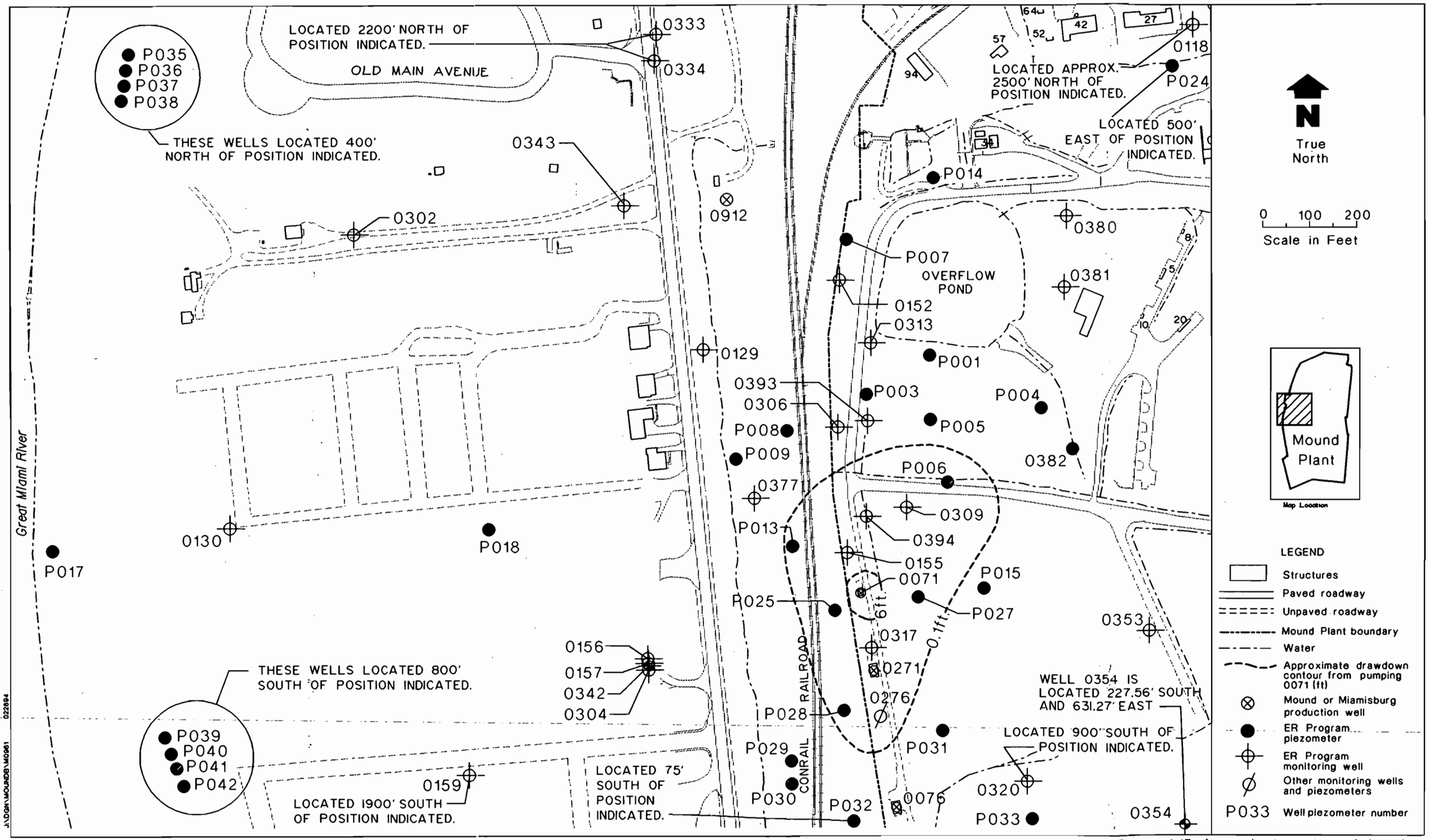


Figure 4.17. Approximate extent of drawdown from pumping 0071 at 60 minutes.

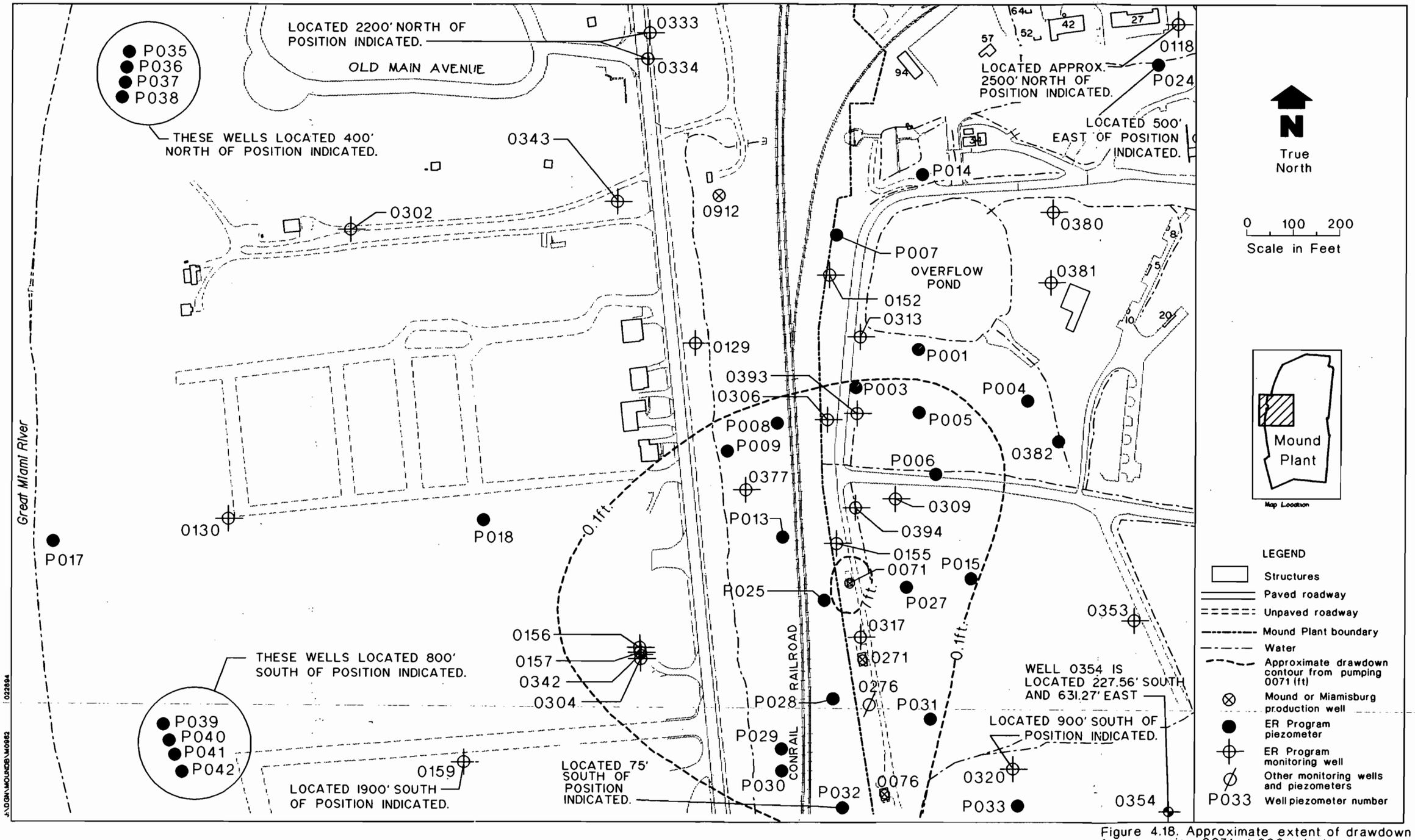


Figure 4.18. Approximate extent of drawdown from pumping 0071 at 600 minutes.

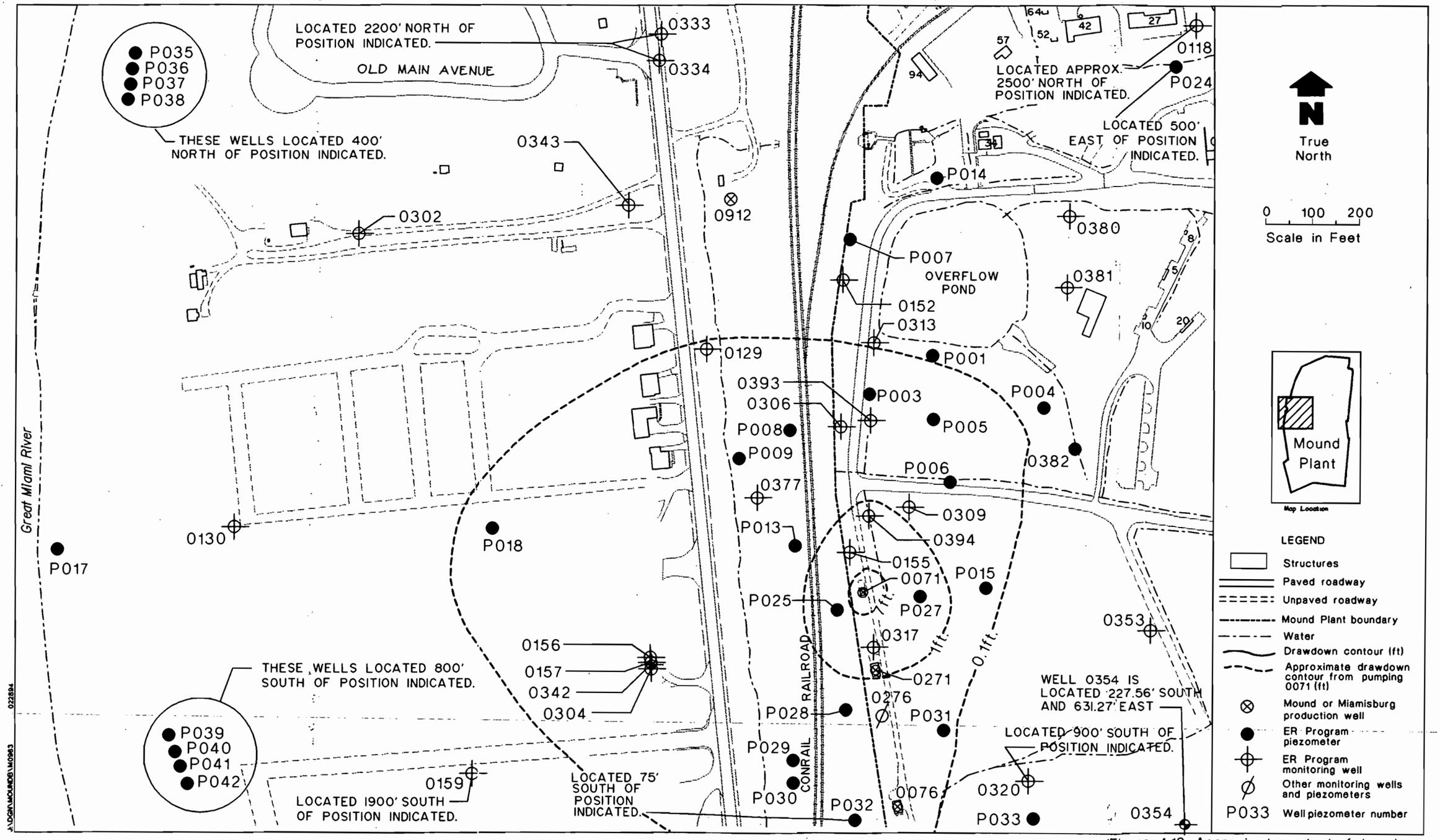


Figure 4.19. Approximate extent of drawdown from pumping 0071 at 1,400 minutes.

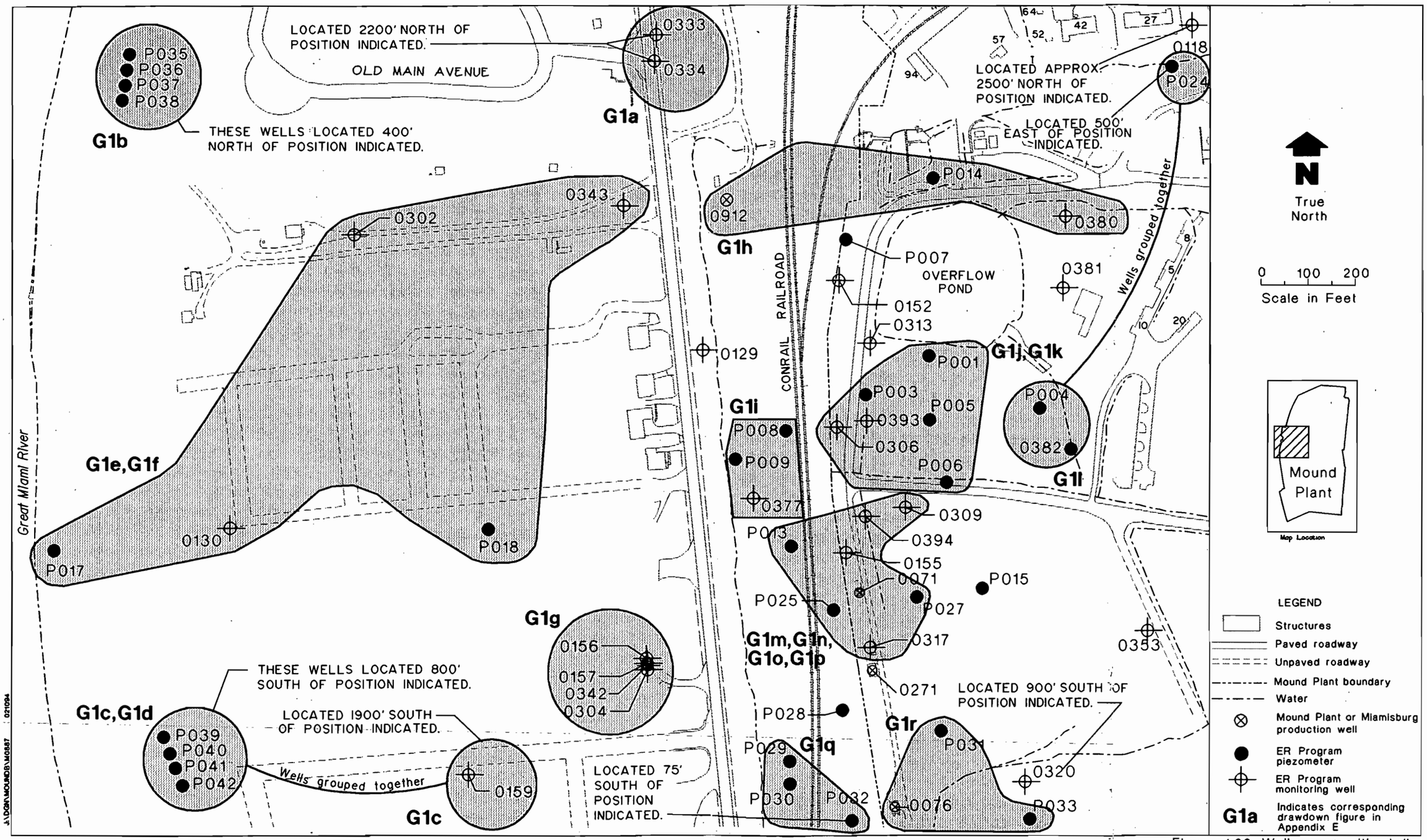


Figure 4.20. Well groups with similar response to May 1993 aquifer test.

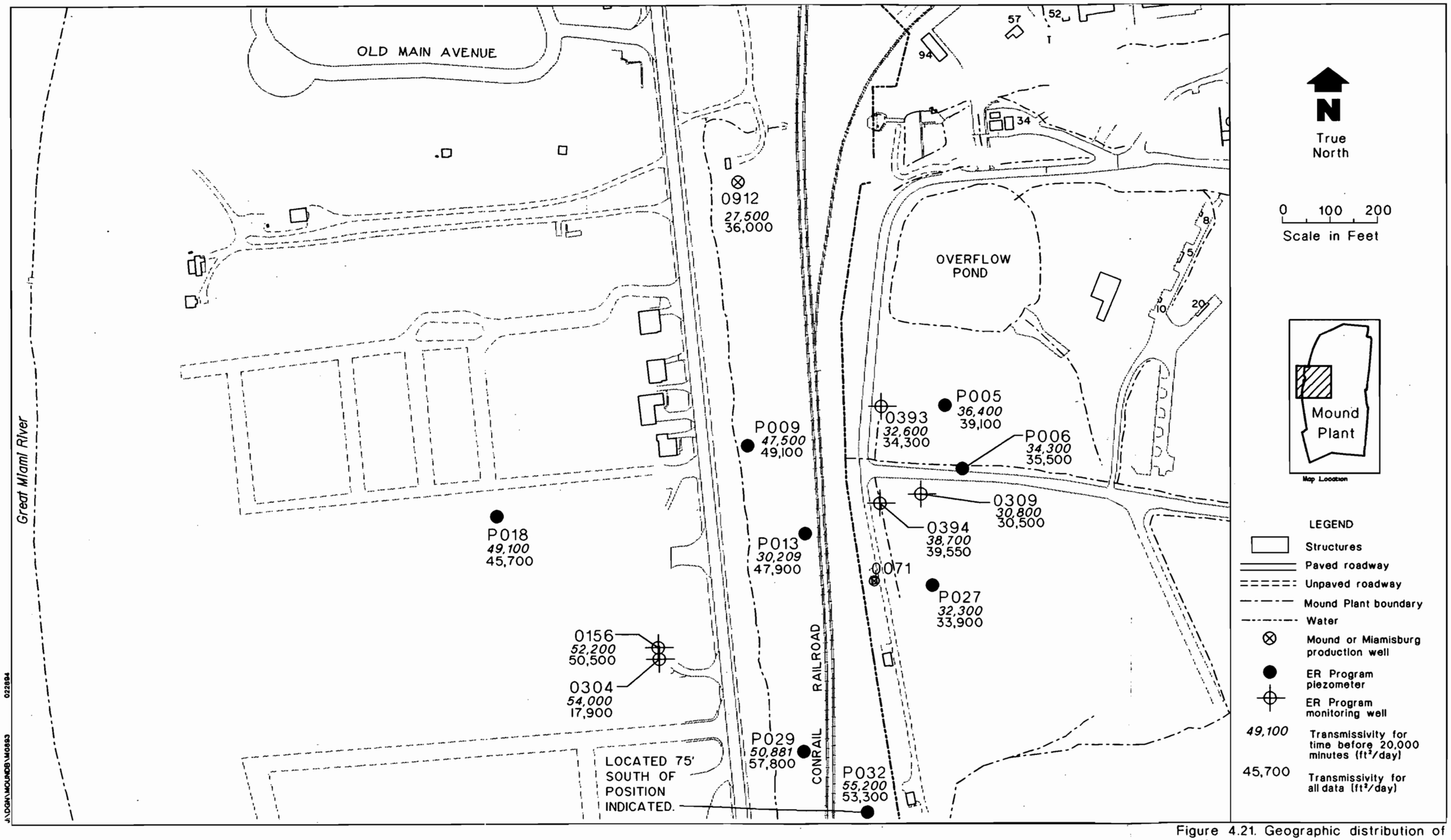
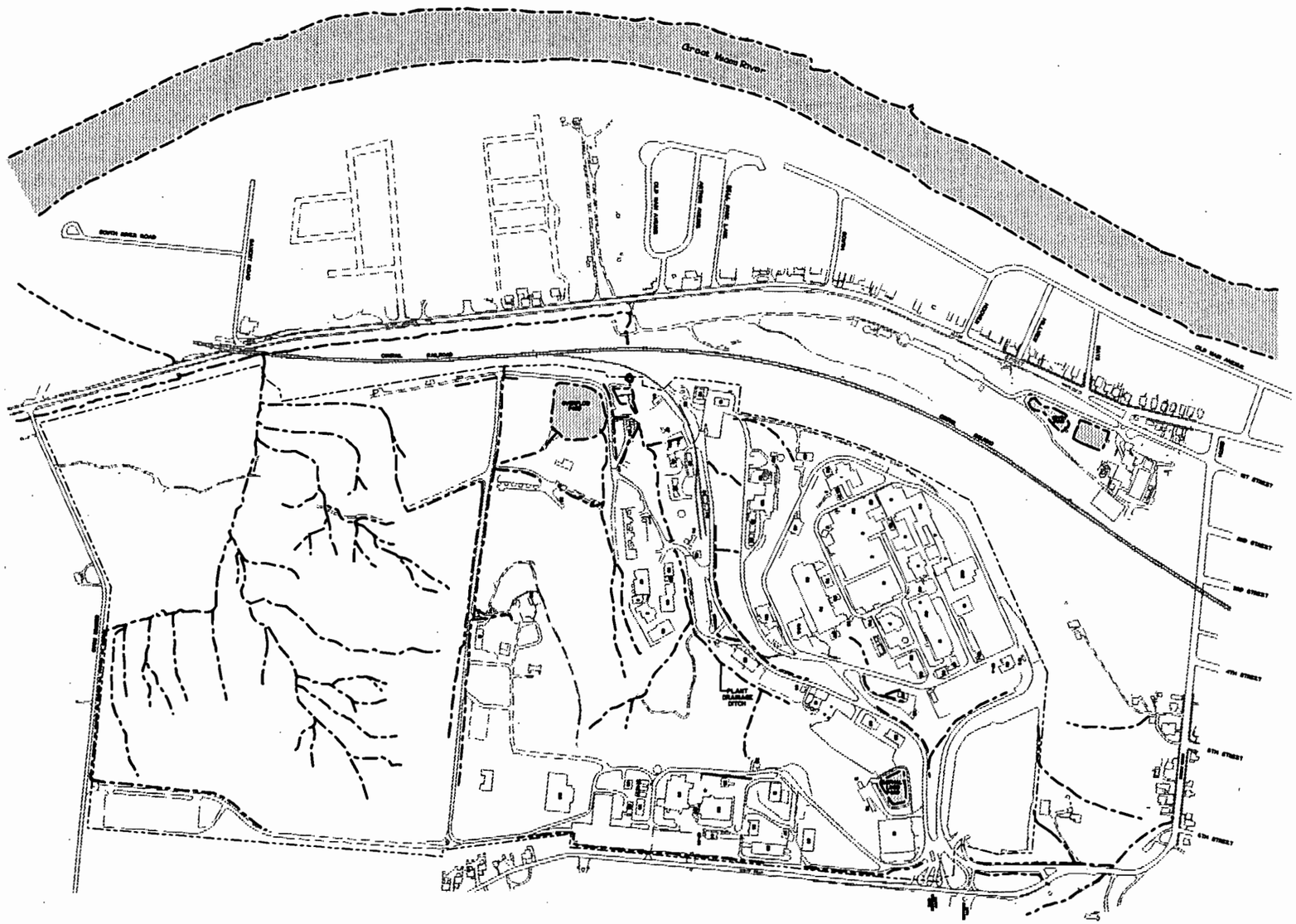


Figure 4.21. Geographic distribution of aquifer parameters calculated from May 1993 aquifer test.



True North N

0 700
Scale in Feet

NOTES:

1. The electronic base map data file was obtained by WESTON from Woolpert Consultants, Inc., Dayton, Ohio. The data were photogrammetrically compiled from aerial photography dated 12/08/85.

2. WESTON converted MOUND plant coordinates to Ohio State Plane Coordinates using an algorithm provided by Oak Ridge National Laboratory, Grand Junction Project Office.

3. Area west of Dayton-Cincinnati Pike was digitized from a hand drafted map, dated 3/12/86 from Monsanto Research Corp.

LEGEND

- 53 Structures
- Paved Roadway
- Unpaved Roadway
- Railroad
- Water
- Fences
- Retaining Wall
- Mound Plant Boundary

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Figure 4.22. Surface water features in the Mound Plant vicinity.

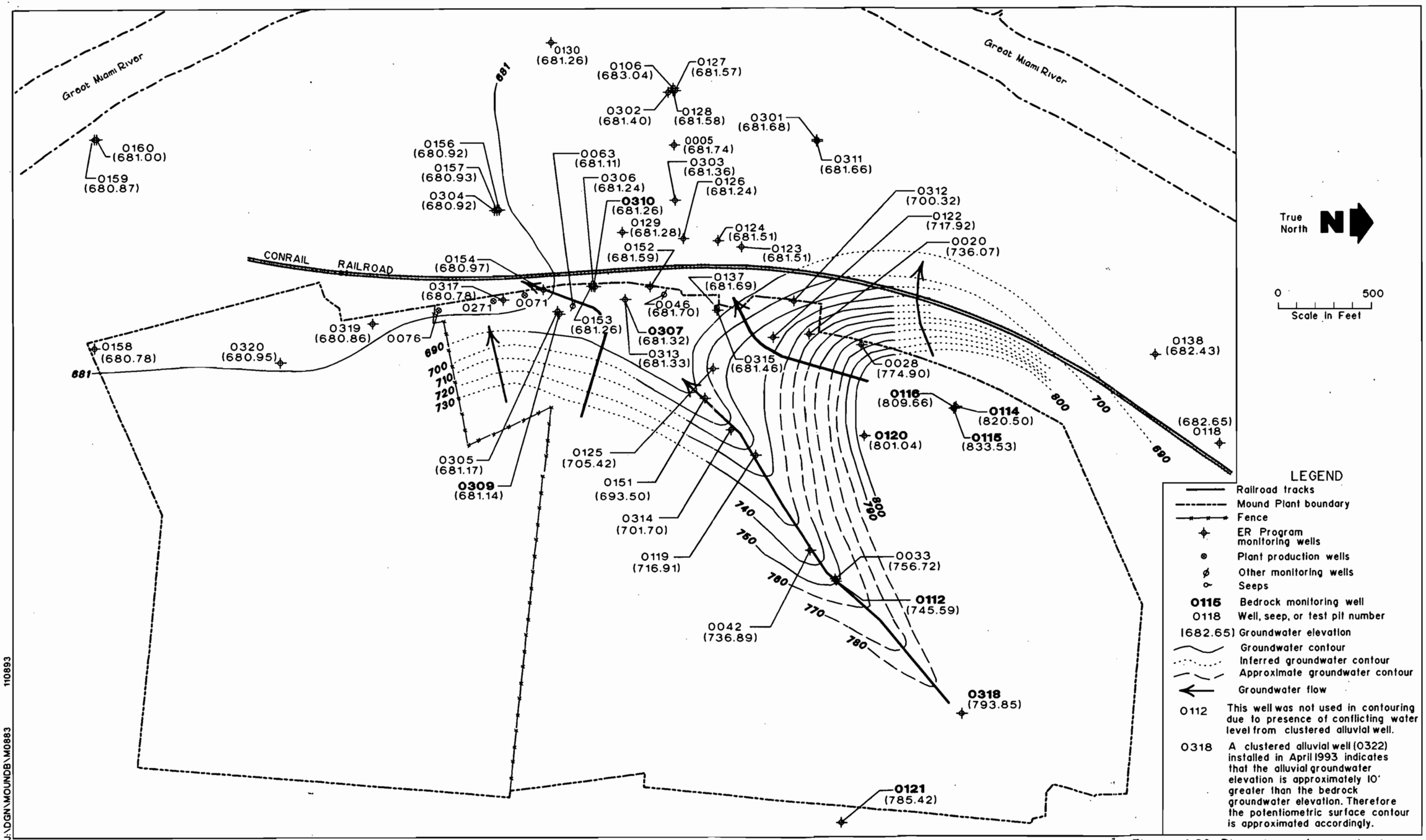

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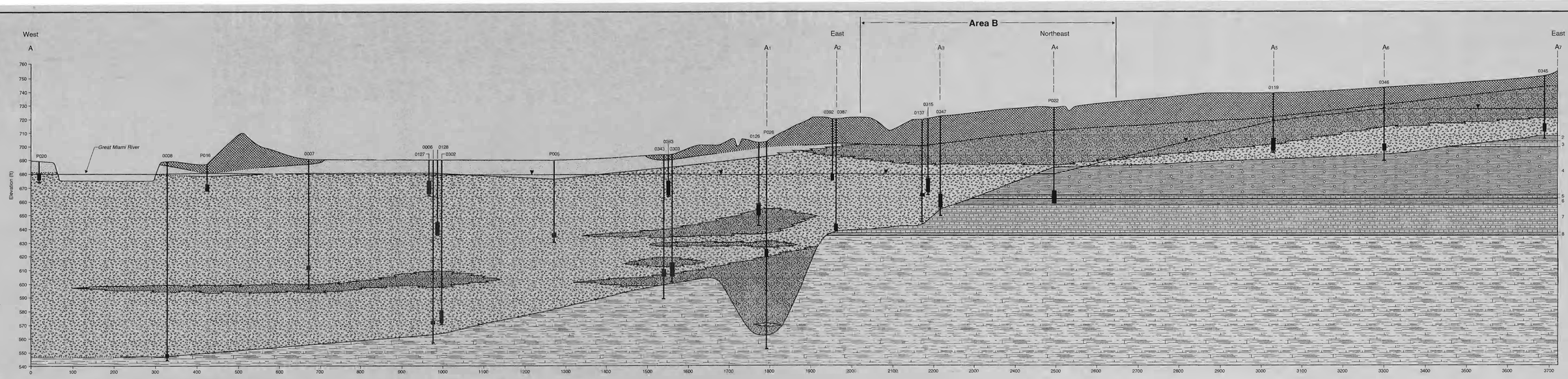
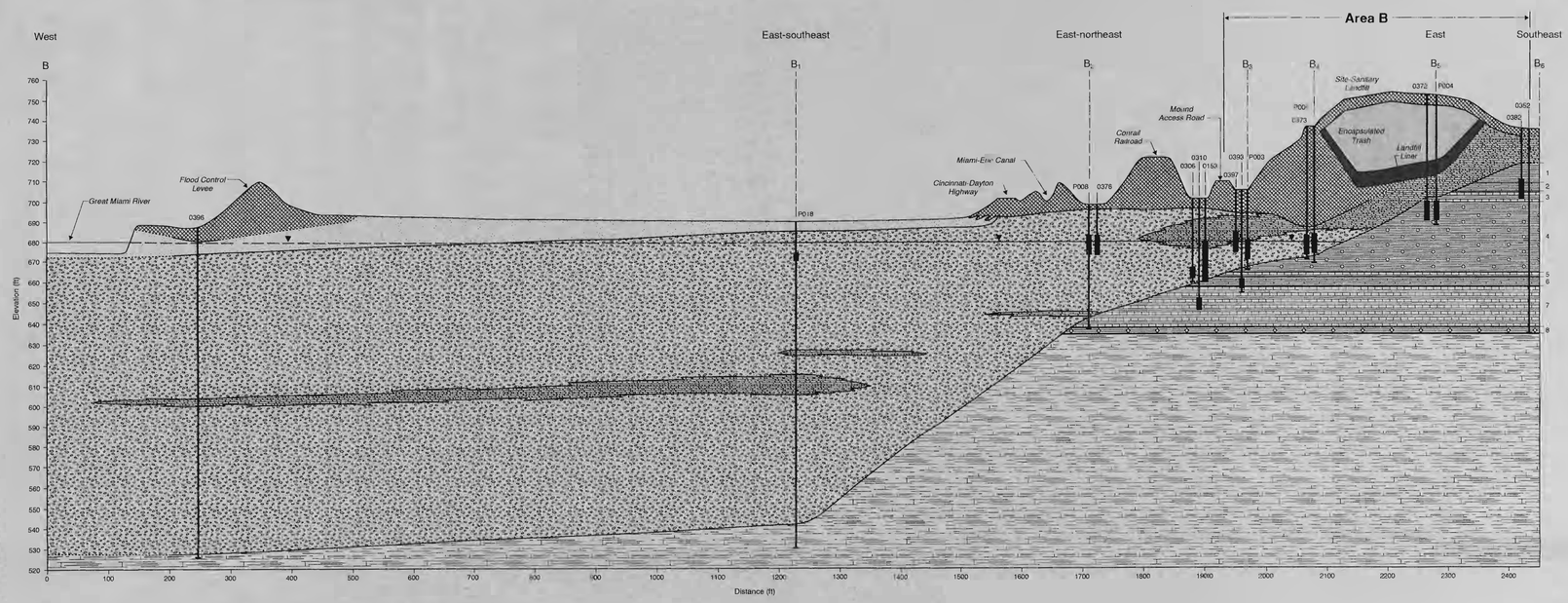
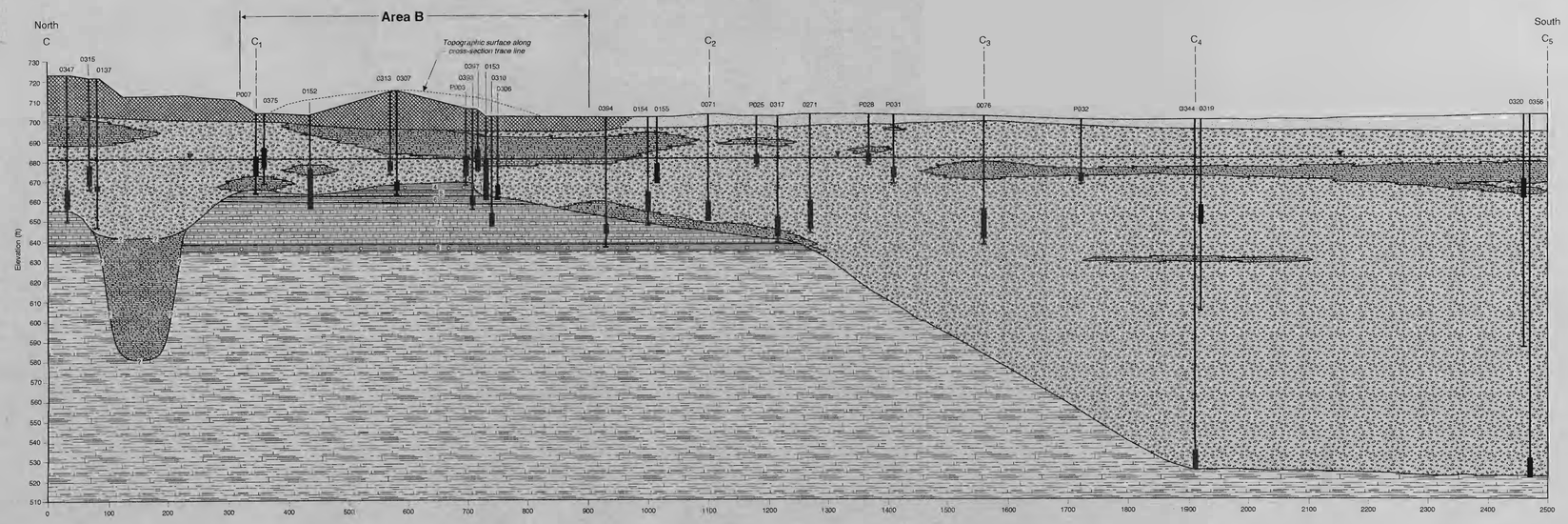
Figure 4.32. Plan view of groundwater flow in the vicinity of Area B.







LEGEND

Unconsolidated Deposits

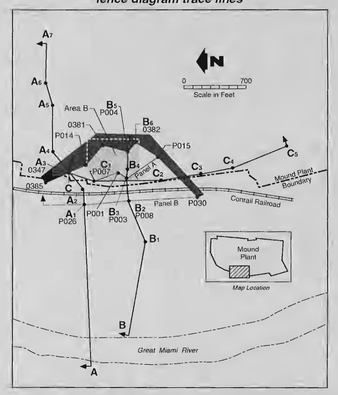
Impermeable		Natural clay: clay containing trace amounts of silt or sand
Variable permeability		Artificial fill: consists of variable proportions of gravel, sand and clay
Moderate permeability		Recent alluvium
Low permeability		Glacial till: clay containing variable proportions of gravel, sand and silt
Moderate to high permeability		Glacial outwash: sand and gravel containing some silt and trace amounts of clay

Bedrock Lithology		***Corresponding Unit No.***
Low permeability	Shale	1
Low fracture permeability	Shale with limestone interbeds	2, 6
Low to moderate fracture permeability	Interbedded limestone and shale	3, 7
Low permeability	Shale with nodular limestone	4, 8
Moderate fracture permeability	Limestone with shale interbeds	5
Variable fracture permeability	Bedrock: specific lithology is unknown	

0153 Well borehole number
P004 Piezometer borehole number
Inferred contact
Inferred water level
Well borehole showing screened interval
Exploratory borehole
Static water

Vertical Scale in Feet: 30, 0
Horizontal Scale in Feet: 0, 100

Location of cross section and fence diagram trace lines



ER PROGRAM

MOUND PLANT

Miamisburg, Ohio

PLATE A.

Geologic cross sections A-A7, B-B6, C-C5.

Operable Unit 1
Remedial Investigation Report
and Environmental Assessment

BOX 28135 210301XXXX-9407190004 #1

ER PROGRAM

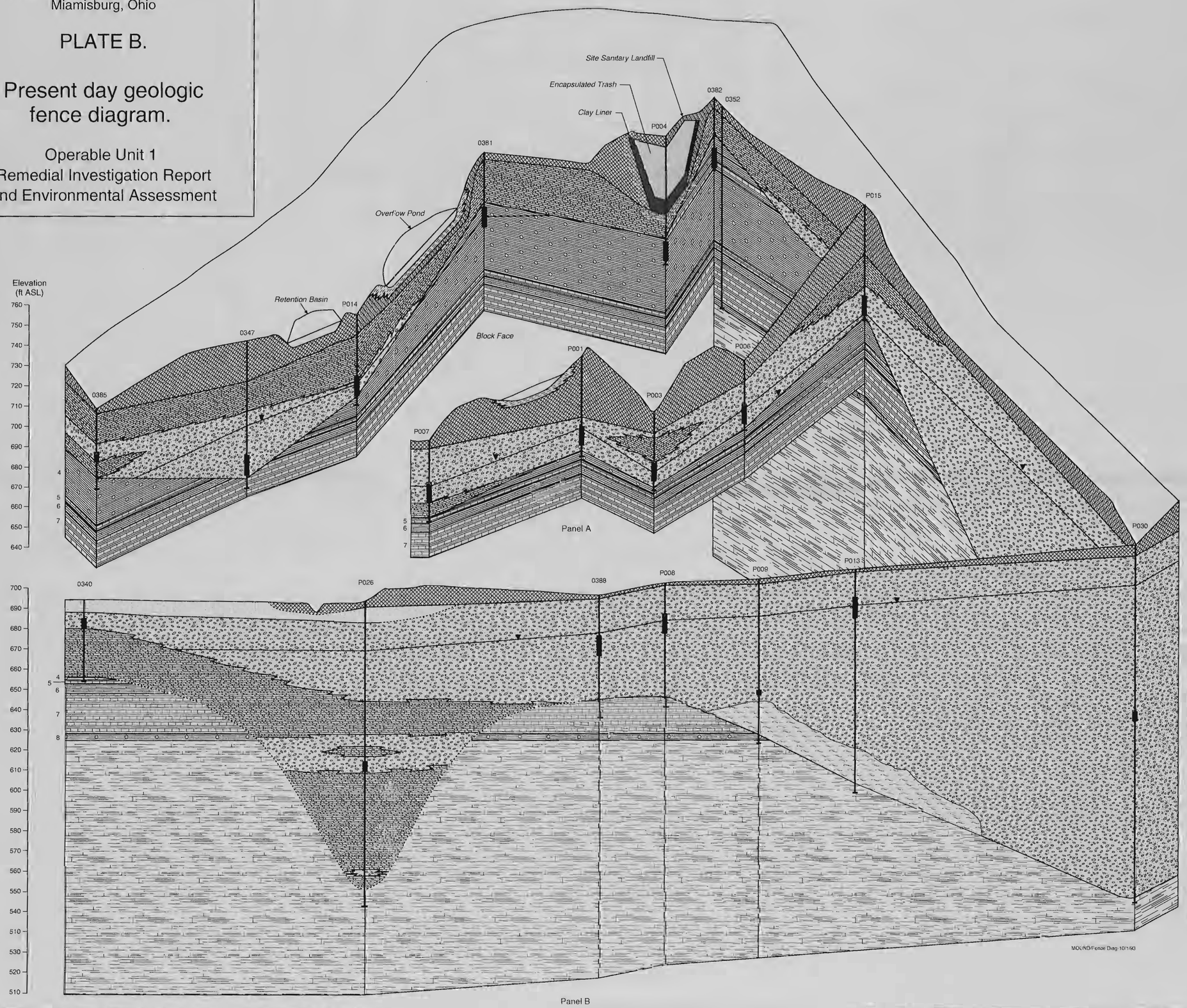
MOUND PLANT

Miamisburg, Ohio

PLATE B.

Present day geologic fence diagram.

Operable Unit 1
Remedial Investigation Report
and Environmental Assessment



LEGEND

Unconsolidated Deposits

Impermeable		Natural clay: clay containing trace amounts of silt or sand
Variable permeability		Artificial fill: consists of variable proportions of gravel, sand and clay
Moderate permeability		Recent alluvium
Low permeability		Glacial till: clay containing variable proportions of gravel, sand and silt
Moderate to high permeability		Glacial outwash: sand and gravel containing some silt and trace amounts of clay
Low permeability		Competent alluvial deposit: clayey silt to silty clay containing numerous angular limestone and quartzite clasts

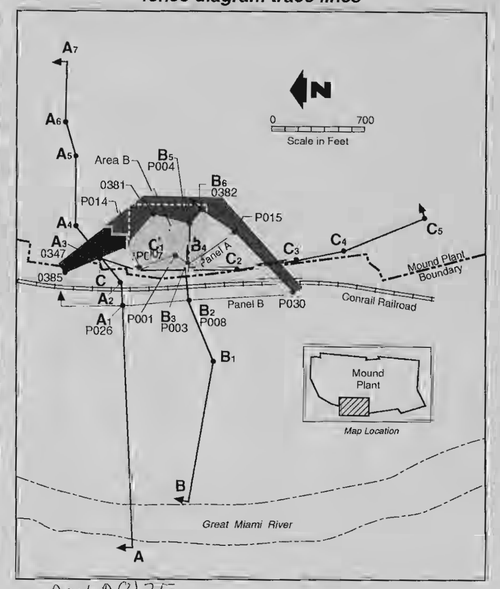
Bedrock Stratigraphy			***Corresponding Unit No.***
Low permeability		Shale	1
Low fracture permeability		Shale with limestone interbeds	2, 6
Low to moderate fracture permeability		Interbedded limestone and shale	3, 7
Low permeability		Shale with nodular limestone	4, 8
Moderate fracture permeability		Limestone with shale interbeds	5
Variable fracture permeability		Bedrock: specific lithology is unknown	

N

0153	Well borehole number
P004	Piezometer borehole number
	Inferred contact
	Inferred water level
	Well borehole showing screened interval
	Exploratory borehole
	Static water

Vertical Scale in Feet: 0 – 30
Horizontal Scale in Feet: 0 – 100

Location of cross section and fence diagram trace lines



BOX 28135
210301XXXX-9407190004 #2