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Final RFI/RI Report Burma Road Rubble Pit (231-4F)

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FINAL
RFI/RI REPORT
BURMA ROAD RUBBLE PIT (231-4F) (U)

VOLUME I

Westinghouse Savannah River Company
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PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-89SR18035

Instructions for the
Final RFI/RI Report Burma Road Rubble Pit (231-4F) (U), Volume I
Revision 1.1, dated September 1995

- Remove pages 5-17, 5-18, 5-31, 5-32, 5-75, 5-76, 5-93 through 5-98, 5-103, 5-104, 5-111, 5-112, 5-117 through 5-120 (revision 1) from the RFI/RI Report.
- Insert pages 5-17, 5-18, 5-31, 5-32, 5-75, 5-76, 5-93 through 5-98, 5-103, 5-104, 5-111, 5-112, 5-117 through 5-120 (revision 1.1) into the RFI/RI Report.
- Remove Chapter 8 (revision 1) from the RFI/RI Report.
- Insert Chapter 8 (revision 1.1) into the RFI/RI Report.

Changes to the
Final RFI/RI Report Burma Road Rubble Pit (231-4F) (U), Volume I
Revision 1, dated July 1995

The entire RFI/RI Report (Volume I) was changed because, upon revision, the document was changed from one computer and software package to another. This resulted in shifting of text. Some page numbers have changed.

The Table of Contents has been updated to reflect the changes in page numbering.

The Executive Summary, List of Acronyms, Chapter 1, and Chapters 3 through 9 have changes in content. The changes are in bold face and a vertical bar is used to indicate where these changes are located. Chapters 1, 2, 4, and 5 have changes in some of the figures. Chapters 4, 5, and 6 have changes in tables.

The appendices have been placed in a separate binder (Final RFI/RI Report, Burma Road Rubble Pit (231-4F) (U), Volume I Appendices).

DOCUMENT APPROVAL SUMMARY
RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION
REPORT FOR
THE BURMA ROAD RUBBLE PIT (231-4F)

DOE FIELD OFFICE

Savannah River Operations Office

DOCUMENTS

RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (231-4F), Revision 1 - July, 1995.

REGULATORY SUMMARY

The RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (231-4F) was developed by request of the regulators to justify the No Further Action Proposed Plan. This revision incorporates comments from EPA and SCDHEC.

BACKGROUND

The Burma Road Rubble Pit (BRRP) 231-4F was constructed in 1951. Hazardous and radioactive wastes were not permitted in the Rubble Pit. From 1973 until 1983, The pits received predominantly construction material/wastes such as lumber, plastic waste, metal waste, wire scrap, concrete, gravel, fluorescent light fixtures, glass, and foam. The BRRP was closed in 1983 by covering it with soil.

The Burma Road Rubble Pit was investigated from November 1993 to February 1994 for the RFI/RI report. These investigations included a ground penetrating radar (GPR) survey, a magnetometer survey, electromagnetic survey, soil gas surveys, soil sampling from the surface and from seventeen borings, surface water and sediment sampling, groundwater well installation (nine wells) and sampling, and a piezocone/hydrocone investigation. The primary objectives of the investigation of the BRRP were to determine whether hazardous substances are present, to determine the extent of contamination existing in adjacent soils and groundwater, to characterize the physical environment, to evaluate the fate of possible contaminants, and to assess the human health and ecological risks as a result of contamination.

Soil sampling analysis was conducted on surface soils and subsurface soils from the base of the pit until two consecutive sample field screened as clean. Soil sample contaminants in this investigation were compared to Criterion Background Concentrations, (CBC) i.e. two times site specific background, as a screening device. If the contaminant exceeded the sample was then compared to the Risk Based Concentration (RBC). If the value exceeded both the CBC and the RBC, then that contaminant merited further analysis in the Baseline Risk Analysis (BRA).

Groundwater flow at the BRRP is generally from the east. The F-Area Process Sewer Line, which transported the waste water to the F-Area Seepage Basins, is up gradient to the BRRP. The majority of the groundwater contamination in the BRRP can be attributed to upgradient sources. Those contaminants which may have the BRRP as a source, exhibit concentrations which are below the F&H Remediation Goals.

The source was characterized by the geophysical surveys, the soil gas surveys, and the documentation generated while drilling through the pits in the process of acquiring soil samples. Field screening via an OVA was also documented and utilized as part of the source characterization.

Based on the field investigation, SRS believes that the nature and extent of contamination associated with the Burma Road Rubble Pit are adequately defined. As stated in the BRA, the risks and hazards attributable to the constituents present in the BRRP are below accepted EPA action levels. For future on-unit workers and future resident scenarios, the carcinogenic risk determined in the BRA is less than 10E-04 and the non carcinogenic hazard is less than 1.0 except for nitrite/nitrate. These values are consistent with recent EPA guidance and indicate that No Action (NA) is required to protect human health or the environment.

Significant changes to this revision include:

1. specifically stating and justifying No Action,
2. inclusion of concentration versus depth by boring cross-sections, (Section 5.3) for applicable contaminants,
3. inclusion of a section on source characterization, (Section 4.4) using information obtained from soil borings,
4. utilizing Criterion Background Concentration, twice site specific background, as screening device.

DOCUMENT APPROVAL

The RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (231-4F) concludes that no further action is needed at this waste unit.

All EPA and SCDHEC comments on the RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (231-4F), Revision 1 have been addressed and are reflected in this document. It is requested that this document be approved.

ATTACHMENTS

Certification page requiring DOE signature

RFI/RI Report with WSRC approval page

Copy of responses to EPA and SCDHEC comments per Rev. 0

1. **In general, it appears that the required data for soil sampling is present but may need to be presented in a format that will more clearly illustrate the extent of horizontal and vertical contamination, if any, that may have actually occurred at the referenced solid waste management unit. The data should be presented in a manner where all reviewers of the document, including the general public, can readily and easily comprehend the data and the actual extent of contamination, if any, that may have occurred. The format changes are suggested.**

   A. **Tables should be provided that present each borehole, including background borings, each depth discrete interval, and all waste contaminants found to be above the background practical quantitation limit at each depth discrete interval. This format should clearly illustrate which soil sampling boreholes had contaminants above the background practical quantitation limits and at what depth they occurred.**

   AGREE. These tables have been included in chapter 5 of the revised document.

   B. **From the data provided in the aforementioned Tables, concentration contour maps illustrating the vertical and horizontal extent of contamination exceeding appropriate background levels should be presented. Basically, the tabular data should also be presented in a graphical format where the contaminant plumes with contaminant concentrations exceeding appropriate background levels can be visually displayed. If possible, three dimensional figures should be used in order to illustrate the contaminant distribution profiles.**

   AGREE. The data has been presented in a graphical format in chapter 5 of the revised document.

   C. **Figure 4-17 on page 4-49 of the referenced report is a cross section through the pit boundaries. This figure should be revised per the following:**

   - **The blue-line reproduction is difficult to read. Sections of the geophysical and stratigraphic logs are "smeared." An alternative reproduction method should be used (either color or black & white).**

     AGREE. This hydrogeologic cross-section has been revised accordingly.

   - **A vertical scale should be provided on the cross section. The top of the land surface should also be indicated.**

     AGREE. This hydrogeologic cross-section has been revised accordingly.

- **An inset location map should be provided on the cross section with the transect clearly delineated. The ends of the cross section should be labeled (i.e., A and A').**

  AGREE. This hydrogeologic cross-section has been revised accordingly.

- **All units and structures of interest should be clearly labeled on the cross section (i.e., water-table, confining units, pit boundaries, potentiometric surfaces for lower aquifers, etc.).**

  AGREE. This hydrogeologic cross-section has been revised accordingly.

D. **Section 4.3.2 Hydrogeology should be revised to include a table with the groundwater elevations for the different wells in the different aquifers. Groundwater elevation contour maps should follow this table for the different aquifers. An estimated groundwater flow direction for the lower aquifers should be calculated using the three data points which are available. These flow directions should be indicated on appropriately scaled with the wells clearly indicated.**

AGREE. Section 4.3.2 has been revised accordingly.

E. **Section 5 should be revised to include the groundwater analytical results in a tabular format. These tables should include the well#, date sampled, and concentration for all constituents detected above background/detection limits. All detections above an MCL should be highlighted in some manner. A similar table for the hydrocone groundwater sampling data should also be provided.**

AGREE. Section 5 has been revised accordingly.

F. **All significant groundwater data should be appropriately displayed on plan-view maps (either as concentration contours or in concentration boxes).**

AGREE. Section 5 has been revised accordingly.

G. **All significant groundwater data should be appropriately displayed on cross section maps of the unit. Concentrations for selection constituents should be displayed at appropriate sampling interval. The cross sections should also show the pit boundaries (horizontal and vertical), water table elevation, and any other pertinent features.**

AGREE. Section 5 has been revised accordingly.

2. **Tables 5-2, 5-4, 5-6, and 5-10 refer to proposed RCRA Action Levels. These Tables should also include the data for the U.S. EPA Region 3 Preliminary Remediation Goals (PRG's).**

AGREE. These Tables have been revised accordingly.

3. **Section 5.3.1 discusses the use of D'Agostino's Test, Students T Test, and the Kruskal-Wallis Test in order to statistically analyze the soil sampling data. References to these statistical tests should be deleted as per the U.S. EPA memorandum "Principles of Agreement for Performing Future Baseline Risk Assessments for the SRS."**

   AGREE. The text has been revised accordingly.

4. **Tables 5-1, 5-3, 5-5, 5-7, and 5-9 provide background data from the background soil sampling locations. Provide additional discussion clarifying how the actual background levels were actually established.**

   AGREE. The revised document has provided additional discussion regarding the establishment of background levels.

5. **Section 8 (Summary and Conclusions) should be revised to include the proposed path forward for this unit. This section should clearly state one of the following:**

   - **Whether or not additional assessment is needed.**
   - **If remediation options should be pursued through an FS.**
   - **Whether or not no further action is warranted.**

   AGREE. Section 8 has been revised accordingly.

6. **All references to the 100 X MCL and 20 X TCLP rules for screening out contamination levels of concern in soil should be deleted. These are not acceptable screening tools. Comparison to the site specific background levels would be more appropriate.**

   AGREE. The revised document has been amended accordingly.

7. **Please add the MCL for tritium to Table 5-25.**

   AGREE. Table 5-25 has been revised accordingly.

General Comments

1. **The rationale for collecting sediment samples at a depth of 6 to 12 inches fails to satisfy Risk Assessment data requirements. How will this data be used and will it adversely affect the generation of a risk assessment?**

   CLARIFICATION. A section has been added to the text in Section 3 discussing the Work Plan strategy and the adequacy of this strategy in determining the nature and extent of contamination at the waste unit. The Work Plan was drafted in accordance with the current risk assessment protocols at the time of work plan development.

2. **Please explain the adequacy of the limited number of surface runoff sediment samples which were collected at the BRRP. In addition to the samples that were collected from the ditch west of BRRP, surface runoff sediment samples should also be collected from the ditch located northwest of the site and from the swale located southeast of the site. No surface runoff sediment samples have been collected from these downgradient features. These samples are needed to determine if contaminants have migrated offsite via the surface water pathway.**

   CLARIFICATION. A section has been added to the text in Section 3 discussing the Work Plan strategy and the adequacy of this strategy in determining the nature and extent of contamination at the waste unit.

3. **No surface water background samples were collected during the RFI/RI for comparison with the onsite surface water samples. Background surface water samples should be collected from a nearby surface water body that is not affected by the BRRP.**

   DISAGREE. A section has been added to the text in Section 3 discussing the Work Plan strategy and the adequacy of this strategy in determining the nature and extent of contamination at the waste unit. During the entire investigation it was observed that standing water was present in a low lying area adjacent to the waste unit. A field decision was made to collect the surface water samples in addition to the sampling specified in the RFI/RI Work Plan for the Burma Road Rubble Pit (WSRC-RP-90-1104, Rev. 2) in order to be conservative and provide additional data not considered during the regulatory review of the Work Plan. Background surface water samples were unavailable because there is no upgradient body of surface water within a reasonable distance of the waste unit from which to obtain a unit-specific background sample. As shown on page 5-73, Table 5-27, analysis of the surface water samples revealed no contaminants for which there exists a MCL to be present above the MCL.

4. **Although a conclusions and summary section is provided for the Burma Road Rubble Pit in the Final RFI/RI Report, recommendations for further activities are not provided. The text should be revised to state whether further actions are needed at the site.**

   AGREE. The text has been revised to include the proposed path forward for this waste unit.

SPECIFIC COMMENTS

Section 1

5. **pg 1-4: This figure is difficult to read because it has been copied so often (This comment applies to several figures in this document). Please correct this problem.**

   AGREE. This figure and all others that have degraded image quality due to multiple generations of photocopying have been corrected.

6. **pg 1-10, Figure 1-5: Figure 1-5 is a water table map for the F and H areas. This figure should also provide the date on which these water levels were measured. This information is necessary to ensure that the water levels on which this map was developed were measured on the same day.**

   DISAGREE. As stated on page 1-10, Figure 1-5, the water levels depicted on the map were taken in the third quarter of 1990 (July - September). The wells shown in the figure were sampled in July and August. Because of the large number of wells and the significant distances between these wells, it would be impractical to attempt to obtain water level measurements for all of these wells in one day. The water table potentiometric surface shown on Figure 1-5 is intended to depict the regional groundwater flow direction, whereas Figure 4-18 is intended to show the local groundwater flow direction for the Burma Road Rubble Pit Waste Unit. Water levels for wells within areas such as F-Area or H-Area are taken within a few days in order to provide groundwater flow information for their respective area, but many waste units such as the Burma Road Rubble Pit fall outside of these areas and are thus not necessarily included in these water level sampling activities. Figure 4-18 is based upon simultaneous water table elevations obtained from the BRR water table wells on April 17-18, 1994. Both Figures have been updated to reflect 2Q94 sampling data.

Section 3

7. **pg 3-13, Paragraph 2: The text states that there were four separate soil gas surveys completed in October, July, September, and July. However, the soil moisture surveys completed in October and September do not appear low enough (considering rain and purge water table with a high capillary zone). The text should explain if seasonal variation affected the results of these values compared with the July reading.**

   DISAGREE. Soil moisture was not measured in any of the aforementioned soil gas surveys.

8. **pg 3-17, Paragraph 3, Sentence 4: One of the Surface and Subsurface Soil Sampling Objectives was to determine contamination within GPR Zone 1, 2, and 3; however, the text does not define the zones within the context of this section. The text should identify the GPR zones or refer the reader to Figure 1-3.**

   AGREE. Page 3-17 has been amended to refer the reader to Figure 1-3.

9. **pg 3-19: The VOC screening methods given here is of limited value; readings should be taken in real time, not 20 minutes after the sample is collected.**

   DISAGREE. The field screening method utilized in this field characterization is more conservative than simply taking a real-time measurement. Field conditions are often windy so that volatile organic vapors which may be present within the soil void spaces are rapidly dissipated. Placing a portion of the sample in a sealed glass jar and waiting twenty minutes allows time for volatile organic vapors to accumulate in the headspace of the sealed sample jar, thus readings would be expected to be higher than they would be if taken immediately upon opening the split spoon. This procedure serves to minimize the potential for discontinuing sampling within a borehole before the vertical extent of contamination is determined and allows for a cost-effective characterization of the horizontal and vertical extent of contamination in one field sampling event. In addition to this screening data which is used to determine the depth of soil borings, the breathing zones of field workers were continually monitored with the OVA to ensure safe working conditions.

10. **pg 3-26: It is not clear why all sample intervals were not analyzed for the same analytical parameters.**

    CLARIFICATION. Analytical suites were determined by taking into account the unit history and the characteristics of the specific contaminants such as mobility within the soil matrix and potential fate and transport mechanisms. Additionally, because the soil volumes obtained by the split spoon sampling device were often insufficient to fill all of the sample bottles (especially on duplicate samples), the analytes had to be prioritized based upon unit history, contaminant mobility, and potential fate and transport mechanisms. Time and cost were also considered during the development of the sampling plan. The rationale utilized in determining the analytical suites and their respective prioritization has been discussed in the revised Section 3.

11. **pg 3-37: It is not clear if the sediment sample was thoroughly mixed before being placed in the sample container.**

    AGREE. The VOC sample jars were filled first directly from the spatula sampling device. The sample was then homogenized in a stainless steel bowl and the other sample jars were filled. The text has been revised to explicitly state the sampling procedure followed.

12. **pg 3-47: How was the decon rinse water disposed of?**

    CLARIFICATION. The decon rinse water was poured onto the ground surface of the waste unit. This statement has been added to the text.

13. **pg 3-51: PVC should not be subjected to high pressure steam or temperatures greater than 100° F because the extreme temperatures reduce the collapse strength of the material.**

    CLARIFICATION. All well materials were steam cleaned prior to placement in the borehole, as specified in 3Q5. Although it is true that PVC pipe should not be used to contain/transport a fluid which is at a sustained temperature of greater than 100° F or sustained high pressure, the well materials are open at both ends and are thus subject to equilibration with ambient atmospheric temperature and pressure. Although the water at the tip of the pressure washer nozzle is at high temperature and pressure, these conditions are not sustained within the PVC pipe for any substantial amount of time. Rather, the jet of hot water/steam is used to rinse off the PVC pipe for only a few seconds. Therefore, it would not be expected that the collapse strength of the well materials would be decreased to any appreciable degree by the steam-cleaning activities specified in WSRC 3Q5.

14. **pg 3-51: Were heaving sands the reason mud rotary was chosen over hollow stem auger drilling techniques?**

    AGREE. Because of problems with flowing sands causing the borehole to cave in, mud rotary drilling techniques are generally used for all borings which are to be advanced below the water table. Text has been added to document.

15. **pg 3-56: Were sieve analyses conducted to determine if the filter pack sand particle size was appropriate for the lithology of this site? If so, are the sieve analyses in Appendix B those used to determine filter pack size?**

    CLARIFICATION. No. In the past, sieve analyses were conducted for all wells for determination of filter pack size. However, the analyses of the soil particle sizes virtually always resulted in selection of the same filter pack particle size. Therefore, per WSRC 3Q5, in order to save both time and expense, Foster Dixiana FX50 filter pack washed silica sand (average particle size 0.50mm) is used in all well installations unless local geologic conditions dictate a deviation from this practice. Data from the continuous cores and the fact the existing wells used the standard grain size filter pack material showed the standard Foster Dixiana FX50 filter pack washed silica sand to be suitable for use in the new BRR wells. To date, no problems have been encountered with the new BRR wells.

Section 4

16. **pg 4-5, Figure 4-2: The figure should include a north arrow.**

    AGREE. A north arrow has been included on the revised figure.

17. **Figures 4-3 through 7: The figures should identify the cross section location points on the map reference and in the text.**

    AGREE. As stated on page 4-1, Figure 4-3 is a marked up sample cross section intended to aid in interpretation of the other cross sections. Figures 4-4 through 4-7 have the line numbers in the upper left corner (the line numbers refer to Figure 4-1). The text has been revised to state this.

18. **pg 4-45: "The second part results from the natural background of these species [hexane and pentane] in the Savannah River Site area." Is this statement implying that hexane and pentane are naturally occurring at SRS?**

    CLARIFICATION. The text has been revised to include the following statement: In support of the natural occurrence of hydrocarbons in the Central Savannah River Area (CSRA), recent geochemical investigations conducted on late Eocene Griffins Landing Member (GLM) of the Dry Branch formation carbonate outcrop samples from Griffins Landing, Georgia, detected the presence of wet saturated hydrocarbons. When fractured, outcrop samples produced a petroliferous odor.

19. **pg 4-46, Paragraph 3, Sentence 2: The text should identify the location of very high methane concentrations in the text and on the map.**

    AGREE. As shown in Appendix F, Table 3, the high methane hit occurred at location #188 on Figure 4-16. The text has been revised to state this.

20. **pg 4-47, Paragraph 1, Sentence 1: The text should compare the result of the past Soil Gas Survey with the results of the current survey within the summary.**

    AGREE. The summary section (Section 4.2.2.1) has been revised accordingly.

21. **pg 4-51, Paragraph 3, Sentence 1: The text reads "one mile to he southeast." This is a typographical error, and the text should be revised.**

    AGREE. The typographical error has been corrected.

22. **pg 4-53: What are the well numbers for these measurements?**

AGREE. The well numbers have been included on the revised figure.

23. **pg 4-59: Were the unretrievable augers lost in the hole at location PC-6 marked so that, in the event geophysical surveys are made in this area, it would not be assumed that the spike on the scan is a drum?**

CLARIFICATION. Yes, the coordinates of the borehole containing the augers were determined by land survey, and the location was marked with a wooden stake. The text has been revised to state this.

24. **pg 4-62: The deviation from the procedure given in WSRC 3Q5 for headspace analysis indicates how important it is that someone from EPA review this procedure for adequacy, before it is implemented. EPA contends that collecting VOC readings from a sample in a plastic bag is bogus, because the OVA is reading the plasticizers from the bag. Hence, the values are viewed by EPA as being suspect.**

AGREE. As stated on page 4-62, a glass jar rather than a plastic bag was used to contain the sample due to the problems mentioned in the above comment. The values obtained in this investigation are therefore valid screening data.

25. **pg 4-62, Paragraph 2, Sentence 3: The text should define STR in the Section of Acronyms.**

AGREE.. The List of Acronyms has been revised accordingly.

26. **pg 4-72: As for the wells BRR-7B and BRR-8D collapsing, another possible cause is steam cleaning the PVC casing prior to use. PVC should not be subjected to high pressure steam or temperatures greater than 100°F because the extreme temperatures reduce the collapse strength of the material.**

DISAGREE. See response for comment # 13.

27. **pg 4-77, Table 4-4: Why are the feet of filter pack, feet of fine sand and feet of bentonite so variable from well to well? Also why as so much sand placed above the top of the screen? Bentonite seals are usually around 2 feet in thickness - not 4 to 9 feet as noted here.**

CLARIFICATION. The wells were installed in accordance with WSRC 3Q5. WSRC 3Q5 states that the bentonite seal shall have a minimum thickness of 4 feet. Thickness of the bentonite seal is often varied in order to ensure a good seal with a local confining unit to minimize the potential for cross contamination between aquifers. The text has been revised to explain the aforementioned variability in filter pack, fine sand, and bentonite.

Section 5

28. **In Section 5, Table 5-6, Table 5-11, and Table 5-12, the text does not recognize that chloroethene and vinyl chloride are actually the same compound. Therefore, the text incorrectly states that there is a regulatory level for vinyl chloride but not for chloroethene.**

AGREE. On page 5-27, the text does state that chloroethene and vinyl chloride are synonyms. Tables 5-6 and 5-12 are in error and have been revised to reflect the proper regulatory level for chloroethene. Tables 5-6, 5-11, and 5-12 have been revised to demonstrate that chloroethene and vinyl chloride are the same compound.

29. **Pg 5-20, Table 5-14: There are numerous inconsistencies between the data on Table 5-14, which shows arsenic concentrations detected in soil samples at BRRP, and Appendix J, which provides the laboratory analyses for the soil samples at BRRP. For example, Table 5-14 shows arsenic concentrations detected in soil sample BRRP 06 collected at a depth of 0 to 2 feet as being 6.07 milligrams per kilogram (mg/kg); however, Appendix J shows the arsenic concentrations for this sample as 3.45 mg/kg. Please explain why these discrepancies exist between Table 5-14 and Appendix J.**

AGREE. The table is in error. Evidently the mistake is the result of a transcription error, since the concentration for Antimony, which is immediately above arsenic in the table in Appendix J, is 6.07 mg/kg. The correct concentration for arsenic is 3.45 mg/kg. An additional error was discovered: Sample BRRP 08, from 0 to 2 feet, should not be in the table because it was actually shown in the lab data as undetected (lab qualifier "U"). Sample BRRP 15, from 0 to 2 feet, however, should be included in the table because it is shown in the lab data as being present at an estimated concentration (lab qualifier "J") of 4.33 mg/kg. Table 5-14 has been revised accordingly.

30. **pg. 5-31, Table 5-16: Does the heading "PRAL" mean proposed RCRA action level?**

AGREE. Yes. This has been added to the List of Acronyms and to the footnotes for the table.

General Comment: It was noted if a constituent was detected during one sampling episode, it might not be analyzed for the next few sampling episodes, but would be some episodes later. How can trends be delineated if samples are collected on such a sporadic schedule?

CLARIFICATION. A section has been added to the text in Section 3 discussing the Work Plan strategy and the adequacy of this strategy in determining the nature and extent of contamination at the waste unit. Because methods for achieving real-time laboratory-quality analytical data were not available at the time of this field characterization, the sampling strategy could not make analytical suites contingent upon contaminants detected in the previous sample.

31. **pg 5-65, Paragraph 3, Sentence 1: The text reads "See Figure 4-18 for Hydrocone sampling locations." However, the figure number should be 4-19.**

    AGREE. The text has been revised accordingly.

32. **pg 5-73: Why weren't background/upgradient samples collected for comparison purposes for sediment/surface water samples? This is a basic sampling protocol.**

    CLARIFICATION. A section has been added to the text in Section 3 discussing the Work Plan strategy and the adequacy of this strategy in determining the nature and extent of contamination at the waste unit. The surface water/sediment samples from the borrow pit were collected in addition to the sampling specified in the RFI/RI Work Plan for the Burma Road Rubble Pit (WSRC-RP-90-1104, Rev. 2) in order to be conservative and provide additional data for the risk assessment not considered to be necessary during the regulatory review of the Work Plan. Background surface water samples were not collected because there is no upgradient body of surface water within the immediate vicinity of the waste unit from which to obtain a unit-specific background sample.

Section 8

33. **In Section 8.1 the text states that the trenches may be sources of contamination. However, in Section 5.3.2.1 the analytical summary on subsurface soil states that the pit contains high concentrations of compounds which have not migrated below the pit. The RI is done to delineate the vertical and horizontal extent of contamination, so the text should determine if the pit is a source of contamination or clearly define the vertical extent of contamination.**

    AGREE. The text has been revised to define the horizontal and vertical of contamination.

34. **It appears from this summary that BRRP is not considered to be the source of some of the constituents for this site. However, there is not work proposed to determine what the source of these compounds is/are. Will this proposal be issued at a later date for review?**

    CLARIFICATION. The purpose of this field characterization was to determine the nature and extent of any contamination emanating from the Burma Road Rubble Pit Waste Unit. Determination of potential contaminant sources which fall outside the boundaries of the waste unit were considered to be outside the scope of the project. Sources of contamination will be determined on a case by case basis as characterization activities are conducted at other waste units in the vicinity of the Burma Road Rubble Pit under separate schedules and/or regulations.

35. pg 8-2, Paragraph 2, Sentence 3: The text reads the "water talbe" instead of "water table." The typographical error should be revised.

AGREE. The typographical error has been corrected.

Appendix C

36. It was noted that there are monitoring well construction logs for wells BRR-7B and BR-8D. Since the casing in these wells collapsed (Section 4, pg 4-72) were these wells abandoned?

CLARIFICATION. Wells BRR-7B and BRR-8D were abandoned. The Well Abandonment Forms have been added to Appendix C for clarification.

Appendix J

37. It was noted that field blanks were prepared with distilled water. EPA protocol requires that only organic-free, analyte-free water should be used for QA/QC blanks.

AGREE. The text has been revised to state "deionized water" rather than "distilled water." Field characterization activities were conducted in accordance with WSRC 3Q5.

38. It was noted that much of the analytical data had a column for qualifiers and a column that may or may not have the notation "LT." It was not clear what the LT stood for.

AGREE. "LT" stands for less than detection limit. This has been added to the List of Acronyms.

39. Were any of the blank QA/QC data submitted for review? No chain-of -custody sheets were included that would have documented which samples were QA/QC blanks.

AGREE. The QA/QC blank sample data have been included in Appendix J.

EXECUTIVE SUMMARY

The Savannah River Site (SRS) is located in Aiken, Barnwell, and Allendale counties, in South Carolina. The Burma Road Rubble Pit (BRRP), also known as the Rubble Pit 231-4F, is located in Aiken County, South Carolina. Certain activities at the SRS require operating or post closure permits issued in accordance with Resource Conservation and Recovery Act (RCRA). The SRS received a RCRA permit from the South Carolina Department of Health and Environmental Control (SCDHEC). This permit mandated that SRS establish and implement a RCRA Facility Investigation program to fulfill the requirements of Hazardous and Solid Waste Amendments (HSWA) Section 3004 (u).

On December 21, 1989, SRS was included on the National Priorities List (NPL). In accordance with Section 120 of Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA), the Department of Energy (DOE) negotiated a Federal Facility Agreement (FFA) with the Environmental Protection Agency (EPA) and the SCDHEC to coordinate cleanup activities at SRS.

The detailed and combined RCRA Facility Investigation (RFI) and Remedial Investigation (RI) for this site determined whether hazardous substances were present in the subsurface, evaluated the nature and extent of contamination, and evaluated the risks posed to the SRS facility due to activities conducted at the BRRP.

The RFI/RI investigation was conducted from November 1993 to February 1994 at the BRRP. To this end, this investigation included performing a ground penetrating radar (GPR) survey, a magnetometer survey, an electromagnetic survey, a soil gas survey, soil sampling, surface water and sediment sampling, groundwater well installation and sampling, and a piezocone/hydrocone investigation.

The BRRP unit consists of two unlined earthen pits dug into surficial soil and filled with various waste materials. The BRRP was used from 1973 until 1983 for the disposal of dry inert rubble such as metal, concrete, lumber, poles, fixtures, and glass. No record of disposal of hazardous substances at the BRRP has been found. In 1983, the BRRP was closed by covering it with soil.

A GPR survey detected three disturbed areas of soil near the BRRP site. Two of these areas are generally rectangular and are suspected to be pits filled with waste materials. A third area of disturbed soil southwest of these pits is believed to contain soil used for backfilling the two pits.

Surface and subsurface soil samples were collected from seventeen locations on site. Soil borings indicate that the soil in the vicinity of the BRRP is of a sandy constituency. Metals, semi-volatile organic compounds, volatile organic compounds, radionuclides, and one pesticide (Aldrin) were detected in soil samples. **Arsenic and beryllium were detected at concentrations that exceeded either the criterion background concentration (CBC), which is equal to two times the average unit-specific background concentration, or the residential risk-based concentration (RBC) for soils. There were no volatiles, semi-volatiles, or pesticides, PCBs, or dioxins/furans detected in soil samples that exceeded either the CBC or RBC levels. There were several radionuclides that exceeded the screening criteria; however, once the risk assessment was completed they were shown to pose no human health risk.**

Metals, volatile organic compounds, semi-volatile organic compounds, radionuclides, and one pesticide were detected in groundwater samples. **Of the compounds detected, nitrate/nitrite (as nitrogen), mercury, carbon tetrachloride, gross alpha particle activity, tritium, and thorium-234 were detected at concentrations that exceeded primary Safe Drinking Water Act-Maximum Contaminant Level (SDWA-MCL) standards. These compounds were shown to be due to migration from upgradient sources.**

Surface water and sediment samples were taken from a borrow pit southeast of the BRRP site (Plate A). Compounds were not detected in surface water **and** sediment samples at concentrations that exceeded **the screening criteria. Arsenic was** detected in runoff sediment samples at concentrations that exceeded **the RBC levels.**

For the soil and sediment samples, it should be noted that since arsenic was used as a component of agricultural chemicals in the period before the SRS existed, the detected arsenic values may be a result of farming activities in the 1930's through 1950.

Based on the review of the analytical data and the screening techniques used to determine the constituents of concern, it is being proposed that no action be performed at the BRRP unit. Analytical data from surface and subsurface soils, sediments, and surface water samples have been demonstrated to pose no risk. However, since the groundwater contamination detected at the BRRP is due to migration from upgradient sources, it is being proposed that the contamination be cleaned up under the RCRA Corrective Action Plan for groundwater remediation in the F- and H-Areas.

be attributed to up-gradient sources. Those contaminants which may have the BRRP as a source, exhibit concentrations which are below the F & H Remediation Goals.

The source was characterized by the geophysical surveys, the soil gas surveys, and the documentation generated while drilling through the pits in the process of acquiring soil samples. Field screening via an OVA was also documented and utilized as part of the source characterization.

Based on the field investigation, SRS believes that the nature and extent of contamination associated with the BRRP are adequately defined. As stated in the BRA, the risks and hazards attributable to the constituents present in the BRRP are below accepted EPA action levels. For future on-unit workers and future resident scenarios, the carcinogenic risk determined in the BRA is less than 1E-04 and the non-carcinogenic hazard is less than 1.0 except for nitrate/nitrite. These values are consistent with recent EPA guidance and indicates that No Action is required to protect human health or the environment.

Changes to this revision include:

- Revised Table 5-18 (included borehole numbers for beryllium)
- Revised Table 5-9 (included RBC for chloromethane)
- Revised Table 5-30 (included number of detections above RBC for Cesium-137 and the borehole numbers where the detections occurred)
- Changed the lead "at the tap" action level from 50 ug/L to 15 ug/L
- Clarified the path forward for the groundwater at the unit
- Provided additional information on Thorium-234 (e.g., sources of contamination, parent elements, etc.)

DOCUMENT APPROVAL

The RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report for the Burma Road Rubble Pit (231-4F) concludes that no further action is needed at this waste unit.

All SCDHEC comments on the RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report for the Burma Road Rubble Pit (231-4F), revision 1, have been addressed and are reflected in the revision 1.1.

Document approval is requested by September 19, 1995 in order to meet the regulatory submittal of September 20, 1995.

ATTACHMENTS

RFI/RI Report revised pages (rev. 1.1) with WSRC approval page

Certification page requiring DOE signature

Copy of responses to SCDHEC comments on the revision 1

DOCUMENT APPROVAL SUMMARY
RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION REPORT FOR THE BURMA ROAD RUBBLE PIT (231-4F) (U)

DOE FIELD OFFICE

Savannah River Operations Office

DOCUMENT

RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (231-4F) (U) - Revision 1.1, September 1995

REGULATORY SUMMARY

The RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report for the Burma Road Rubble Pit (231-4F) was developed by request of the regulators to justify the No Action Proposed Plan. This revision incorporates comments from SCDHEC on the revision 1 document. EPA approval of the revision 1 document has been received.

BACKGROUND

The Burma Road Rubble Pit (BRRP) (231-4F) was constructed in 1951. Hazardous and radioactive wastes were not permitted in the Rubble Pit. From 1973 until 1983, the pits received predominantly construction material/wastes such as lumber, plastic waste, metal waste, wire scrap, concrete, gravel, light fixtures, glass and foam. The BRRP was closed in 1983 by covering it with soil.

The BRRP was investigated from November 1993 to February 1994 for the RFI/RI Report. These investigations included a ground penetrating radar survey, a magnetometer survey, electromagnetic survey, soil gas surveys, soil sampling from the surface and seventeen borings, surface water and sediment sampling, groundwater well installation (nine wells) and sampling, and a piezocone/hydrocone investigation. The primary objectives of the investigation of the BRRP were to determine whether hazardous substances are present, to determine the extent of contamination existing in adjacent soils and groundwater, to characterize the physical environment, to evaluate the fate of possible contaminants, and to assess the human health and ecological risks as a result of contamination.

Soil sampling analysis was conducted on surface soils and subsurface soils from the base of the pit until two consecutive samples field screened as clean. Soil sample contaminants in this investigation were compared to criterion background concentration (CBC) (e.g., two times site specific background) as a screening device. If the contaminant exceeded the CBC, the sample was then compared to the risk-based concentration (RBC). If the value exceeded both the CBC and the RBC, then that contaminant merited further analysis in the Baseline Risk Assessment (BRA).

Groundwater flow at the BRRP is generally from the east. The F-Area Inactive Process Sewer Line, which transported the waste water to the F-Area Seepage Basins, is up-gradient to the BRRP. The majority of the groundwater contamination in the BRRP can

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List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirements
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
BNA	Base Neutral Acid
BRRP	Burma Road Rubble Pit
CBC	**Criterion Background Concentration**
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSRA	**Central Savannah River Area**
DOE	Department of Energy
DWEL	Drinking Water Equivalent Level
EM	Electromagnetic Survey
ESADDI	**Estimated Safe and Adequate Daily Dietary Intakes**
FFA	Federal Facility Agreement
GLM	**Griffins Landing Member**
HRS	**Hazard Ranking System**
GPR	Ground Penetrating Radar
HSWA	Hazardous and Solid Waste Amendments
LT	**Less Than (Detection Limit)**
MSA	(Standard) Metropolitan Statistical Area
MSL	Mean Sea Level
NPL	National Priorities List
OVA	Organic Vapor Analyzer
PCB	Polychlorinated Biphenol
PPB	Parts Per Billion
PPM	Parts Per Million
PRAL	**Proposed RCRA Action Level**
PRG	**Preliminary Remediation Goal**
RBC	**Risk-Based Concentration**
RCRA	Resource Conservation and Recovery Act
RDA	**Recommended Dietary Allowance**
RFI	RCRA Facility Investigation
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study

List of Acronyms (continued)

SARA	Superfund Amendment and Reauthorization Act
SDWA MCL	Safe Drinking Water Act Maximum Contaminant Level
SCDHEC	South Carolina Department of Health and Environmental Control
SREL	Savannah River Environmental Laboratory
SRS	Savannah River Laboratory
STR	**Subcontract Technical Representative**
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TOX	Total Organic Halogens
UTR	**Upper Three Runs**
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WSRC	Westinghouse Savannah River Company

CERTIFICATION PAGE

Revision 1.1
RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (U)

"I certify under the penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations."

Date: 9/19/95

Signature: C. Bener for AMS
Title: A. M. Schwartzman, Manager
Environmental Restoration
Westinghouse Savannah River Company
Contractor for the U. S. Department of Energy
Savannah River Operations

Date: 9/20/95

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Title: C. V. Anderson, Director
Environmental Restoration Division
U.S. Department of Energy
Savannah River Field Office

REGULATORY DOCUMENT PREPARATION SUMMARY AND APPROVAL FORM

Rev. 5

A. DOCUMENT REQUIREMENTS

ocument Title and Number: ESH-CGP-95-0456 Submittal of the Rev.1.1 RFI/RI Report for the Burma Road Rubble Pit (WSRC-RP-94-1217)

Regulatory Agency Due Date:

B. DOCUMENT PREPARATION

Div. and Dept. Preparing Document: SWER

SRS Procedures/Regulatory Driven Used in Preparation: FFA

(Procedures summarize document preparation and quality assurance.)

For Organizations other than EPD:

Preparer and Title: S. McFalls

Preparer's Signature: Shelia L. McFalls Date: 9-15-95

C. EPD REVIEW

Date Document Received:

Review Actions: Transmit and comment response review

EPD Coordinator and Title: (Qualifications on file at EPD)

Coordinator's Signature: EBDeWitt Date: 9-18-95

D. GENERAL COUNSEL OFFICE (GCO) REVIEW

Date Document Received:

Review Actions: ☐ Comments Resolved (If Any)

CO Reviewer and Title:

Signature: Date:

E. WSRC APPROVALS

Document Approvals, as required: Document Classification: (Attach OSR 14-357, Document Approval Sheet)

EPD Manager J. W. Cook EBDeWitt for Date Approved: 9-18-95

ER Manager A. Schwartzman for AMS Date Approved: 9/18/95

Mgr. Name GFS K. S. Wierzbicki K S Wierzbicki Date Approved: 9/15/95

VP Approval & Division Date Approved:

VP Approval & Division Date Approved:

F. DOE-SR CONCURRENCE

Concurrence Required? Y ☑ N ☐ Date Transmitted to DOE-SR: 9-18-95

Name:	Division:	Signature:	Date:
C. V. Anderson	DOE-ERD		9/20/95
A. B. Gould	DOE-ECD		9/19/95

G. TRANSMITTAL & DOCUMENT CONTROL

:received from DOE-SR 9-21-95

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Date sent to Rec. Administration 9-22-95

Revision 1.1
RCRA Facility Investigation/Remedial Investigation Report for the Burma Road Rubble Pit (U)

Printed in the United States of America

Prepared For
U.S. Department of Energy
and
Westinghouse Savannah River Company

WSRC-RP-94-1217, Rev. 1.1
SEPTEMBER 1995

FINAL
RFI/RI REPORT
BURMA ROAD RUBBLE PIT (231-4F) (U)

VOLUME I

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-89SR18035

1.0 INTRODUCTION

1.1 Purpose of the RCRA Facility Investigation/Remedial Investigation

1.1.1 *The RCRA Facility Investigation (RFI) Program*

The Savannah River Site (SRS) is located in Aiken, Barnwell and Allendale counties, in South Carolina. The SRS manages certain waste materials which are regulated under the 1976 Resource Conservation and Recovery Act (RCRA). RCRA is a comprehensive law requiring stringent management of hazardous wastes. The Hazardous and Solid Waste Amendments (HSWA) were passed in 1984 to further augment the 1976 RCRA requirements.

Certain activities conducted at the SRS require operating or post closure permits issued in accordance with RCRA. Disposal units covered under RCRA and HSWA are classified as either regulated or non-regulated. Regulated units are those surface impoundments, landfills, and waste piles (collectively termed "land-disposal units") which have received hazardous waste since November 19, 1980 and require RCRA operating or post-closure permits. The SRS has received a RCRA permit from the South Carolina Department of Health and Environmental Control (SCDHEC). Part V of the permit mandates that SRS establish and implement a RCRA Facility Investigation program to fulfill the requirement of HSWA Section 3004 (u).

HSWA Section 3004 (u) mandates investigation and corrective action at non-regulated units. These non-regulated units have been termed Solid Waste Management Units (SWMUs) and include units where hazardous constituents are uncontrolled and could be released to the environment. Section VA.1 of the SRS RCRA Permit lists 65 SWMUs that were identified by the United States Environmental Protection Agency (EPA) Region IV through the RCRA Facility assessment process. The permit mandates that these 65 SWMUs be further investigated to determine the actual or potential impact of each unit to the environment. The Burma Road Rubble Pit (BRRP) is a non-regulated unit that must be addressed in accordance with the permit requirements.

1.1.2 *CERCLA Remedial Investigation (RI) Program*

The Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), regulates the investigation and cleanup of hazardous waste sites. The Hazard Ranking System (HRS) is used to evaluate the risks that hazardous waste sites pose to human health and the environment. The National Priorities List (NPL) is a list of hazardous waste sites which pose the most significant risk to human health or the environment. On the basis of HRS scores and state requests, sites are placed on the NPL.

On December 21, 1989, SRS was included on the NPL. In accordance with Section 120 of CERCLA, the DOE has negotiated a Federal Facility Agreement (FFA) with the EPA and the SCDHEC to coordinate cleanup activities at SRS.

A detailed remedial investigation (RI)/ feasibility study (FS) is required for sites which are listed on the NPL. The RI/FS evaluates the nature and extent of risks posed by hazardous waste sites and evaluates remedial options in order to select the best remedial alternative. The RI serves as a mechanism to collect data to characterize conditions on site, to evaluate the fate of contaminants on site, and to assess the risks to humans and the environment, which result from site conditions. The FS uses the site specific information generated during the RI to evaluate remedial alternatives and to select an appropriate remedy for the site.

This RFI/RI report contains the results of the investigation conducted from November 1993 to February 1994 at the BRRP. This investigation included a ground penetrating radar (GPR) survey, a magnetometer survey, an electromagnetic survey, a soil gas survey, soil sampling, surface water and sediment sampling, groundwater well installation and sampling, and a piezocone/hydrocone investigation. This report presents an evaluation of the results of these investigations to characterize the site and contamination on site and presents recommendations for future action.

The primary objectives of this investigation of the BRRP were to determine whether hazardous substances are present, to determine the extent of contamination existing in adjacent soils and groundwater, to characterize the physical environment, to evaluate the fate of possible contaminants, and to assess the human health and ecological risks as a result of contamination. More specific objectives of this RFI/RI investigation are detailed in Section 3.

1.2 Unit Background

1.2.1 *Unit Location and Description*

The BRRP, also known as the Rubble Pit 231-4F, is located at the SRS (formerly the Savannah River Plant) in Aiken County, South Carolina (Figure 1-1). The BRRP is approximately one-half mile

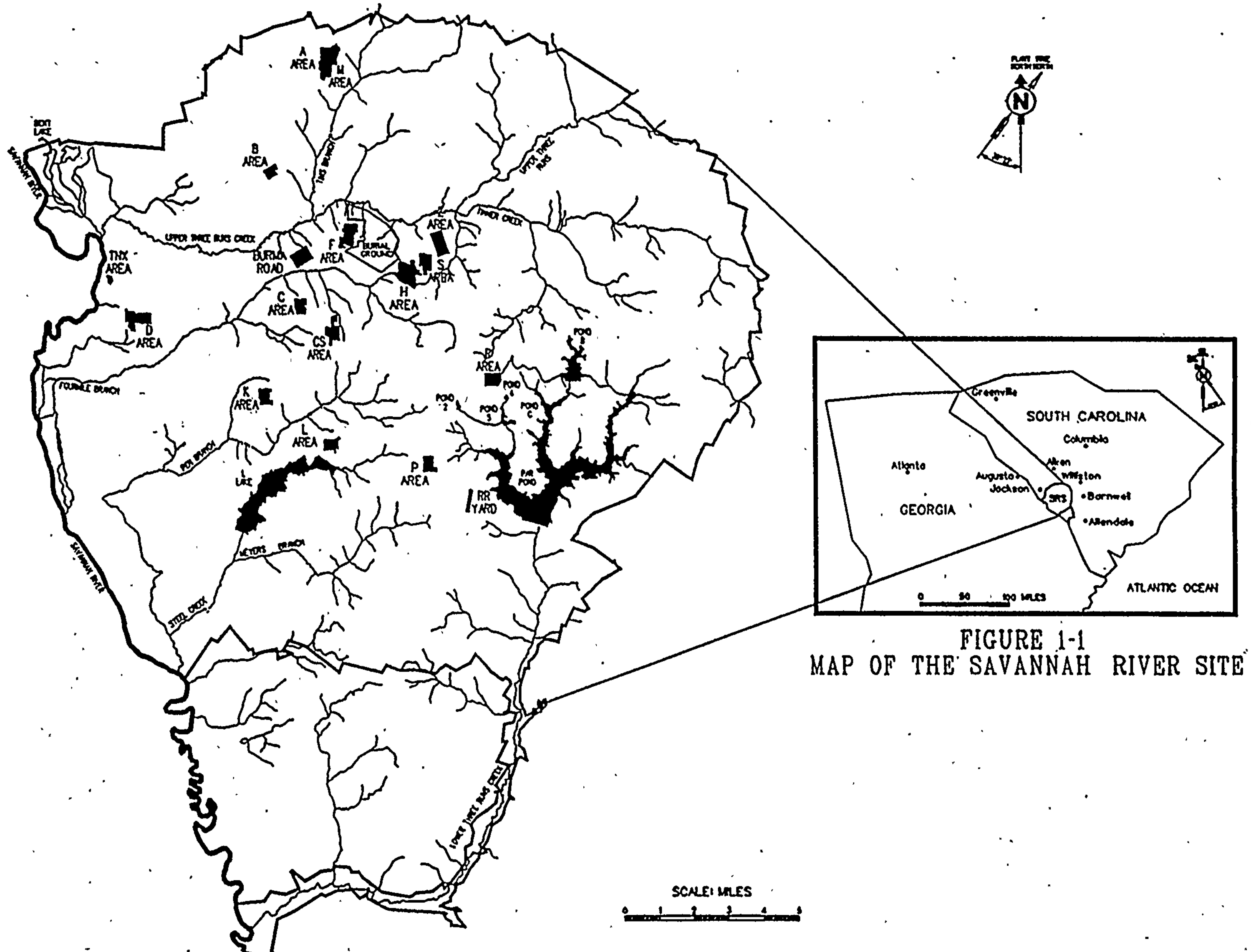

FIGURE 1-1
MAP OF THE SAVANNAH RIVER SITE

southwest of the F-Area Separations Facility and one-tenth mile southwest of C Road (Figure 1-2). The BRRP is located between Upper Three Runs Creek (approximately 4000 feet to the northwest) and Four Mile Creek (approximately one mile to the southwest). Plate A is an aerial photograph of the site location.

The BRRP unit consists of two unlined earthen pits dug into surficial soil and filled with various waste materials. The BRRP was originally reported to be 485 feet long, 125 to 150 feet wide, and at least 10 feet deep. Recent GPR data indicate that the BRRP area consists of two generally rectangular pits, each about 400 feet long, up to 50 feet wide and 10 feet deep (GPR Zones 1 and 2, Figure 1-3). A small circular area of disturbed soil (GPR Zone 3, Figure 1-3) was detected adjacent to these pits and may have been used as a source of backfill for the other two pits.

1.2.2 *Unit History*

The BRRP was used from 1973 until 1983 for the disposal of dry inert rubble such as metal, concrete, lumber, poles, light fixtures, and glass (Plates B-D). No record of the disposal of hazardous substances at the BRRP has been found (Gordon *et al.*, 1987). In 1983, the BRRP was closed by covering it with soil. Plate E illustrates the current condition of the BRRP. The area is currently delineated by orange marker balls.

1.2.3 *Previous Investigations*

1.2.3.1 Ground Penetrating Radar (GPR) Survey

As discussed above (Section 1.2.1) a GPR survey has detected three disturbed areas of soil. Two of these areas are generally rectangular (400 feet long, 50 feet wide and 10 feet deep) and are suspected to be pits filled with waste materials. A third area of disturbed soil southwest of these pits is believed to contain soil used for backfilling the two pits.

1.2.3.2 Ground Water Sampling

Five monitoring wells (BRR-1D through BRR-5D, Figure 1-4) were installed in 1990 in the vicinity of the BRRP to monitor groundwater quality. Analyses of groundwater samples collected from the second quarter of 1990 through the second quarter of 1992 indicated that tritium, lead, manganese, iron, chromium, total organic halogens (TOX), total radium, and alpha radium have exceeded the

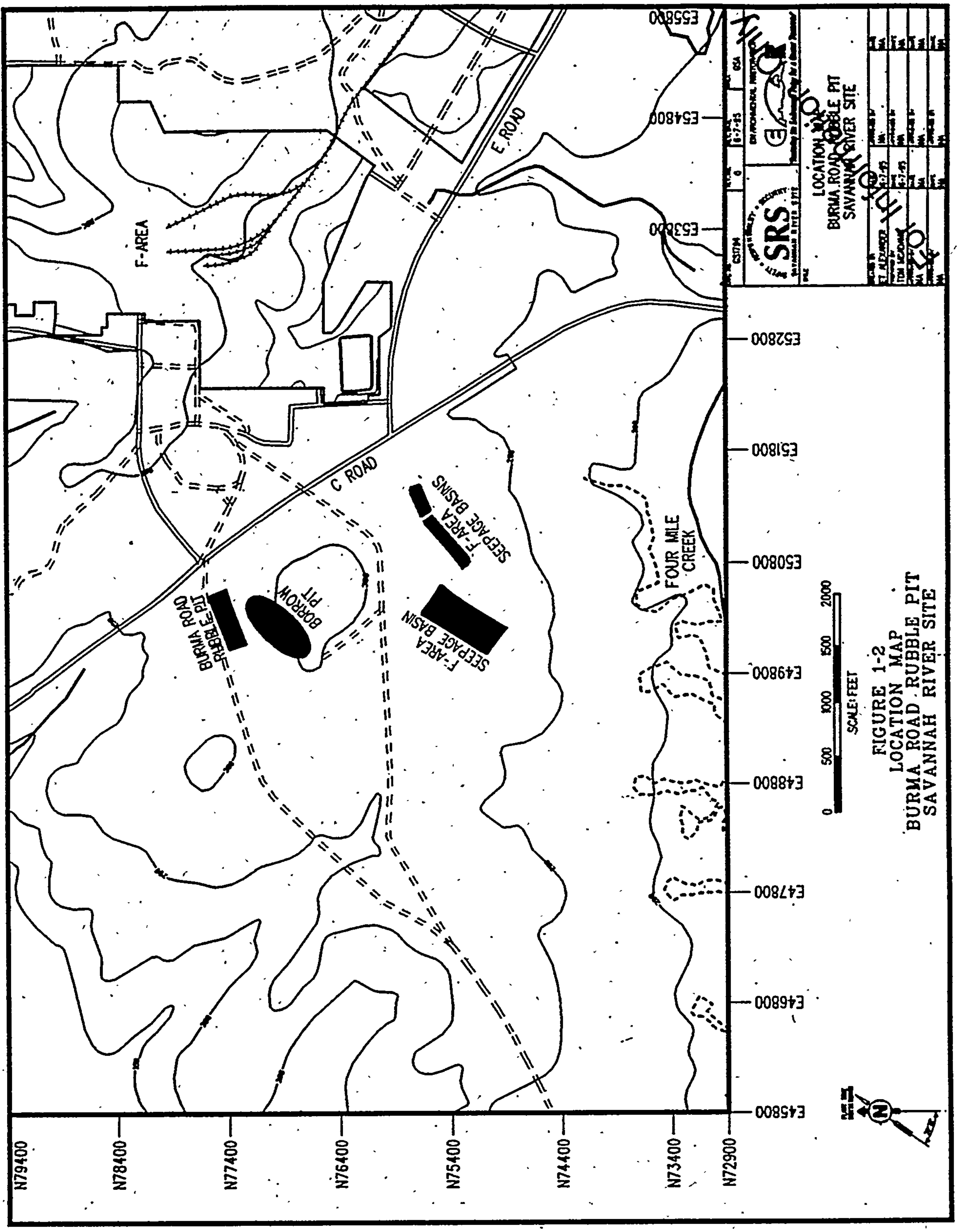

FIGURE 1-2
LOCATION MAP
BURMA ROAD RUBBLE PIT
SAVANNAH RIVER SITE

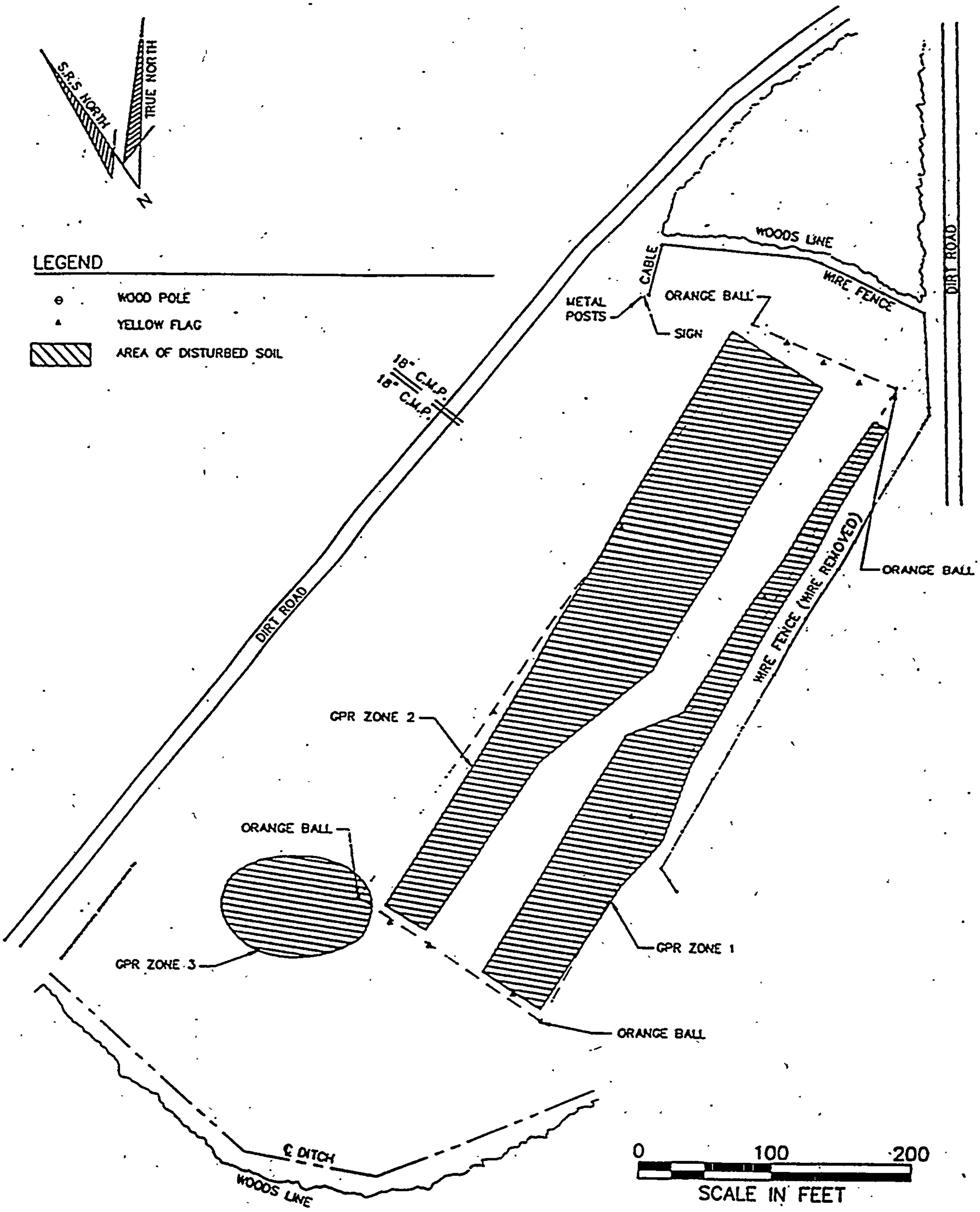

Figure 1-3 - Burma Road Rubble Pit.

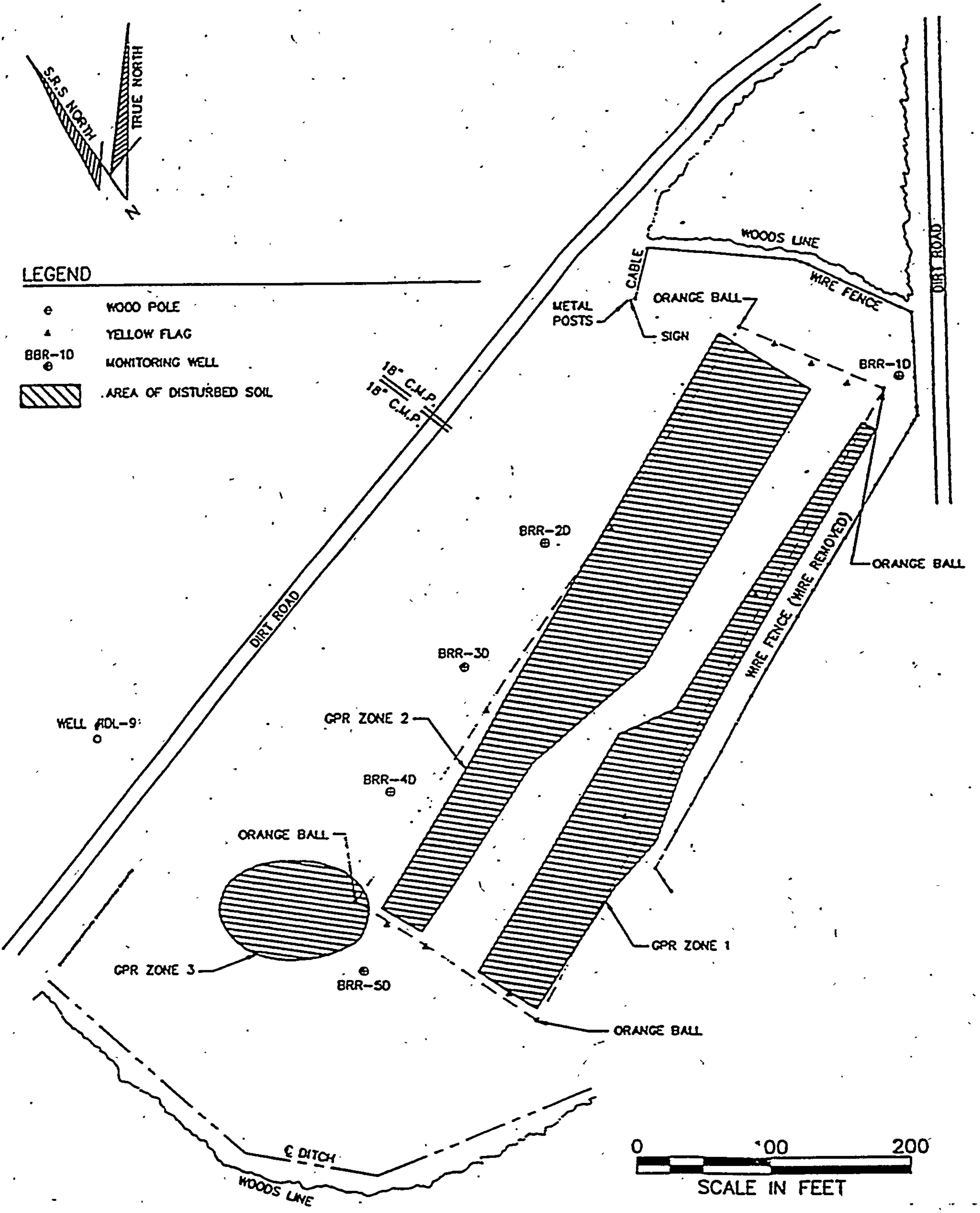

Figure 1-4 - Burma Road Rubble Pit.

primary drinking water standards (Safe Drinking Water Act Maximum Contaminant Levels, SDWA MCL) in at least one BRR well during this time (Table 1-1). Chromium concentrations exceeded the MCL in wells BRR 1, BRR 3, BRR 4, and BRR 5 in the second quarter of 1990 samples, but were below the MCL in all BRR wells in the third quarter of 1990 samples. Total radium exceeded the MCL once (BRR 3, third quarter of 1991). Alpha radium also exceeded the MCL in only one sample (BRR 3, second quarter of 1992).

The groundwater samples collected from the second quarter of 1990 through the second quarter of 1992 were filtered. Samples collected in this RFI/RI investigation have not been filtered. Therefore, the earlier data is not suitable for direct comparison with the data collected in this investigation, and has been presented as historical information only.

Figure 1-5 illustrates the water table surface **(i.e., the regional groundwater flow direction)** in the vicinity of the BRRP as calculated from **second quarter (April - June) 1994** data from nearby wells. The map indicates west-northwestward flow of the shallow aquifer system groundwater in the BRRP area. The water table in the BRRP area was found from 61 to 83 feet below the ground surface.

Groundwater data from two nearby areas, the F-Area Seepage Basins and the F-Area Separations Facility, suggested the possibility that these areas may have impacted the BRRP. The F-Area Separations Facility is located approximately 2,000 feet northeast of the BRRP. Wells screened in the water table indicate the water levels are 11 feet higher at the F-Area Separations Facility than at the BRRP. Limited groundwater data are available from this area. Radioisotope analyses of groundwater data from the F-Area Separation Facility indicate no contamination above background levels (WSRC, 1993). Well cluster BRR 6 has been installed as part of the RFI/RI to determine if groundwater at the BRRP has been impacted by contaminants from the F-Area Separations Facility.

The F-Area Seepage Basins are located approximately 1,100 feet to the southeast of the BRRP. Tritium has been detected at concentrations greater than background levels in two monitoring wells adjacent to the basins.

Table 1-1 Summary of Constituents above Primary Drinking Standards (in any one BRR well during quarter, 2Q90-2Q92)

QUARTER	ANALYTE	BRR1D	BRR2D	BRR3D	BRR4D	BRR5D	UNITS
2Q1990	Tritium	16	110*	83*	21*	13	pCi/ml
3Q1990	Tritium	17	120*	71*	89*	11	pCi/ml
4Q1990	Tritium	17	140*	150*	79*	6	pCi/ml
1Q1991	Tritium	15	160*	73*	100*	7.1	pCi/ml
2Q1991	Tritium	18	190*	63*	150*	10	pCi/ml
3Q1991	Tritium	11	180*	260*	130*	7.6	pCi/ml
4Q1991	Tritium	6.9	210*	89*	120*	7	pCi/ml
1Q1992	Tritium	6.8	140*	320*	30*	6	pCi/ml
3Q1990	Lead	<2	733*	50*	3.9	5	ug/l
3Q1991	Lead	<3	<3	16*	<3	5.1	ug/l
1Q1992	Lead	20*	<3	8.5	<3	4.5	ug/l
2Q1992	Lead	11	24*	8.3	4.9	<3	ug/l
2Q1990	Manganese	76*	135*	192*	68*	38	ug/l
3Q1990	Manganese	55*	133*	152*	49	36	ug/l
4Q1990	Manganese	50*	75*	112*	43	18	ug/l
1Q1991	Manganese	39	61*	93*	55*	42	ug/l
3Q1991	Manganese	54*	59*	86*	27	22	ug/l
1Q1992	Manganese	54*	18	69*	37	24	ug/l
2Q1990	Iron	644*	46	1630*	904*	165	ug/l
3Q1990	Iron	130	28	17	488*	15	ug/l
1Q1991	Iron	134	49	146	562*	409*	ug/l
2Q1990	Chromium	89*	22	427*	115*	45*	ug/l
2Q1990	TOX	32*	<5	<5	15	<5	ug/l
4Q1990	TOX	26*	<5	<5	15	<5	ug/l
3Q1991	TOX	5080*	104*	31	<5	<5	ug/l
4Q1991	TOX	<5	<5	11	68*	10	ug/l
1Q1992	TOX	22	84*	8.8	8.8	<5	ug/l
3Q1991	Total Radium	1.9E-9	1.6E-9	7.0E-9*	<1.0E-9	<1.0E-9	uCi/l
2Q1992	Alpha Radium	1.3E-9	1.9E-9	1.0E-8*	<1.0E-9	1.1E-9	uCi/l

TOX means total organic halogens

* indicates those samples that exceed MCL

Note - data are derived from filtered samples and are not suitable for comparison with later samples.

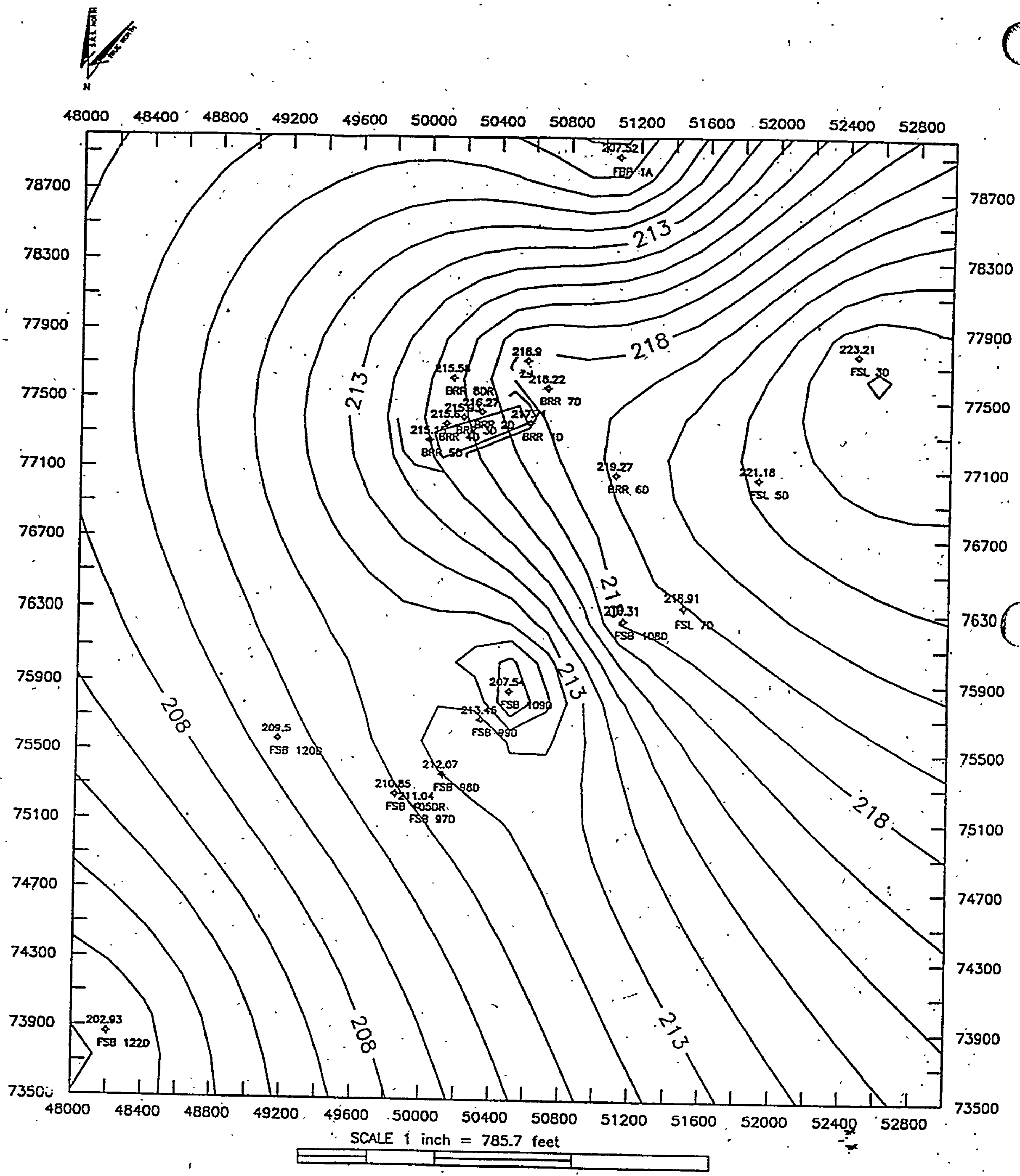

Figure 1-5 - Water Table Map (Zone 7C), F- and H-Areas (Second Quarter, 1994).

1.2.3.3 Soil Gas Survey

Three previous soil gas surveys have been carried out. A three-foot deep soil gas Geoprobe survey was conducted at the BRRP in October 1990 and in July 1991. A 10 to 20 foot deep soil gas Geoprobe survey was conducted in September 1992. The surveys were capable of monitoring the presence and distribution of light hydrocarbons (i-butane, n-butane, decane, ethane, ethylene, hexane, heptane, methane, nonane, octane, pentane, propane, and propylene), aromatic hydrocarbons (benzene, ethyl benzene, toluene, m&p xylene and o-xylene), chlorinated hydrocarbons (carbon tetrachloride, chloroform, methylene chloride, tetrachloroethylene, trichloroethylene, trans-1,2-dichloroethylene, 1,1,1-trichloroethane and vinyl chloride), and mercury. Figure 1-6 summarizes the results of these surveys. Appendix F contains the results of these surveys.

Of the chlorinated hydrocarbons, only tetrachloroethylene, trichloroethylene, trans 1,2-dichloroethylene, and 1,1,1- trichloroethane are present in amounts exceeding the minimum detection level. Tetrachloroethylene and 1,1,1-trichloroethane are present in both trenches. Concentrations of both species are low: the highest observed concentration of tetrachloroethylene was 147 ppbv at 3 feet in the northern trench; the highest observed concentration of 1,1,1-trichloroethane was 164 ppbv in the southern trench. 1,1,1-Trichloroethane was observed above the minimum detection limit in virtually every sample, while the occurrence of tetrachloroethylene was less frequent. The compound 1,1,1-trichloroethane was monitored only in survey III which largely consisted of Geoprobe sites, thus a depth distribution comparison is not possible for this compound.

The compounds trichloroethylene and trans 1,2-dichloroethylene are found only in the southern trench and largely in the eastern edge of that trench. Their distribution at 3 feet and at lower depths (samples were taken from depths as low as 25 feet) are well correlated, although the distribution of trans 1,2-dichloroethylene at depths lower than 3 feet is somewhat larger and at higher concentrations than the distribution at 3 feet.

The aromatic hydrocarbons, benzene, toluene, ethylbenzene and xylenes are present in anomalous amounts, particularly in the southern trench. These hydrocarbons could be due to the presence of gasoline or other light petroleum distillates as a part of the materials buried. In general, the observed concentrations of aromatic hydrocarbons are much larger than the chlorinated hydrocarbons.

The saturated hydrocarbons (C5-C10) are also found in anomalous concentrations particularly in the southern trench. The distribution of pentane, hexane, heptane and octane are for the Geoprobe sites

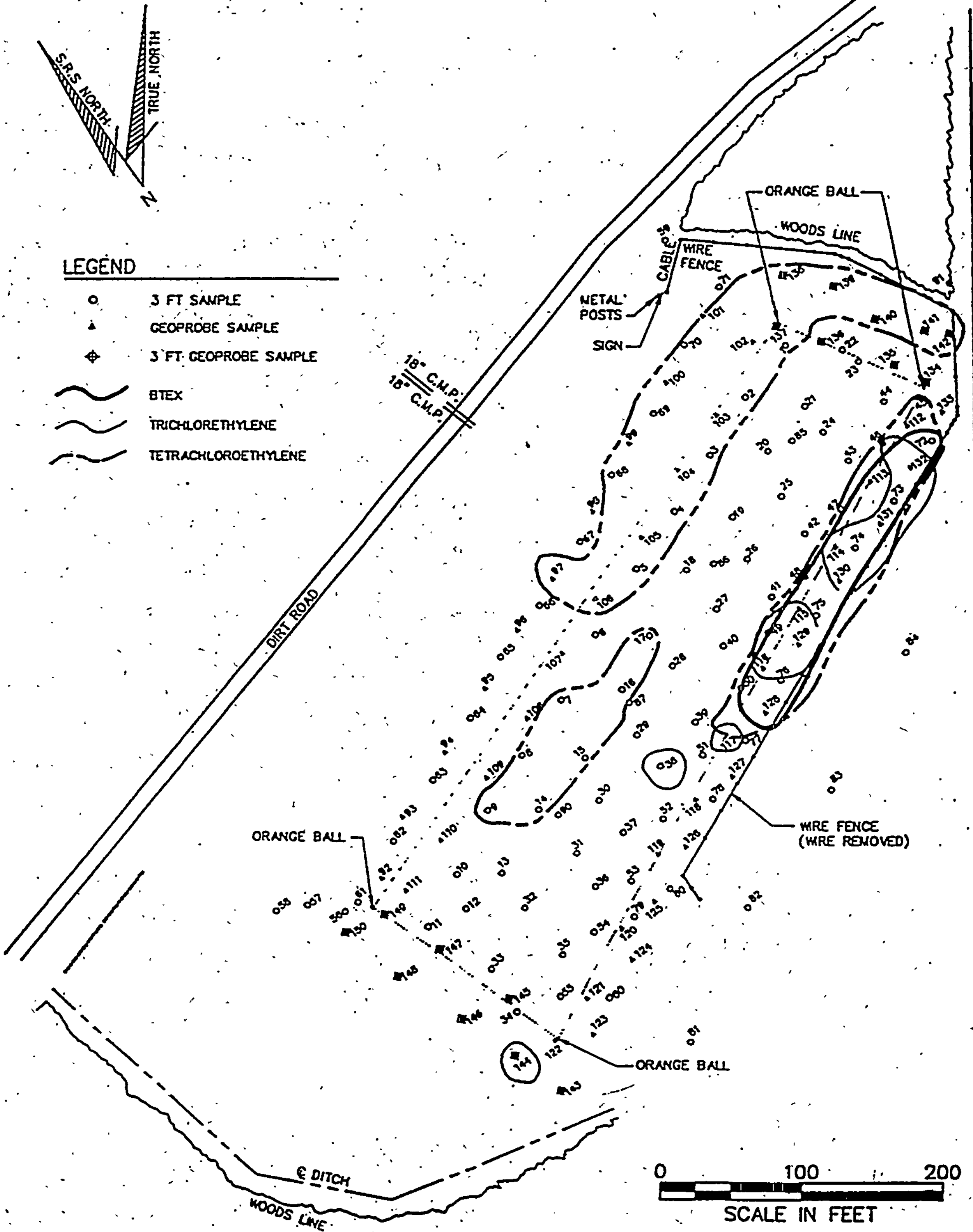

Figure 1-6 - Occurrence of Selected Organic Compounds in the Soil Gas at Burma Road Rubble Pit.

only since these hydrocarbons were measured only in Survey III. The distribution of octane and heptane are very localized and well correlated; both are similar to the distribution of the aromatics discussed above. The distribution of the hexane is also similar; however, small concentrations of hexane are observed outside the localized area of octane and heptane contamination. The distribution of pentane is much more general. It is probable that the observed distributions of hexane and pentane are comprised of two parts, the first and most prominent results from hydrocarbon fuel contamination in a restricted area of the eastern end of the southern trench. The second part results from the natural background species in the Savannah River Site area. Only in the cases of pentane and hexane do the background concentrations exceed the minimum detection levels of the analytical methods.

Anomalous levels of the light hydrocarbons are clearly associated with the observed aromatic hydrocarbons in the southern trench. The presence of methane may be due to bacterial degradation of the buried rubble. The distribution of ethane appears inversely correlated to the distribution of methane. This may be due to the fact that in the presence of very large methane concentrations, ethane is not well separated chromatographically and in these cases is not well determined. The remaining light hydrocarbons are obviously correlated to the contamination in the eastern end of the southern trench; however, these hydrocarbons are also mixtures related to the contamination and to the natural background as discussed above for pentane and hexane. It may be that the highest concentrations of the C2+ fraction are generated from the buried waste via microbial degradation.

Finally, the mobile mercury found in the soils at the BRRP are very low and probably reflect background levels only.

1.3 Report Organization

This RFI/RI Report has nine chapters. Chapter 1 describes the purpose of this investigation and summarizes background information regarding the BRRP's location, description, and history, as well as previous investigations of the BRRP. Chapter 2 discusses the characteristics of the region. Chapter 3 discusses the methods used to investigate the BRRP and the objectives of these procedures. Chapter 4 describes the results of the investigation. Chapter 5 presents the nature and extent of contamination found on site. In Chapter 6, the physical characteristics of the area and the nature and extent of contamination are analyzed to evaluate contaminant fate and transport. Chapter 7 presents the results of a human health and ecological baseline risk assessment (the full risk assessment is included as

Volume II). Chapter 8 summarizes the report and presents the conclusions of this investigation. The references are presented in Chapter 9.

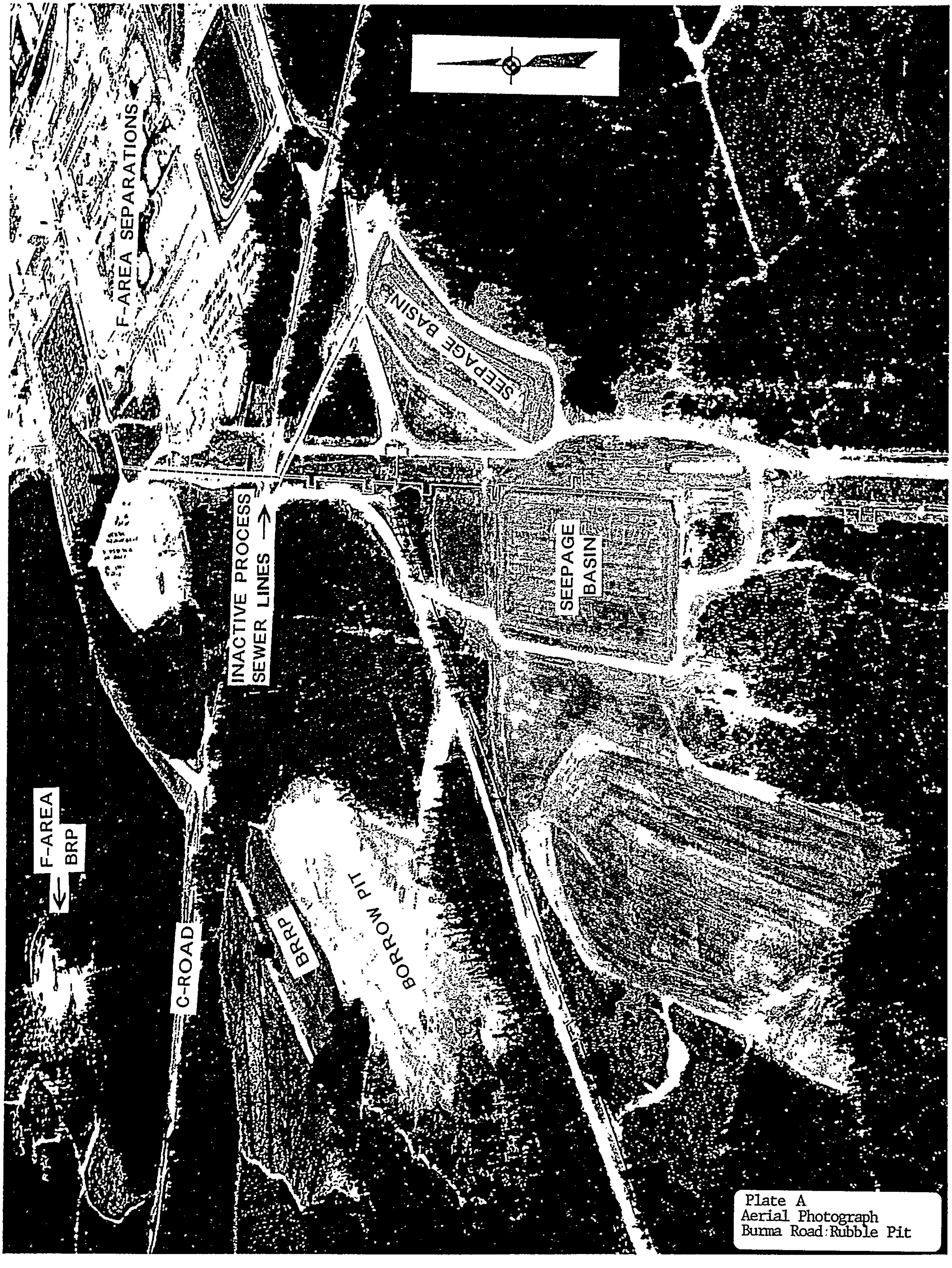

Plate A
Aerial Photograph
Burma Road Rubble Pit

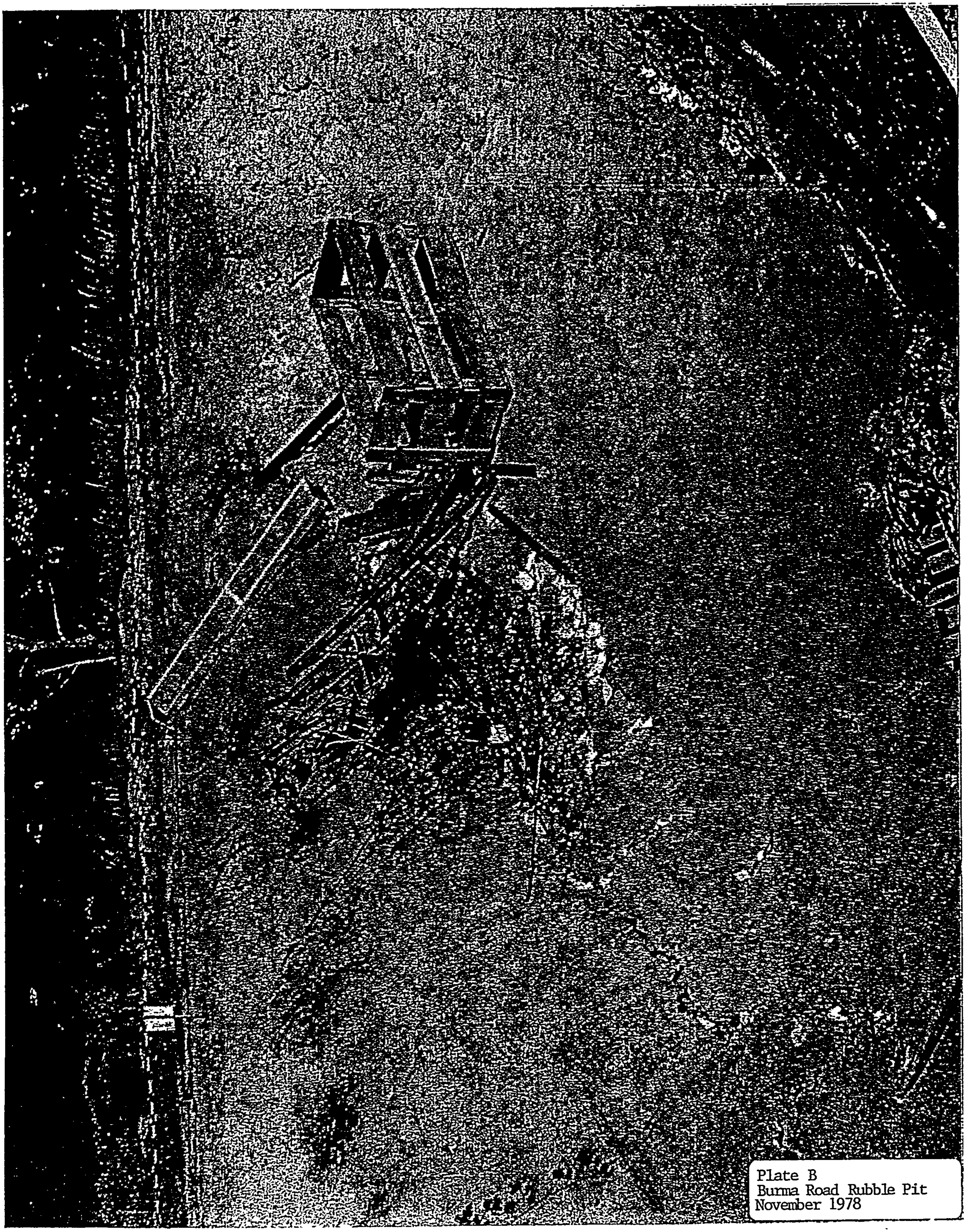

Plate B
Burma Road Rubble Pit
November 1978

Plate C
Burma Road Rubble Pit
November 1978

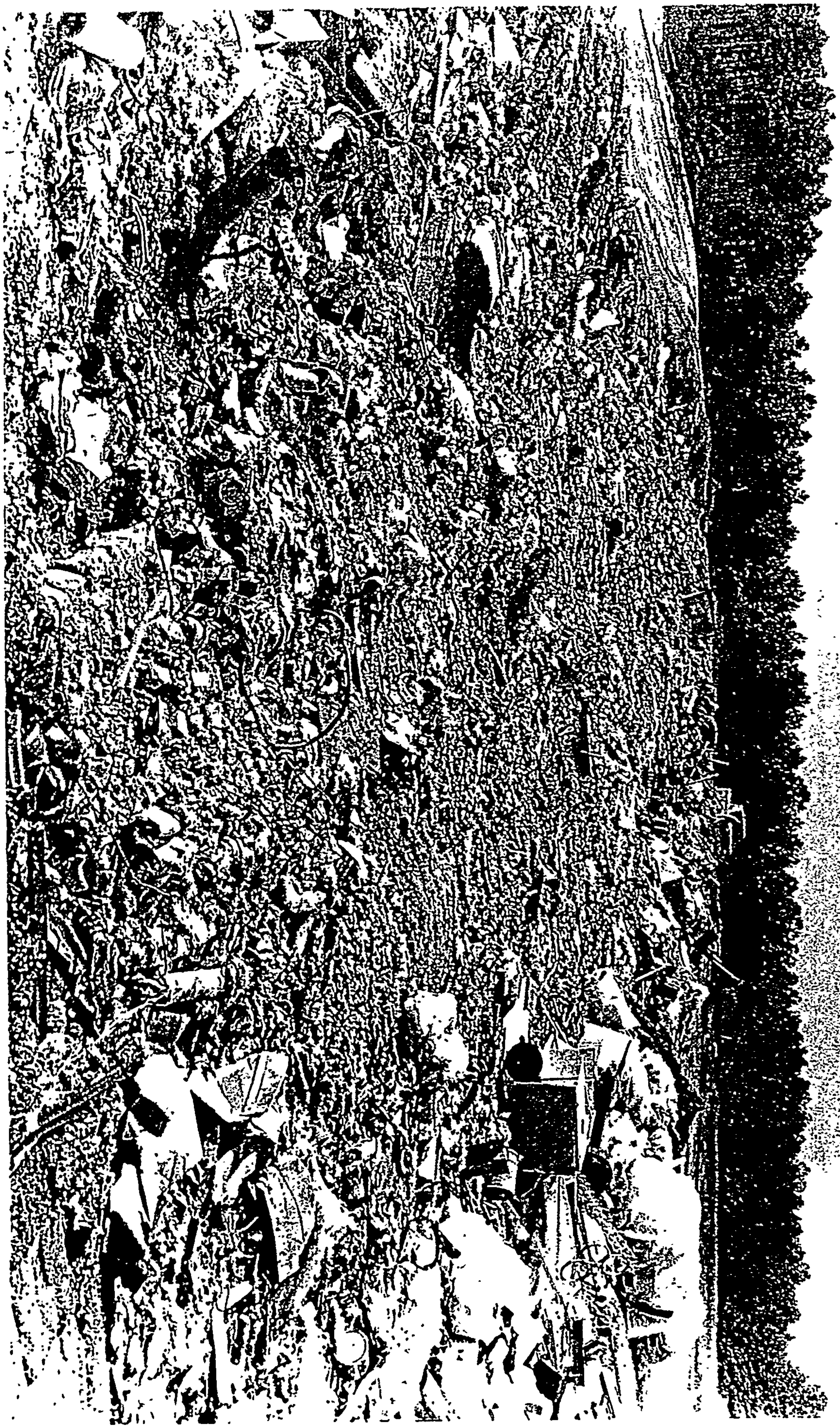

Plate D
Burma Road Rubble Pit
Circa 1983

Plate E
Burma Road Rubble Pit
CIRCA 1994

2.0 ENVIRONMENTAL SETTING

2.1 Surface Topography and Drainage Patterns

The local surface drainage for the BRRP Site flows radially to a system of swales and ditches which surround the BRRP Site. The dominant flow off-site is to the east and west, where it is intercepted by the ditch system and channelled to the west of the site. From there, runoff passes under Burma Road through a culvert. On the west side of Burma Road, the land grades generally to the south and west, toward a mixed pine-oak forest. A borrow pit, located to the east of the BRRP Site, receives runoff from its excavated sides, but surface runoff from the BRRP Site is not expected to flow toward the borrow pit because its ditch system redirects surface flow to the west (See Figure 2-1). Seeps were not observed along the west edge of the borrow pit. Therefore, leachate is not expected to drain into the borrow pit. At the time of observation, standing water was apparent at the bottom of the borrow pit. However, this was attributed to a heavy July rainfall. Reportedly, the borrow pit was dry during previous summers.

Regionally, the Four Mile Branch, the Upper Three Runs Creek, and tributaries of the Upper Three Runs Creek are the predominant surface water features in the vicinity of the BRRP Site (See Figure 2-2). Southwest flowing tributaries of the Savannah River include the Pen Branch Creek, Steel Creek, Meyers Branch Creek, and the Lower Three Runs Creek. The Upper Three Runs Creek tributary is the closest surface water body to the BRRP Site. Surface water runoff is not expected to reach the Upper Three Runs Creek tributary from the BRRP Site except under flood conditions. If flood conditions were to occur, the flow from the site would be northwestward to the tributary of the Upper Three Runs Creek.

2.2 Climate

The SRS area has a temperate climate with mild winters and relatively warm and humid summers. During the winter months the region is subject to the influence of cool continental air. The extreme effects of occasional Arctic air incursions into the United States are moderated by the Appalachian Mountains to the northwest. The site and the surrounding area are characterized by gently rolling hills with no unusual topographic features that would significantly influence the local climate (Hunter, 1989).

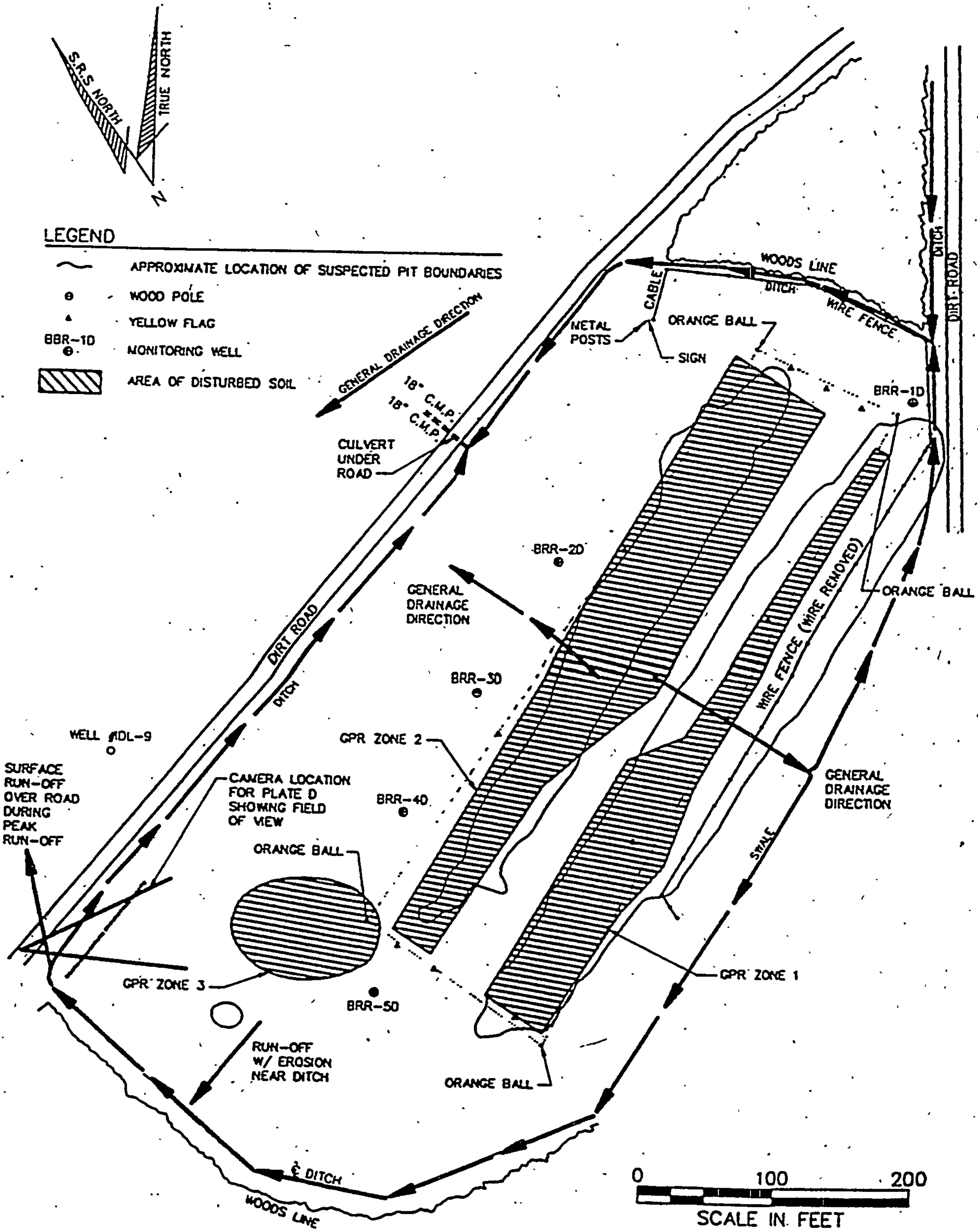

Figure 2-1 - Burma Road Rubble Pit.

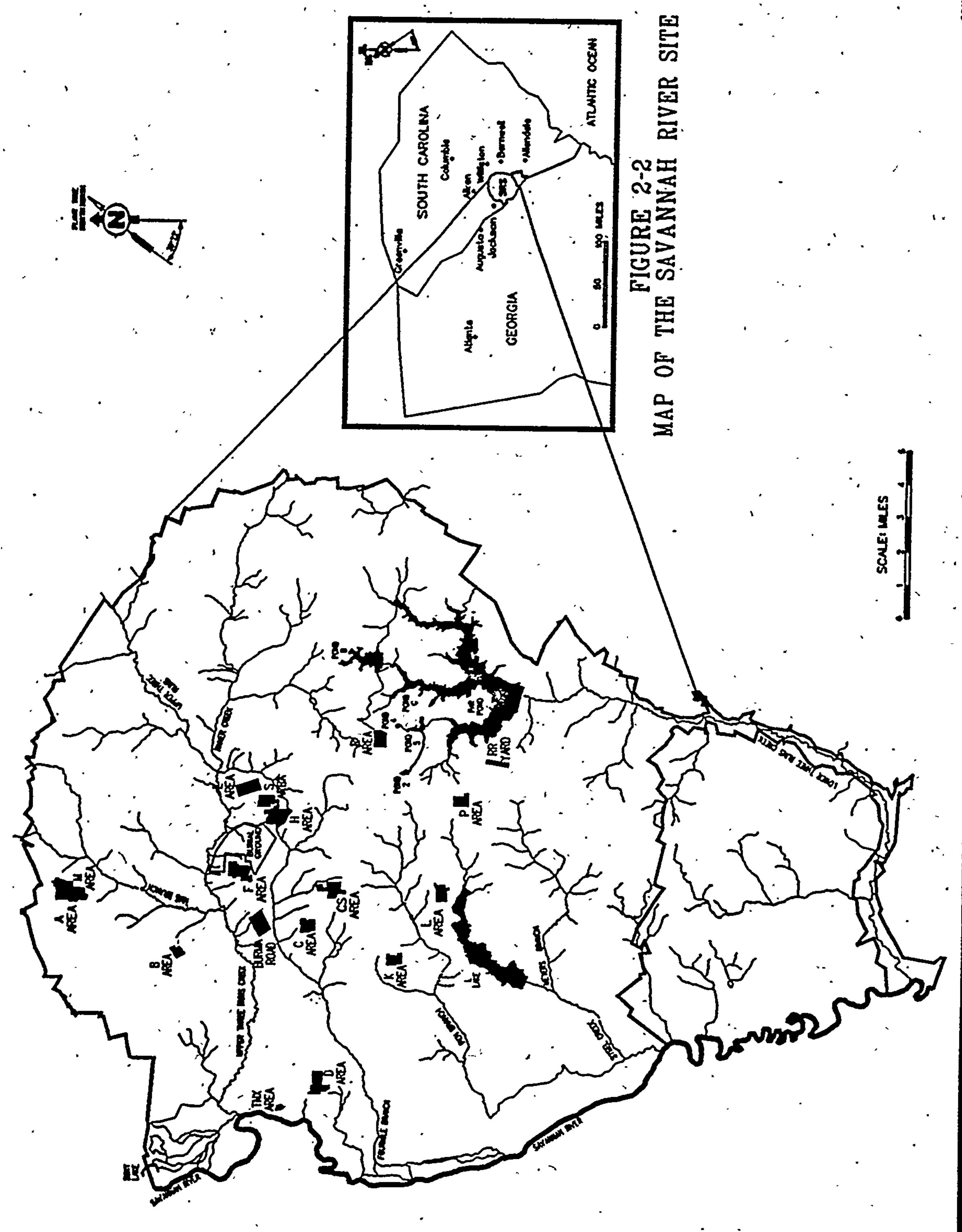

FIGURE 2-2
MAP OF THE SAVANNAH RIVER SITE

The winds in the area are relatively light with an annual average speed of about three meters per second (9.84 ft/sec). Due to seasonal changes in prevailing weather patterns, winds tend to blow somewhat more frequently from the northwest during the winter, from the west and southwest during the spring, and from the east and northeast during the summer and fall (Hunter, 1989).

Average temperatures in the SRS area are warmest in July (81.1°F) and coldest in January (45.4°F). Based on temperature data from a thirty-year period, 1961 through 1990, temperatures ranged from a maximum of 108°F to a minimum of -3°F. Temperatures below freezing occur approximately 58 days per year (Hunter, 1989).

The average annual rainfall at the SRS, based on data from 1952 through 1990, is about 122 centimeters (48 inches). Precipitation is fairly well distributed throughout the year. Average rainfall during the fall is slightly less than that for either of the other seasons. The annual average snowfall is 1.1 inches (Hunter, 1989).

On average, there are 56 thunderstorm days per year in the SRS area. Thunderstorms occur during every month of the year, but are more prevalent during summer afternoons. Thunderstorm activity in the winter and spring is associated with the passage of cold fronts through the area (Hunter, 1989).

Nearly half of the tornadoes reported in Georgia and South Carolina occur in March, April, and May. However, tornadoes have occurred during every month of the year. Based on tornado statistics for a thirty year period from 1954 through 1983, South Carolina can be expected to experience one or two tornadoes per year.

A total of thirty-six hurricanes have caused damage in South Carolina over the period from 1700 through 1900. Due to the inland location of the SRS, wind speeds usually diminish below hurricane intensity at the site (WSRC, 1991).

2.3 Physiography

Groundwater and surface water characteristics are largely controlled by physiography and subsurface stratigraphy. The following subsections present a summary of the primary physiographic features, general stratigraphic succession, and known hydrogeology surrounding the SRS. The purpose of this framework is to describe the relationships between SRS hydrogeology and larger scale hydrogeologic systems. The discussion will provide the basis for understanding the hydrogeologic framework existing at the BRRP Site.

SRS occupies an area of approximately 300 square miles of the Atlantic Coastal Plain, primarily on the Aiken Plateau (part of the "Upper Coastal Plain"). The Aiken Plateau is bounded by the Piedmont Physiographic Province on the north and by the Savannah and Congaree Rivers on the west and east, respectively. The plateau slopes southward from an elevation of 650 feet above mean sea level (MSL) at the Fall Line, which is approximately 20 miles northwest of the SRS, to its southern boundary. The southern boundary of the plateau is marked by a regional break in slope (Orangeburg scarp) at an approximate elevation of 290 feet MSL. The surface of the Aiken Plateau is characterized by broad inter-fluvial areas dissected by narrow, steep-sided stream valleys. See Figure 2-3 for further illustration.

SRS lies wholly within the Savannah River Drainage Basin, with the Savannah River forming the southwestern boundary of the SRS. Major tributaries to the Savannah River that flow southwestward across the SRS are Upper Three Runs Creek, Tinker Creek, Four Mile Creek (also known as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs Creek.

Ground surface elevations at the SRS range from approximately 70 feet MSL at the mouth of Lower Three Runs Creek to over 400 feet MSL on the Plateau.

The BRRP Site is located in an inter-fluvial area between Upper Three Runs Creek (4,000 feet to the northwest) and Four Mile Creek (1 mile to the southeast). A westward-trending tributary to the Upper Three Runs Creek is located approximately 2,000 feet to the north. The ground surface elevation at the BRRP Site is approximately 280 feet MSL. Surface runoff from the unit is northwestward to a tributary of Upper Three Runs Creek.

2.4 Geology of the SRS Area

The Atlantic Coastal Plain is underlain by a seaward thickening wedge of unconsolidated and semi-consolidated sediments. These sediments range from Late Cretaceous to Holocene in Age. The late Cretaceous sediments rest directly on saprolite derived from underlying crystalline basement rocks of Precambrian/Paleozoic age or on Triassic age sediments. A generalized cross-section of the Atlantic Coastal Plain through the SRS is shown in Figure 2-4. A generalized stratigraphic column for the SRS is shown on Figure 2-5.

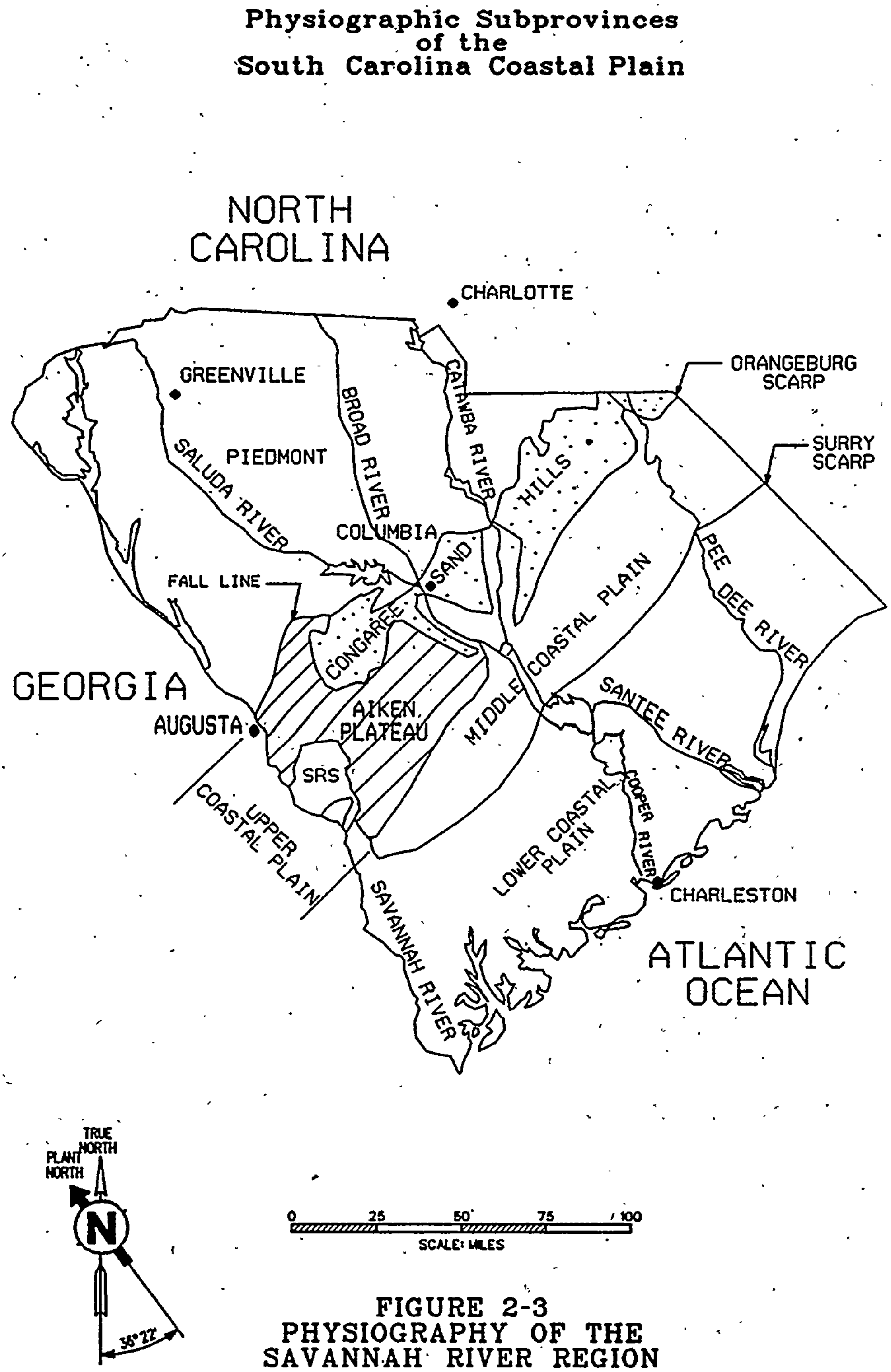

FIGURE 2-3
PHYSIOGRAPHY OF THE
SAVANNAH RIVER REGION

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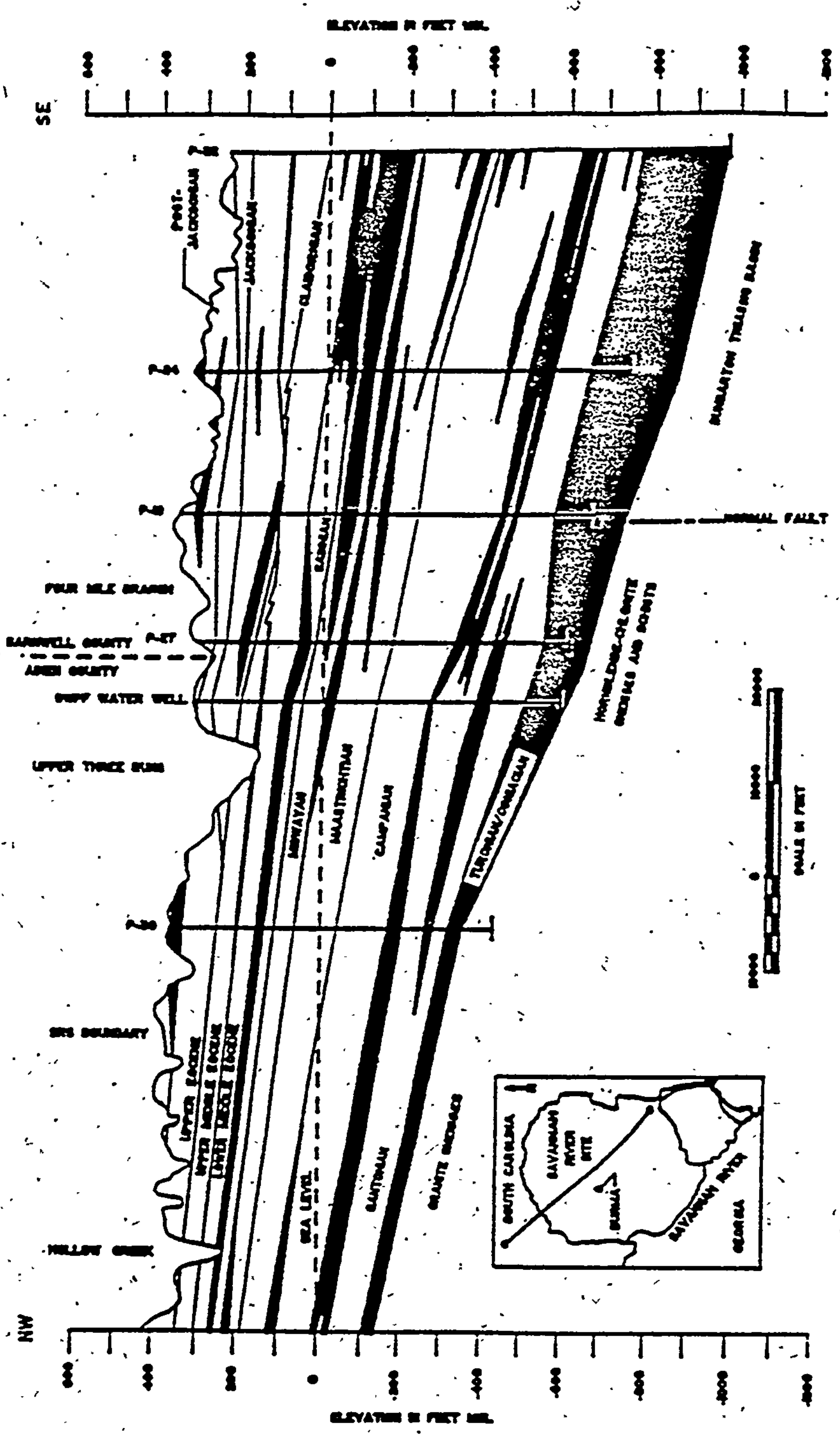
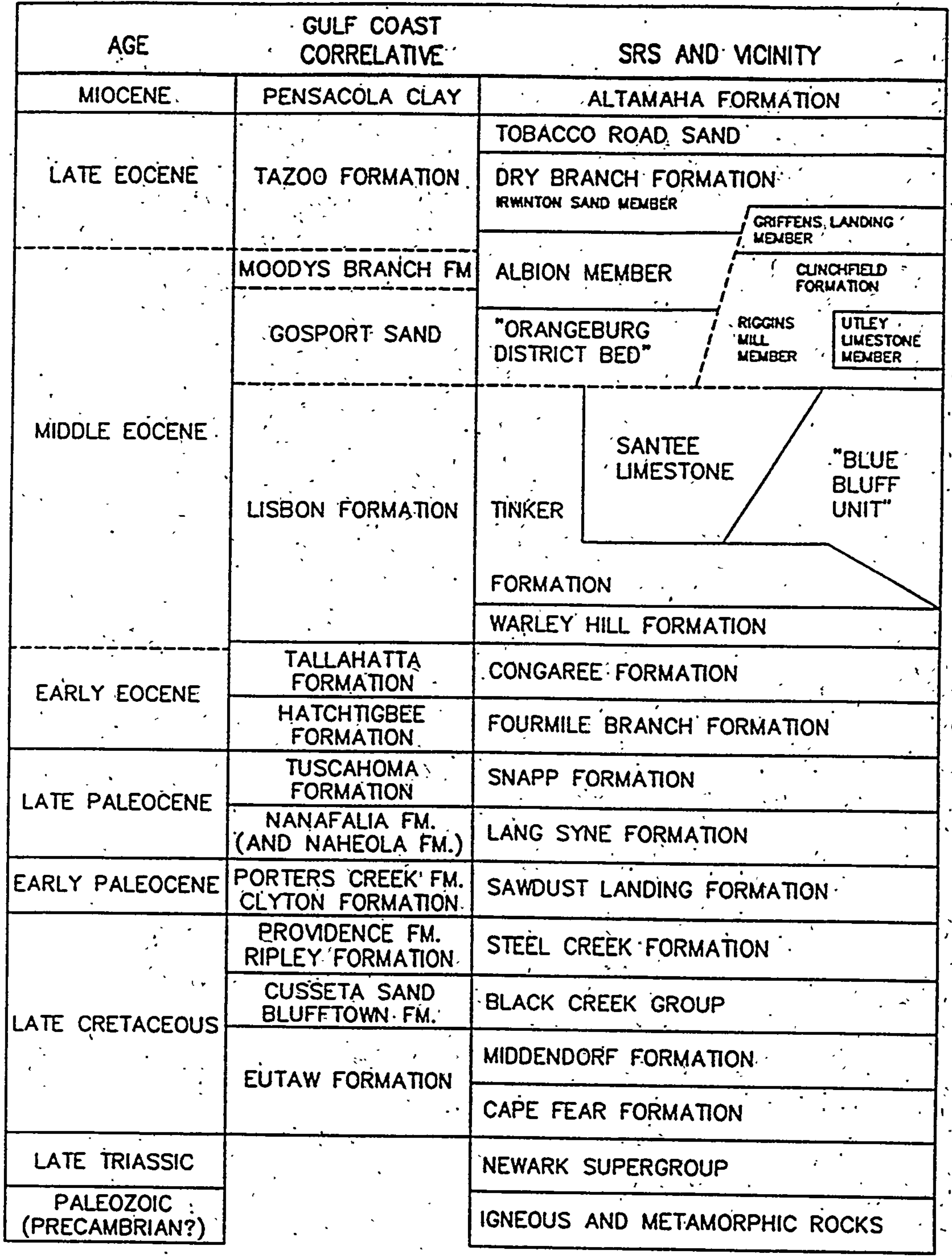


Figure 2-4 - NW-SE Geologic Cross Section through SRS (Modified from Price, 1988).



AGE	GULF COAST CORRELATIVE	SRS AND VICINITY
MIOCENE	PENSACOLA CLAY	ALTAMAHA FORMATION
LATE EOCENE	TAZOO FORMATION	TOBACCO ROAD SAND
		DRY BRANCH FORMATION IRWINTON SAND MEMBER GRIFFENS LANDING MEMBER
MIDDLE EOCENE	MOODYS BRANCH FM	ALBION MEMBER CLINCHFIELD FORMATION
	GOSPORT SAND	"ORANGEBURG DISTRICT BED" RIGGINS MILL MEMBER UTLEY LIMESTONE MEMBER
	LISBON FORMATION	TINKER FORMATION SANTEE LIMESTONE "BLUE BLUFF UNIT"
		WARLEY HILL FORMATION
EARLY EOCENE	TALLAHATTA FORMATION	CONGAREE FORMATION
	HATCHTIGBEE FORMATION	FOURMILE BRANCH FORMATION
LATE PALEOCENE	TUSCAHOMA FORMATION	SNAPP FORMATION
	NANAFALIA FM. (AND NAHEOLA FM.)	LANG SYNE FORMATION
EARLY PALEOCENE	PORTERS CREEK FM. CLYTON FORMATION	SAWDUST LANDING FORMATION
LATE CRETACEOUS	PROVIDENCE FM. RIPLEY FORMATION	STEEL CREEK FORMATION
	CUSSETA SAND BLUFFTOWN FM.	BLACK CREEK GROUP
	EUTAW FORMATION	MIDDENDORF FORMATION
		CAPE FEAR FORMATION
LATE TRIASSIC		NEWARK SUPERGROUP
PALEOZOIC (PRECAMBRIAN?)		IGNEOUS AND METAMORPHIC ROCKS

Figure 2-5 - Stratigraphic Units of the Coastal Plain.

Three distinct geologic and hydrologic systems occur in the subsurface beneath the general area of the SRS:

- Igneous and metamorphic rock of Paleozoic age,
- Lithified mudstones, sandstones, and conglomerates of Triassic age, and
- Unconsolidated to semi-consolidated Coastal Plain sediments of Late Cretaceous and Tertiary ages.

Precambrian and Paleozoic slates, phyllites, schists, gneisses, volcanics, metavolcanics, granites, and mafics were formed under the influence of several orogenic episodes in the Appalachians. These metamorphic rocks have been intruded by somewhat younger Paleozoic granite plutons. Similar Paleozoic metamorphic and igneous rocks crop out in the Piedmont Province north of the Fall Line, located approximately 20 miles northwest of the SRS.

The Dunbarton Basin is a graben filled with sediments of Triassic Age. The basin is buried within the Paleozoic metamorphic rock under approximately 1,300 feet of Coastal Plain sediments in the southeastern part of the SRS. The Triassic Newark Supergroup sediments fill the basin and consist of poorly sorted consolidated gravel, sand, silt, and clay.

Both the Paleozoic and Triassic rocks were leveled by erosion and are unconformably overlain by unconsolidated to semi-consolidated Coastal Plain Sediments. The Late Cretaceous to Recent Coastal Plain sediments comprise a clastic wedge that thickens and dips toward the southeast. In the vicinity of the SRS, these sediments consist predominantly of sandy clays and clayey sands, although occasional beds of clean sand or clay also occur. Two bioclastic limestone zones occur intermittently within the Eocene strata. These calcareous zones vary in thickness, where present, from about 1 to approximately 80 feet. They appear to be lens-like bodies that pinch out laterally into sand or clay facies. The calcareous zones' erosional surface feature dips approximately 35 feet/mile to the southeast.

Known faults beneath the SRS are shown in Figure 2-6 and include the Pen Branch Fault; the Steel Creek Fault, located southeast of the Pen Branch Fault and parallel to it; the Ellenton and ATTA Faults that trend northwest and may intersect the Pen Branch Fault; and the northeast trending Crackerneck Fault in the northernmost part of the SRS.

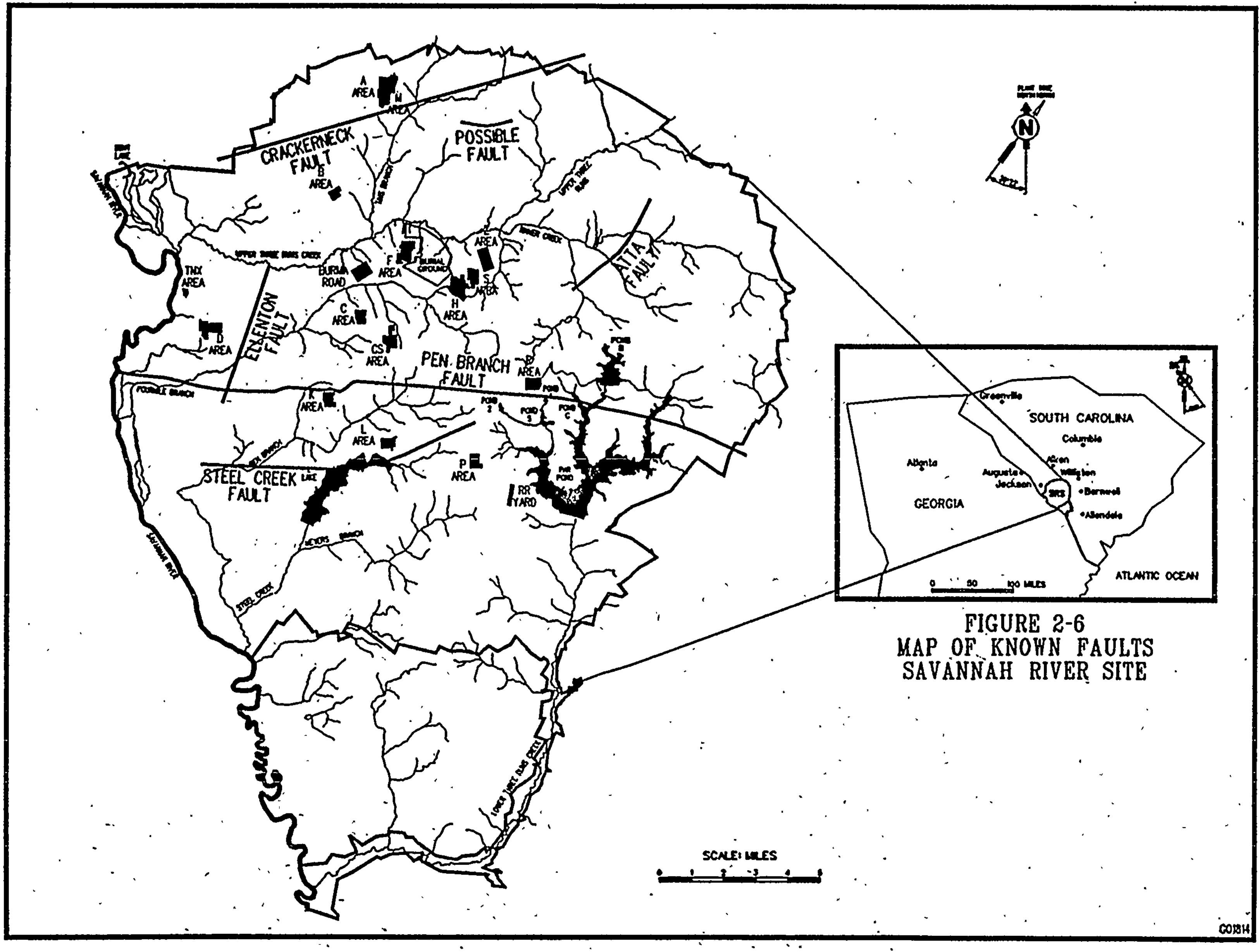


FIGURE 2-6
MAP OF KNOWN FAULTS
SAVANNAH RIVER SITE

Following the most recent stratigraphic interpretation by Fallaw and Price (1994), approximately two-thirds of the Coastal Plain section consists of Cretaceous and Tertiary quartz sands and clays, which have the characteristics of fluvial and deltaic deposits. These sediments have been assigned to the Cape Fear Formation, the Middendorf Formation, the Black Creek Group, and the Steel Creek Formation. Paleocene deposits are composed of quartz sands and clays of the lower Paleocene

Sawdust Landing Formation and the upper Paleocene Lang Syne and Snapp Formation. They appear to be deltaic and lagoonal. The lower Eocene Fourmile Branch Formation consists of quartz sands and clays and appears to be marine and transitional marine. Early Eocene quartz sands of the Congaree Formation are interpreted as shallow marine. Middle Eocene sediments of the Warely Hill and Tinker formations were deposited in marine and transitional marine environments. Calcareous sediments of the Santee Limestone and the "Blue Bluff" unit are considered marine and transitional marine environments. The overlying Clinchfield Formation consists of Riggins Mill Member quartz sands and calcareous sediments of the Utley Limestone Member, both shallow marine deposits. The upper Eocene Dry Branch Formation is composed of quartz sands and clays of the Irwinton Sand Member and calcareous sediments of the Griffins Landing Member. These deposits have marine and lagoonal characteristics. The muddy quartz sands of the Tobacco Road Sand overlie the Dry Branch and were deposited in shallow marine and transitional marine environments. Fluvial deposits of poorly sorted muddy quartz sands, clays, and pebbly and cobbly beds overlying the Tobacco Road are assigned to the Miocene Altamaha Formation. The following illustrates the geologic age of the SRS formations:

Cretaceous

- The Cape Fear Formation, Middendorf Formation, the Black Creek Group, and the Steel Creek formation.

Paleocene

- Sawdust Landing Formation (Lower Paleocene), Lang Syne Formation (Upper Paleocene), Snapp Formation (Upper Paleocene).

Eocene

- Fourmile Branch (Early Eocene), Congaree Formation (Early Eocene), Warley Hill (Middle Eocene), Tinker Formation (Middle Eocene), Santee Limestone (Middle Eocene), Blue Bluff Unit (Middle Eocene), Utley Limestone Member of the Clinchfield Formation (Middle Eocene), Dry Branch Formation (Upper Eocene), Tobacco Road Sand (Upper Eocene).

Miocene

- Altamaha Formation

2.4.1 *Cretaceous Sediments*

The Cape Fear Formation is composed of Upper Cretaceous, poorly sorted, silty to clayey quartz sands and interbedded clays. The sands are arkosic (containing more than 25% feldspars) in places. Muscovite and iron sulfides also occur. Pebbly sands and gravelly layers are common. Sands typically fine upward into clays and appear to be composed of two crudely fining upward sequences of equal thicknesses. The Cape Fear Formation is more indurate than other Cretaceous formations because of high clay content and the abundance of cristobalite in the matrix. Bedding is irregular and marine fossils are rare. Because of the poor sorting and the high degree of oxidation, this indicates that the sediments were deposited in fluvial and deltaic environments. The Cape Fear Formation sediments thicken across the SRS, ranging from 30 feet at the northwest SRS site boundary to more than 180 feet at the southeast SRS site boundary.

The Middendorf Formation, is a composite of mostly medium and coarse grained sands. Pebbly zones are common within the sand and clay clasts occur in places. Parts of the unit are feldspathic, micaceous, and lignitic. Cross-bedding is well developed in the lower section. A kaolinitic clay and interbedded sand forms the top of the unit. The lower contact between the Middendorf and the Cape Fear Formations is marked by a pebbly zone. Wood fragments, spores, pollen, and rare dinoflagellates occur in the unit. The scarcity of marine fossils, the presence of wood fragments, and the discontinuous bedding indicate that most of the Middendorf was deposited in fluvial and deltaic environments. The Middendorf is approximately 100 feet thick near the northwestern boundary of the SRS and thickens to more than 180 feet near the southeastern boundary.

The Black Creek Group is generally comprised of interbedded quartz sands, silts, and clay. It is generally darker, more micaceous, and more lignitic than other Cretaceous units. Layers of pebbles and clay clasts are common and feldspathic zones occur locally. In the central and downdip parts of the SRS, a southeasterly thickening wedge of dark, fissile, lignitic, pyritic, micaceous clay and dark, interbedded sands and silts occurs in the middle (McQueen Branch Confining Unit) and upper parts of the formation. The upper part of the formation consists mostly of tan and light grey sands (lower Crouch Branch Aquifer). In general, the Black Creek contains more dark clays, lignite, and muscovite that the Middendorf. Light-colored sands and large oxidized clay lenses suggest delta plain conditions in the lower Black Creek in the northwestern part of the SRS. Dark clays and sands are abundant in the southeastern part of the site and suggest delta front and prodelta environments. The Black Creek Formation is about 110 feet thick at the northwestern boundary of the SRS and thickens to more than 250 feet near the southeastern boundary.

The Steel Creek Formation contains poorly to well sorted, fine to coarse, quartz sand and silty sand in the lower section. Concentrations of feldspar and lignite occur. Pebble zones are common, as are layers with clay clasts. The upper part of the Steel Creek, in most places at the site, is oxidized kaolinitic clay. In general, the Steel Creek has more oxidized clays, fewer and much thinner dark clays, and less lignite than the Black Creek. The Steel Creek grades into the calcareous siliciclastics of the Peedee Formation to the northeast and southeast. To the southwest, it grades into the calcareous sands of western Georgia. The lateral limits of the Steel Creek have been arbitrarily set where the calcium carbonate content of the sediments is 5%. Wood fragments, spores, pollen, and rare dinoflagellates have been found. Scarce marine fossils, irregular bedding, and large bodies of oxidized clay suggest that the sediments were probably deposited in fluvial and delta plain environments. The Steel Creek is about 60 feet thick at the northwest SRS boundary and 140 feet thick at the southeastern boundary.

2.4.2 *Paleocene Sediments*

The Sawdust Landing is composed of micaceous poorly to moderately sorted, silty and clayey quartz sands, and pebbly sands with interbedded, dark grey clays. In the northwestern part of the SRS, it consists of micaceous quartz sands. Locally feldspathic, iron sulfides and lignite are common in the darker parts of the section. Clays are fissile in places and contain micaceous silt and fine sand laminae. In general, the Sawdust Landing has more feldspar and iron sulfide than the Steel Creek, is darker, and sorting is poorer. The clays of the Sawdust Landing are more fissile that those of the Steel Creek. The Sawdust Landing is about 10 feet thick near the northwestern boundary of the SRS and thickens to about 40 feet near the southern boundary. The Sawdust Landing appears to consist of the lower parts of the: Ellenton Formation, Black Mingo Formation, and the Rhems Formation. Fallaw and Price (1994) believe that the term "Ellenton" should not be used because the sediments named by Siple (1967) consist of two different sedimentary sequences with different lithologies. Most type sections of the "Ellenton" consist of the upper Lang Syne Formation. The term "Sawdust Landing" rather than "Rhems" is used by Fallaw and Price (1994) because the lithology at the SRS is more similar to the type stratigraphy in the Sawdust Landing in central eastern South Carolina than it is to the type stratigraphy in the Rhems Formation in the eastern South Carolina. Light-colored, moderately to poorly sorted, micaceous quartz sands, feldspathic in place, which, interpreted by Fallaw and Price (1994) as upper delta plain deposits, are common in the northwestern part of the SRS, with darker, poorly sorted, micaceous, lower delta plain facies becoming dominant in the southern part.

Lang Syne Formation consists of dark grey and black, lignitic clays and poorly and moderately sorted, micaceous, lignitic, muddy quartz sands and pebbly sands. Both sands and clay are glauconitic with the basal unit consisting of a green sand in places. Deposits composed of moderately to poorly sorted, micaceous quartz sands are common in the northwestern part of the SRS, with darker, poorly sorted, micaceous facies becoming dominant to the southeast. Basal sands lie on dark clays or dark sands of the Sawdust Landing with a pebbly zone common at the contact. In general, the Lang Syne contains more glauconite, muscovite, lignite, and iron sulfide than the Sawdust Landing and the clay beds are much thicker. Light-colored, moderately to poorly sorted, micaceous quartz sands are common in the northwestern part of the SRS and are interpreted by Fallaw and Price (1994) as upper delta plain sediments. The thick dark clays probably accumulated in lagoons or bays. Darker, poorly sorted, micaceous lower delta plain and prodelta facies become dominant in the southeastern part of the SRS. The unit appears to be sporadic in the northwestern part of the SRS and thickens to about 80 feet near the southeastern boundary where it is calcareous.

The Snapp Formation sediments also referred to as the "Williamsburg Formation", are typically light grey, tan, orange, yellow, silty, micaceous, medium to coarse grained quartz sands and pebbly sands interbedded with kaolinitic clays. Sorting in the sands is generally poor. The Snapp is well developed at the southern boundary where there are two fining-upward sequences but appears to pinch out updip near Upper Three Runs. It is about 70 feet thick near the southeastern boundary. The Snapp was designated by Fallaw and Price (1994) as a new formation name because the lithology is not similar to that of the type stratigraphy in the Williamsburg and Black Mingo located in eastern South Carolina. Snapp sands are usually lighter in color than Lang Syne sands and contain less lignite, iron sulfide, and glauconite. The Snapp probably grades into siliciclastics and limestones of the upper part of the Williamsburg Formation. The boundary has been arbitrarily placed where the section is 5% calcium carbonate (Fallaw and Price, 1994). The near absence of marine fossils, the generally poorly sorted sands, and the oxidized clays indicate that the environment of deposition was probably mostly upper delta plain.

2.4.3 *Early-Middle Eocene Sediments*

The Fourmile Branch Formation is composed of quartz sand with some interbedded clays. It is mostly orange, green, gray, yellow, and tan, moderately to well-sorted, fine to coarse grained quartz sand with green and gray clays a few feet thick in the middle and at the tip. The dark clays are rich in organic matter and tend to be more abundant in the northwestern part of the SRS. Glauconitic clays are more common to the southeast. The unit is about 30 feet thick in the northwestern part of the SRS and appears to thin to the southeast and toward the Savannah River from the center of the SRS. Going across the Lang Syne/Fourmile Branch contact, the sands become cleaner, iron sulfide and lignite content decreases, colors become lighter, and clay bed thickness decreases in the northwestern part of the SRS. Going across the Snapp/Fourmile Branch contact to the southeast, sands become cleaner, glauconite increases, and clay bed thickness decreases. Downdip, the Fourmile Branch grades into the Fishburne Formation (Gohn and others, 1983), a limestone. The contact is defined by Fallaw and Price (1994) where 25% of the section is composed of calcium carbonate. The only well-preserved fossils recovered from the Fourmile Branch are palynomorphs. The glauconite, the abundant dinoflagellates, and the moderate to good sorting indicate that the environment of deposition was shallow marine, with dark clays in the northwestern part of the SRS probably forming in bays or lagoons, and glauconitic clays in the southeastern part being deposited in near neritic conditions.

The Congaree Formation consists of yellow, orange, tan, gray and greenish gray, well sorted, quartz sand with thin clay laminae, pebbly layers, clay clasts, and glauconite. Quartz grains tend to be better rounded than in the rest of the stratigraphic column. The top section of the Congaree Formation is cemented with silica in many areas of the SRS and is slightly calcareous in other areas. They are consistently calcareous near the southeastern boundary. The Congaree is similar to the Fourmile Branch but glauconite decreases, muscovite decreases, clay beds and laminae become less common, sorting becomes better, pebble content decreases, and colors become lighter above the contact in the Congaree. Molluscan shell fragments, usually silicified, have been found in the Congaree at the SRS. Dinoflagellates were found in the lower and middle parts of the Congaree for age determination. The well-sorted sands, the occurrence of glauconite, and the dinoflagellate assemblages indicate a shallow marine environment. The Congaree Formation is approximately 60 feet thick at the northwestern SRS boundary and thickens to approximately 85 feet near the southeastern SRS boundary.

The Warley Hill is a fine to medium grained, poorly to well sorted quartz sand and muddy quartz sand, glauconitic, and thickens from a few inches to about 15 feet above the Congaree. The sand fines upward with a clay occurring at the top. Common colors are brown, green, gray, yellow, tan, an orange. The top of the Congaree is picked at the top of a clean sand sequence. The Warley Hill is difficult to identify and appears to be missing from the northwestern part of the SRS. Dinoflagellates, spores, and pollen have been recovered from the unit at the SRS. Glauconite and dinogflagellates suggest marine conditions, with the middle sands indicating lower energy levels than those prevailing when the Congaree was deposited. The high mud content could have been developed by flocculation at the fresh water/salt water interface. The Warley Hill and the Caw Caw Members make up what has been informally referred to in many SRS reports as the "Green Clay". The "Green Clay" is composed of glauconitic, silty and clayey quartz sands and silty clays.

Most of the middle Eocene section consist of three laterally gradational units: the Santee Limestone, the Tinker Formation, and the informally named "Blue Bluff" unit (Huddlestun and Hetrick, 1986).

Much of the Santee is composed of cream-colored, slightly to moderately indurate calcarenite and calcilutite with well-indurated calcareous nodules lying on tip of the quartz sands and clays of the Warley Hill. Better developed in a northeasterly trend across the middle of the SRS it is sporadic in the vicinity of the Upper Three Runs and rare to the northwest. To the southeast it interfingers with and grades into the "Blue Bluff" unit. The term "McBean" has been applied to these sediments. Huddlestun (1982) and Hetrick and Huddleston (1986) suggested that the term "McBean" be restricted to the calcareous facies. Because the "McBean" is not defined as a lithologically homogeneous unit and because of confusion involved in the use of the term, Fallaw and Price (1994) concur that the carbonate below the lowest quartz sands in the section should be assigned a name (Santee) different from that applied to the sands. The carbonates are more similar to those in the type area of the Santee. Microfossils and megafossils are abundant in the Santee. The environment of deposition was probably mostly inner to middle neritic, judging from the abundant fossils and calcareous sediments.

Calcareous strata along the Savannah River valley in the same stratigraphic position as the Santee Limestone occurs with sufficient areal extent, thickness, and distinct lithology to warrant recognition as a separate unit, informally named the "Blue Bluff" unit by Fallaw and Price (1994). The "Blue Bluff" is gray and green, clayey, laminated calcilutite, calcarenite, and calcareous silt and clay, with shell layers, indurated nodules, thin indurated limestone lenses, calcareous muds, and quartz sand laminae in place. The sediments are widespread in the southern part of the SRS interfingering and grading into the cream-colored Santee facies and, in general, tend to be more common in the lower part of the section than the lighter-colored carbonates. The "Blue Bluff" sediments lie on poorly sorted quartz sands and clays, calcareous in places, of the Warley Hill. It is about 90 feet thick at the southeastern boundary of the SRS. A benthic foraminiferal species appears to be a marker for the Santee and "Blue Bluff" in this area (Huddlestun and Hetrick, 1986) with numerous molluscan taxa present. The fine grain size, the lamination, and fragile molluscan shells in the "Blue Bluff" suggest a lower energy environment than that of the Santee, probably farther out in the neritic zone.

The Tinker Formation consists of quartz sands, silts and clays which, in general, occur updip from the Santee. The sands are typically finer grained than the ones above and below, contain more heavy minerals, and are more likely to contain glauconite, although glauconite is often found in the Warley Hill. Yellow, tan, and white sand are common with pale green sands occurring in the center of the SRS. Clay beds and laminae are more abundant in the Tinker Formation than in the underlying and overlying units. Tan clays are prominent in the overlying Dry Branch Formation, while Green Clays are more common in the Tinker (among them the "Green Clay and contain less sand that the clays of the Warley Hill. The Tinker Formation grades downdip into the carbonates of the Santee and the "Blue Bluff". The Tinker is about 40 feet thick at the northwestern boundary of the SRS and the "Blue Bluff" is about 90 feet thick at the southeastern boundary. The Tinker is most of the siliciclastic parts of the "McBean Formation" as used by many workers. The boundary between the Santee and "Blue Bluff" carbonates and the Tinker siliciclastics is defined by Fallaw and Price (1994) as where 25% of the section is composed of calcium carbonate. Where the Warley Hill is missing and the Tinker overlies the Congaree, colors become darker, grain size decreases, sorting becomes poorer, green clay or glauconitic sand becomes more common, and heavy minerals become more abundant upward in the section. Where the Tinker overlies the Warley Hill, Tinker sands tend to be finer and cleaner that the underlying sand, and the clays have a lower sand content. Palynomorphs and silicified shells and molds of mollusks have been found in the Tinker. Most of the Tinker sands were probably formed in barrier and inner neritic environments and the silts and clays in bays, lagoon, and low energy shelf areas.

The Clinchfield consists of quartz sand and clay, calcareous in places, and carbonates. The sands are tan and yellow, poorly to well-sorted, and fine to coarse grained. The Utley Limestone Member is an indurated, bioclastic and biomoldic, glauconitic limestone in some places, and in others, a calcareous sand and calcarenite. The lower contact of the Clinchfield may be marked by a change from calcareous sediments of the Santee and "Blue Bluff" to poorly to well sorted sands. The Utley Limestone tends to be more indurated and coarsely glauconitic than the underlying carbonates. It also contains abundant sand dollar specimens. The Clinchfield is exposed along the Savannah River opposite the SRS. Approximately 30 feet thick in the southeastern part of the SRS, the Clinchfield pinches out or becomes difficult to identify updip in the middle of the SRS. The quartz sand of the Clinchfield at the SRS may be the Riggins Mill Member, as defined by Huddlestun and Hetrick (1986). The concentrations of the sand dollars in the carbonates and the sorting of the sands suggest a littoral and inner neritic environment.

2.4.4 *Late Eocene Sediments*

The Dry Branch Formation includes quartz sands, clays, calcareous siliciclastics, and carbonates. Calcilutite, calcarenite, bioclastic and biomoldic limestone, calcareous sand and shelly, calcareous clay occur in the Griffins Landing member. The Griffins Landing is less glauconitic than the carbonates of the underlying Utley, Santee, and the "Blue Bluff". It is not known to be present northwest of the Upper Three Runs within the SRS boundary but it is at least 50 feet thick in the southeastern part of the SRS. The rest of the Dry Branch Formation is divided into tan clays (Twiggs clay lithofacies), and the Irwinton Sand Member.

The Irwinton Sand Member contains tan, yellow, and orange, moderately sorted quartz sand with interlaminated and interbedded clays typically tan. Glauconite is rare. Irwinton sands are generally coarser that those of the underlying Tinker Formation. Tan clays are more common above and green and gray clays are more common below the contact. This clay lithofacies, which is tan, light gray, and brown, varies in thickness up to 12 feet at the SRS, but is not laterally continuous. The Dry Branch Formation is about 50 feet thick near the northwestern SRS boundary and about 80 feet thick near the southeastern boundary. Fossils like foraminifers, barnacles, crabs, starfish, crinoids, shark and ray teeth, and fish bones have been found in the Griffins Landing Member. Palynomorphs and silicified fossils have also been found in the Irwinton Sand member. Common planktonic Foraminifera from the Griffins Landing indicate some open ocean influence. Calcareous clay beds containing foraminiferal genera indicate bay or lagoonal environments. Irwinton sands are probably inner neritic and barrier deposits; the clays probably formed in lagoons or bays.

The Tobacco Road Formation, which overlies the Dry Branch formation, consists of red, brown, tan, purple, and orange quartz sands and clayey quartz sands. These sands are fine to coarse, moderately to poorly sorted, with minor clay laminae. In general, the sands of the Tobacco Road are muddier, more micaceous, and more highly colored that those of the Dry Branch. The base of the Tobacco Road is marked in placed by a coarse layer that contains flat quartz pebbles. No datable fossils have been recovered from the Tobacco Road at the SRS, but Ophiomorpha burrows can be seen and silicified shell fragments are common which indicate a marine or transitional marine environments. Clay laminae in the upper part of the Tobacco Road suggests that some of the unit was deposited in a transitional, low energy environment, such as a tidal flat. The Tobacco Road outcrops at the surface at may locations throughout the site and ranges in thickness from 20 to 30 feet.

2.4.5 *Altamaha Formation (Upland Unit)*

The Altamaha formation is composed of poorly sorted, clay to silty sands, with lenses and layers of pebbly and cobbly quartz sands with extreme lateral and vertical variation. The presence of the Altamaha Formation in this area is inconsistent, occurring predominantly at higher elevations around the SRS. Sediments are red, purple, gray, orange, yellow, and tan, with a fine to coarse grain size. Cross-bedding is prominent in places, and muscovite flecks of weathered feldspar are locally abundant. In general, the Altamaha has poorer sorting, larger and more common weathered feldspar grains, more abundant and thicker clay beds, more argillaceous and indurated sands, larger pebbles, and, in place, more muscovite than the underlying Tobacco Road. It is up to 70 feet thick in parts of the SRS. Very few fossils have been reported from the Altamaha and its equivalents. The conglomerates, poorly sorted sands, and lay lenses have the characteristics of fluvial sediments. Possible Ophiomorpha and Foraminifera (Siple, 1967) suggests an occasional transition marine influence.

2.5 Soils

The soil survey entitled "Report of Savannah River Plant, Parts of Aiken, Barnwell, and Allendale Counties, South Carolina (USDA, 1990)", indicated that the soil type that exists at the BRRP Site consists of Udorthents. Three subdivisions of Udorthents exist; Udorthents of a friable substratum (Uo), Udorthents with firm substratum (Ud), and Udorthents of an urban land complex with gentle slopes (Ur). Udorthent-Uo is the predominant soil type at the BRRP Site.

Udorthents are difficult to identify since they are the result of construction work and pit filling and include areas predominantly composed of more than one soil type. The absence of the upper part of the original soil horizon is characteristic of Udorthents. Typically, the surface layer of Udorthent soil is sandy clay loam to sandy loam, coarsely mottled in shades of red, brown, yellow, and grey. Udorthents are commonly associated with well drained to excessively drained upland soils but, also ranges from moderately slow to rapid drainage. Udorthents have a low organic content and are strongly acid to extremely acid. Extreme variability within short distances requires careful on site evaluation. These soils are fairly suitable for open wildlife (SCS, 1990).

Because of the low availability of nutrients and the high acidity, these soils are not fit for row crops. Seeding mortality is moderate. Erosion is a moderate hazard. Intensive management and onsite evaluation are needed because of a wide variability in soil properties and environmental conditions. These soils are fairly suited for habitable openland and woodland wildlife and are very poorly suited for wetland wildlife habitat.

Usually included in the mapping area of the Udorthents are soil types form the Dothan, Ailey, Blanton, Norfolk, Wagram, and Fuquay soils. These soil types have layers of loamy and sandy overburden 5 - 15 inches thick. More specifically, immediately surrounding the Udorthent soil type of the BRRP Site are the Dothan (DoA, DoB), Blanton (BaB), and Ailey (AeB) soils.

The Blanton sand (BaB) is an excessively drained soil and is located in broad upland swales and on low-lying ridges and side slope of the Coastal Plain and Sand Hills. The upper part of the Blanton sand consists of brown sandy loam and the lower part consists of fine sandy loam. The Blanton sand has a low content of organic mater and a very low available water capacity. The soil is moderately acid to very strongly acid in the surface layer and subsurface layer and in the subsoil. Because of the low water availability, the low organic content, and the high acidity, the soil is not suited for row crops but it is suited for pine tree growth.

The Dothan sand (DoA, DoB) is a well drained soil and can be found on broad ridgetops on uplands of the Coastal Plain and in areas intermingled with the Sand Hills. The strata of this soil type is divided into four zones: the upper zone consists of sand, the upper middle consists of sandy loam, the lower middle zone consists of sandy clay loam, and the lower zone consists of sandy clay loam with plinthite. Permeability is moderately low in the subsoil. The Dothan soil has a low organic matter content and a moderate available water capacity. It is moderately to very strongly acid above the plinthite and ranges to extremely acid below the plinthite.This soil is well suited for row crops and timber production.

The Ailey sand (AeB) is a well drained soil and is usually located on narrow ridgetops and short, undulating side slopes of the Sand Hills. The surface and subsurface layer consists of sand; the subsoil layer consists of sandy clay loam and the substratum consists of a sandy loam. The Ailey soil has a low content of organic matter and a low available water capacity. It is strongly acid and very strongly acid throughout. Permeability is slow in the subsoil. Dense, brittle layers in the subsoil partly restrict the root zone. The soil is poorly suited for row crops but is suited for timber production.

Figure 2-7 provides a generalized soil map showing the distribution of the Udorthents and surrounding soil types.

2.6 Regional Hydrostratigraphy of the SRS Area

The Coastal Plain sediments constitute a multilayered hydrologic system in which confining beds are interspersed with beds that transmit water more readily. Groundwater flow paths and flow velocities for each of these units are governed by the hydraulic properties, the geometry of the particular unit, and the distribution of recharge and discharge areas. Groundwater is found in the pore spaces of the unconsolidated sediments. The predominant sand beds are aquifers, and the clay-rich beds are aquitards. Local aquitards may occur within aquifers. No generally accepted formal code exists for naming hydrostratigraphic units. The use of formal stratigraphic names is restricted to actual stratigraphic units. Hydrologic units are based upon hydrologic characteristics, such as hydraulic conductivity and effective porosity. Price (1988) proposed eight hydrologic units, designated Zone 1 through Zone 8. Aadland (1990, 1992) proposed revised hydrostratigraphic nomenclature for use at the SRS. A comparison of the Price (1988) and Aadland (1990) hydrostratigraphic sections is shown on Figure 2-8. An illustration of Aadland's updated hydrostratigraphic units (1992) are illustrated in Figure 2-9. Use of the Aadland (1992) and Price (1988) hydrostratigraphic nomenclature will be commingled in this text to gain a thorough understanding of the "older" hydrostratigraphic division nomenclature versus the "newer" hydrostratigraphic division nomenclature. Price's lithological units versus Aadland's 1992 hydrostratigraphic units are illustrated in Figure 2-10.

The stratigraphic and hydrologic units names for the Tertiary sediments are based on subsurface data from near the H-area, approximately two miles east of the BRRP unit, and are not necessarily

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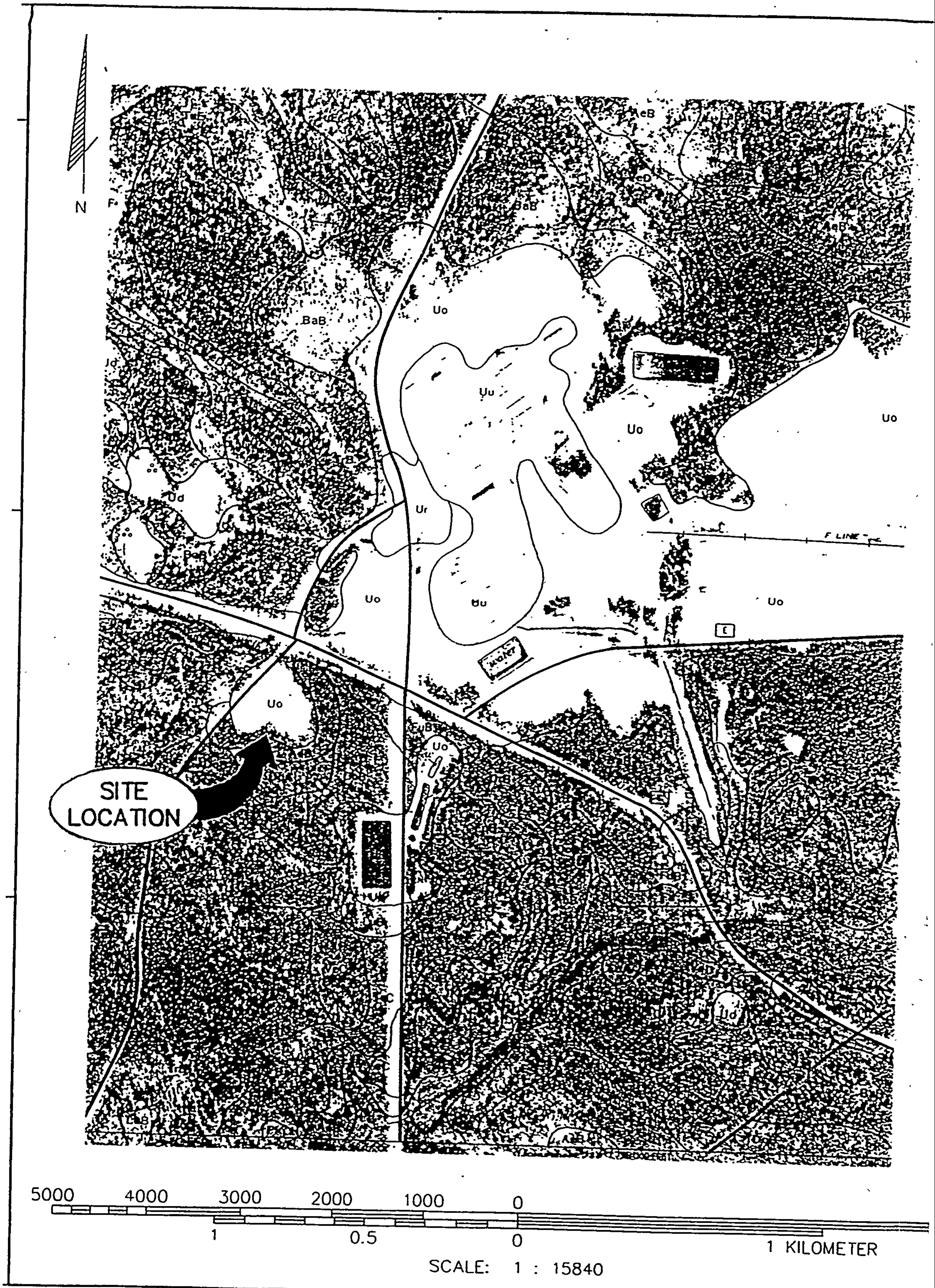

N
SITE LOCATION
BaB
Uo
Uu
Ur
Ud
eB
F LINE
Water
5000
4000
3000
2000
1000
0
1
0.5
0
1 KILOMETER
SCALE: 1 : 15840

LEGEND:

Uo, Ud - UDORTHENT SOIL
DoA, DoB - DOTHAN SOIL
BaB - BLANTON SOIL
AeB - AILEY SOIL

SOURCE: SOIL SURVEY REPORT ENTITLED, "REPORT OF SAVANNAH RIVER PLANT, PARTS OF AIKEN, BARNWELL, AND ALLENDALE COUNTIES, SOUTH CAROLINA (USDA, 1990)."

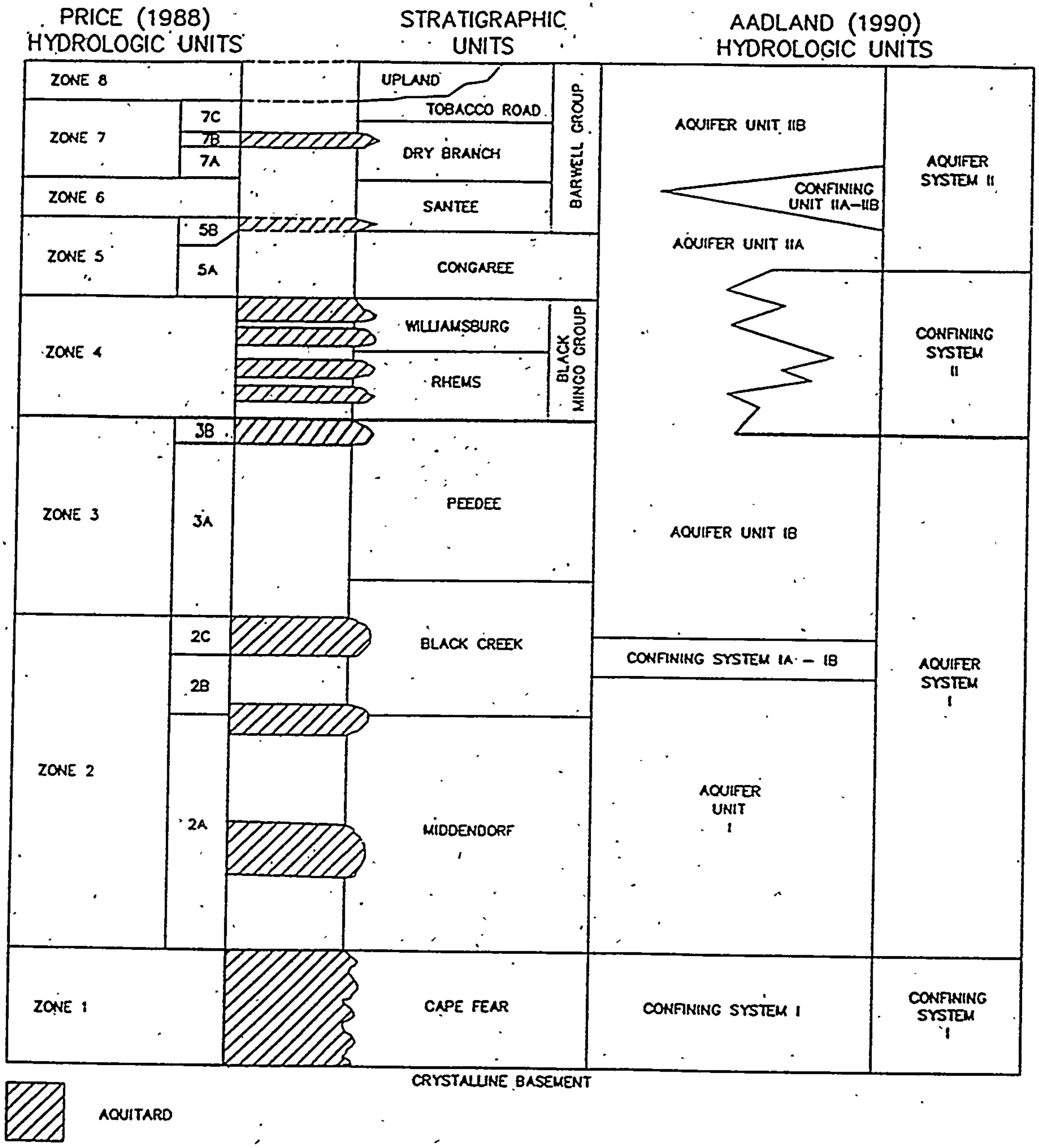
000 FEET

METCALF & EDDY

SOIL SURVEY

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
2–7



(MODIFIED FROM PRICE, 1988)

Figure 2-8 - Relationship Between Stratigraphic and Hydrogeologic Units at SRS.

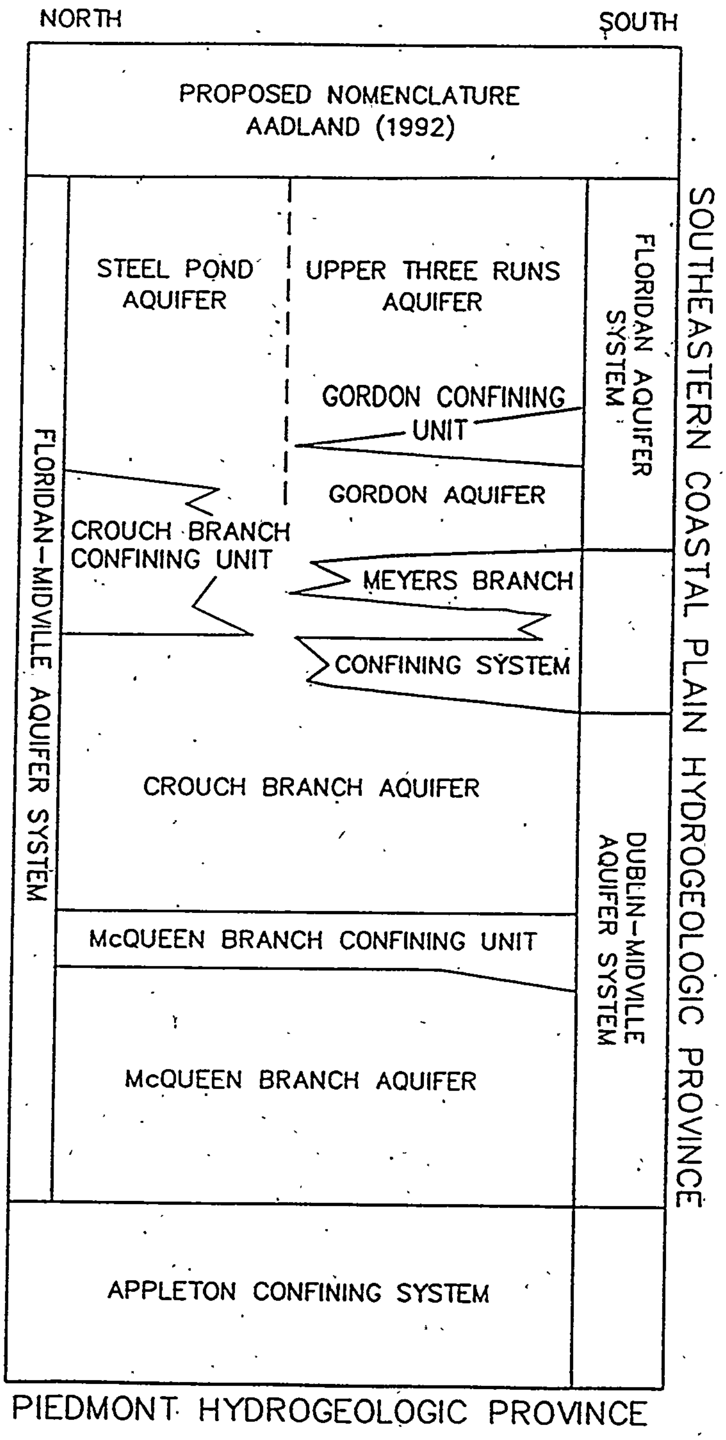


Figure 2-9 - Hydrostratigraphic Nomenclature.

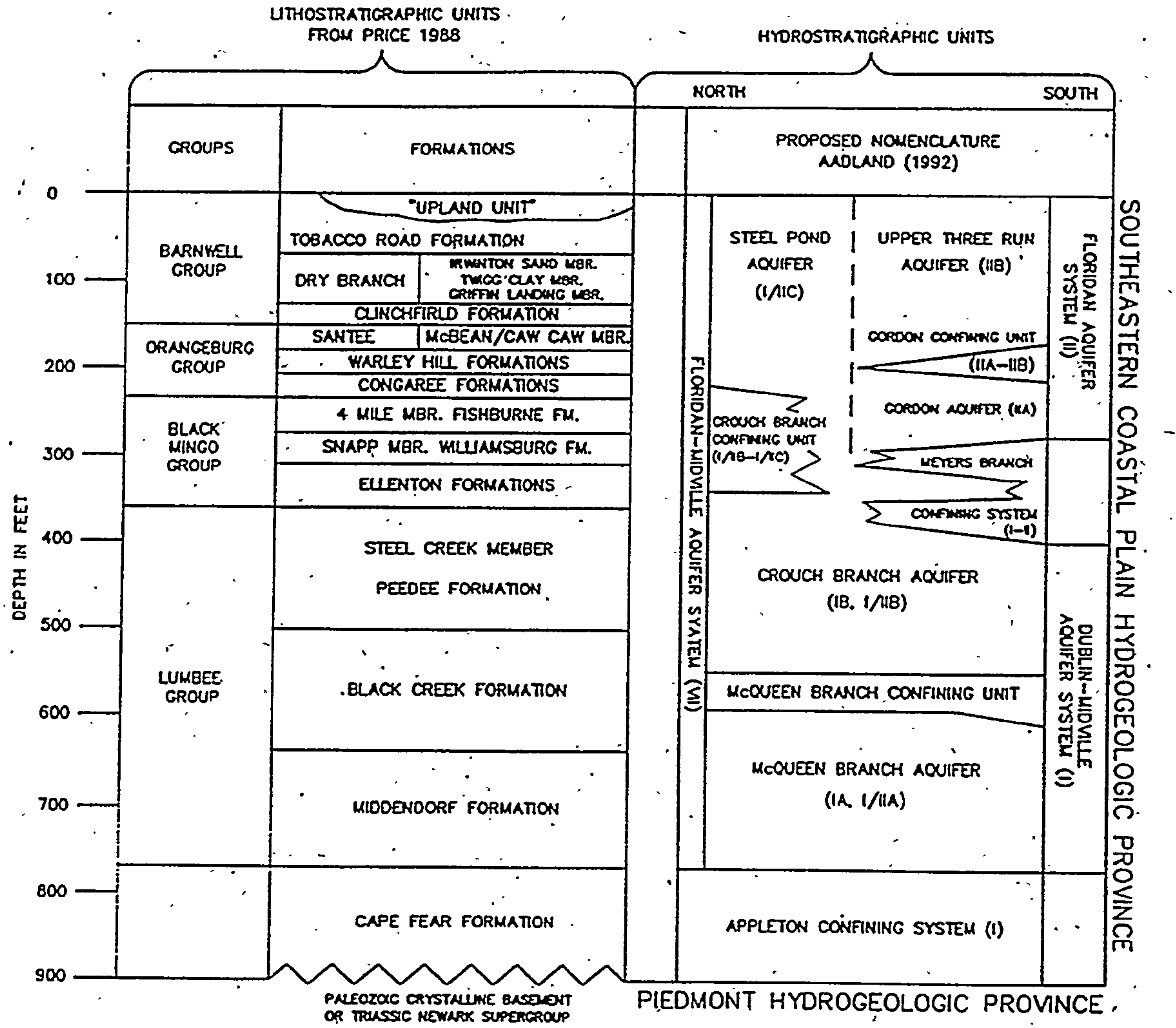


Figure 2-10 - Hydrostratigraphic Nomenclature (Lewis and Aadland, 1992).

representative of the entire SRS. Some units have no utility north of SRS because the hydrologic characteristics of the Coastal Plain sediments change rapidly northward toward the Fall Line. Unconformities have only limited hydrologic significance, and therefore are not discussed.

Based on Aadland's hydrologic nomenclature, some zones are subdivided based on the heterogeneity of their lithologic and hydrogeologic characteristics. For example, hydrogeologic unit IIA consists of an aquifer and an aquitard. Other zones are not subdivided because of the homogeneity of their lithologic and hydrogeologic characteristics.

Confining System I is an aquitard which corresponds to the Cape Fear Formation (the Appleton Confining System) and consists of clay layers and semi-consolidated, clayey, silty sands. Some aquitards such as this system are effective seals throughout the SRS area. However, because of lateral and vertical changes in permeability, other beds referred to as aquitards inhibit vertical flow between aquifers in some places but allow its passage in others.

Aquifer Unit I consists of an aquifer which corresponds to the Middendorf Formation (McQueen Branch Aquifer System). Confining System IA - IB is an aquitard and corresponds to the Middle Black Creek Formation (the McQueen Branch Confining Unit). The aquifer unit consists predominantly of dirty to clean, fine-to coarse-grained sands with interspersed clay layers. The clay beds in Aquifer Unit I appear to have lateral continuity, but they are only locally impervious. Thus, this unit is hydrologically connected to sands in the overlying Lower Black Creek Formation. The aquitard, Confining System IA - IB, is locally fissile clay layer in the Black Creek Formation. It is a confining layer in some parts of SRS, but it does not form an effective seal or is not continuous in other places.

Aquifer Unit IB consists of a lower sand aquifer and an upper aquitard (Confining System II). Aquifer Unit IB corresponds to the Upper Black Creek and Lower Steel Creek Formation (the Crouch Branch Aquifer System) and Confining System II corresponds to the Upper Steel Creek Formation (Lower Meyers Branch Confining System). Confining System II is an effective aquitard in many places at SRS, but at other places it allows upward flow of groundwater to the basal, sand portion of Confining System II.

Confining System II consists of the Sawdust Landing Formation, Lang Syne Formation, Snapp Formation, and the Fourmile Branch Formation. These units are known formerly as the Rhems (Ellenton) and Williamsburg Formation of the Paleocene Black Mingo Group. These formations comprise the Meyers Branch Confining System.. This zone contains lignitic clay interbedded with sand layers. The sand at the base of this system may be water bearing but is only a minor portion of the section. Most of the zone consists of virtually impermeable material; therefore, Confining System II is considered to be an aquitard.

Aquifer Unit IIA consists of clastic sediments of the Congaree Formation which corresponds to the Steel Pond Aquifer in the northern portion of the SRS and the Gordon Aquifer System in the southern portion of the SRS. Aquifer Unit IIA is an aquifer that consists predominantly of fine- to coarse-grained quartz sand. Clay laminae occur throughout the section, but they are too thin and discontinuous to be effective aquitards. This aquifer unit has been further subdivided in some areas because of the existence of a limestone unit. Where this limestone is present, it is believed to influence the vertical migration of water through the aquifer unit by retarding movement in some areas and allowing rapid movement in other areas. Consequently, a head difference may be observed across this aquifer unit attributable to the limestone. In these areas, Aquifer Unit IIA is further subdivided into lower and upper hydrologic units. Confining Unit IIA - IIB corresponds to the Gordon confining unit and consists of glauconite bearing sand and clays (Green Clays). This zone is characterized by rapid facies changes. It consists of dirty to clean sands that enclose clay lenses. The clay lenses attain a maximum thickness of 10 feet. The permeability of this formational clay varies greatly, causing it to act as a confining or semi-confining layer at some locations and a moderately transmissive layer at other locations.

Confining Unit IIA - IIB and Aquifer Unit IIB corresponds to calcareous and noncalcareous sands and clays of the Middle Eocene Sediments of the follow formations: the Warley Hill Formation, the Santee Formation (McBean Member/Blue Bluff Formation and the Caw Caw Member), the Tinker Formation, and the Clinchfield Formation (Riggins Mill Member and the Utley Limestone Member). These units comprise the Gordon Confining Unit and the Upper Three Runs Aquifer in the southern portion of the SRS site). The hydraulic conductivity of the zone is moderately low to moderate to moderately high. Groundwater leaks into this zone from the sands of the overlying Dry Branch Formation.

Aquifer Unit IIB is divided into three hydrogeologic subzones and consists of the Late Eocene Dry Branch Formation and its Irwinton Sand Member and the Griffins Landing Member. This aquifer consists of predominantly fine to coarse grained sand, but clay laminae are locally common. Local hydraulic interconnections between Confining Unit IIA - IIB and Aquifer Unit IIB exist such that these units may be considered as a single hydrologic unit. Groundwater occurs under unconfined to semi-confined conditions. A confining unit within Aquifer Unit IIB consists of dirty to clean sands enclosing clay lenses that pinch out over short distances. Thus, the Twiggs Clay is a local aquitard only, and the Dry Branch and Tobacco Road Formation are hydraulically connected in some places. The groundwater in Upper Aquifer Unit IIB (the Lower Three Runs Aquifer) occurs under unconfined conditions at most places. Where the Tobacco Road Formation outcrops along the valley of nearby streams, the sediments are unsaturated.

Aquifer Unit IIB corresponds to the Altamaha (the Upper Three Runs Aquifer). Dirty to moderately clean, cross, bedded sands are dominant in this unit, but clay bodies are common. Conspicuous quartz pebbles are common locally, and large to small clay balls occur sporadically. Nearly all of the sands within this unit are unsaturated, but perched water occurs above some of the clay bodies.

2.7 Demography and Land Use

The 1980 estimated population in an 80 kilometer area around the SRS was approximately 563,000 persons. The largest cities in this area are Augusta, Georgia and Aiken, North Augusta, and Barnwell, South Carolina. There are 31 incorporated communities in this area, 16 of which had a population under 10,000 while 11 had a 1980 population between 1,000 and 5,000. The Augusta Standard Metropolitan Statistical Area (SMSA) had a total 1980 population of 327,400. Approximately two-thirds of the 1980 population within 80 kilometers of SRS lived in rural areas.

Access to the Savannah River Site is limited by guards and security forces. However, once on site, access to the BRRP Site is not limited. The BRRP Site is located near the intersection of Road C and the entrance road to F-area. The BRRP Site is located approximately one-half mile southwest of the F-Area, where the average daily work population is approximately 8000. The BRRP Site is presently not used for any specific purpose.

2.8 Ecology

The BRRP Site and the area surrounding the BRRP Site is characterized by well-established herbaceous cover, dominated by grass, with plants averaging 2.5 feet in height. The pit is flanked by dirt roads to the north and west. Except for the borrow pit, the surrounding areas are predominantly pine and pine-oak forest. The pine forest is dominated by loblolly pine (*Pinus taeda*) with a profusion of kudzu-vine (*Pueraria lobata*) present. The mixed pine-oak forests are dominated by loblolly pine in the overstory; laurel oak (*Quercus laurifolia*) and water oak (*Quercus nigra*) in the understory; kudzu-vine and muscadine (*Vitis rotundifolia*) as the dominant vines; and very few herbaceous species in the herbaceous layer, probably due to a dense accumulation of pine needles on the forest floor. The trees in the canopy of the pine-oak forests were estimated to average 65 feet in height.

The rubble pit is approximately 98% covered by grasses and forbs, which were planted to establish vegetative cover. The dominant species in this field community are *Paspalum sp.* (a grass) and *Lespedeza sp.* (bush cover). None of the vegetation growing on the pit exceeded three feet in height.

The area between the rubble pit and the surrounding forest communities is a successional, old field habitat. Grasses and bush clover are present as well as partridge-pea (*Cassia fasciculata*) and few small persimmons (*Diospyros virginiana*), and rabbit tobacco (*Gnaphalium purpureum*), and some blackberry (*Rubus sp.*) and greenbrier (*Smilax sp.*).

A total of twenty-three bird species were observed on, flying over, or adjacent to the rubble pit during the August 1994 site reconnaissance. Special attention was given to snags of dead trees and the pooled water in the borrow pit, which may serve as habitat areas. Tracks of wild turkey (*Meleagris gallopavo*) were frequently observed on the exposed sandy soils throughout the area, especially to the east in the borrow pit. Several snags in the vicinity of the rubble pit were observed to have suspected woodpecker cavities. Although none were observed to have any activity, these may be occupied by the numerous species of woodpecker that inhabit the area.

Few direct observations of mammals were made, but numerous signs of mammal activity were found. Tracks of white-tailed deer (*Odocoileus virginianus*) were observed in the open sandy areas adjacent to the BRRP Site. Leaf nests of the grey squirrel (*Sciurus carolinensis*) were observed in areas of the site. Several scat were observed and were identified and those of the eastern cottontail (*Sylvilagus floridanus mallurus*) and the raccoon (*Procyon lotor*). Signs of foraging activities of the feral swine were evident in the woodland north of the BRRP Site. The lack of a permanent water body on site limits the use of the BRRP Site for reptiles/amphibians. The herptiles observed include the green tree frog (*Hyla cinerea*), and tadpoles.

Threatened or endangered species of plants or animals were not observed during the ecological site reconnaissance.

A Draft Preliminary Site Characterization report was prepared for the BRRP Site. This report includes derivations and maps of the terrestrial and wetland habitats existing at the BRRP Site, lists of flora identified in each major habitat identified at the unit, and wildlife observations from the August 1994 unit reconnaissance. Site characterization information is provided in Volume II of this report (Final RFI/RI Report Burma Road Rubble Pit (231-4F) (U) Volume II Baseline Risk Assessment, WSRC-RP-94-1218).

3.0 ENVIRONMENTAL INVESTIGATIONS

The environmental investigation conducted at the BRRP consisted of four phases: a geophysical investigation; soil gas investigation; the collection of soil, sediment and water samples; and the installation of groundwater monitoring wells. The objectives of this investigation were to delineate the BRRP trench boundaries, identify any large buried metallic objects such as drums and determine the lateral and vertical extent of potential contamination. Directional references pertain to True North rather than SRS North. This section describes the methodologies utilized during the performance of this study area investigation.

3.1 Field Investigation Strategy

The field investigation strategy utilized for the BRRP was outlined in the RFI/RI Work Plan for the Burma Road Rubble Pit (WSRC, 1993). This section provides a brief description of the Work Plan strategy and its application to the BRRP field investigation.

The soil assessment sampling plan was completed in order to identify areas of potential hazardous substance release and to confirm the presence or absence of contamination in the soil at the waste unit. The sampling plan consisted of three phases. The first phase consisted of three geophysical techniques - ground penetrating radar (GPR), electromagnetic (EM), and magnetometer surveys to determine if disturbed soil or buried waste was present and to delineate trench boundaries at the unit. The second phase was a fourth soil gas survey to detect volatile organic compounds in the soil. This fourth survey augmented the three previous surveys by sampling around the perimeter of the trenches to better bound the lateral extent of volatile organic compound contamination found during the initial surveys. The third phase (soil sampling) consisted of chemical analyses of samples obtained by surface and subsurface soil sampling. The soil sampling was conducted to confirm the results of the geophysical and soil gas surveys; to provide general characterization of waste disposed in the pits; and to detect the presence of any semi-volatile organic compounds and metallic constituents in the soil. Soil sampling was conducted inside and outside the BRRP waste unit boundaries. The results of analyses of the soil samples obtained from the pits were compared with the results of analyses performed on background soil samples to determine the magnitude of soil contamination in the vicinity of the pits.

The groundwater assessment sampling plan was completed in order to obtain data on the hydrogeologic characteristics at the waste unit, to determine whether hazardous substances had

been released to the groundwater, and to determine the extent of contamination resulting from possible migration of hazardous substances beyond the waste unit. Cone penetrometer technology (CPT) was utilized to obtain stratigraphic, lithologic, and water table data. Nine new monitoring wells (3 3-well clusters) were installed to complement and clarify the data received from the existing monitoring wells. The new well clusters were installed upgradient, lateral, and downgradient to the BRRP. The new wells were drilled to collect groundwater data to aid in determining if contaminants detected at the BRRP were the result of releases from other sources in the vicinity.

During the entire investigation, it was observed that standing water was present in a low lying area adjacent to the BRRP waste unit. A field decision was made to collect surface water samples in addition to the sampling specified in the RFI/RI Work Plan for the Burma Road Rubble Pit (WSRC, 1993) in order to be conservative and to provide additional characterization data. Background surface water samples were unavailable because there is no upgradient body of surface water within a reasonable distance of the waste unit from which to obtain a unit-specific background sample.

3.1.1 *Adequacy of Field Investigation*

The work which was done at the BRRP was performed to delineate the area for analysis and to characterize the potential contamination of the soil and groundwater at the BRRP. The geophysical analyses performed delineated the two areas where disposal of the waste material occurred. These surveys found that the areas so noted were approximately physically located where they were thought to have occurred. Minor excursions beyond the orange markers were experienced. There were no significant surprises as to the physical location of the pit themselves; and, there were no new pits or areas found by the geophysical surveys. One small area of disturbed soil existed to the west of the two pits, and when drilled yielded only soil. This is thought to have been a borrow pit for the BRRP waste unit.

The magnetic survey of the BRRP revealed several prominent magnetic anomalies. The largest magnitude anomalies form two parallel, northeast trending dipole features that are interpreted to result from ferrous metallic objects contained within the trenches. Both magnetic data and the electromagnetic data indicate that the northeastern ends of the trenches probably contain larger amounts of metallic material. Individual delineation of the contents was not possible since there were such large concentrations of the metallic objects. Evidence indicated that no significant amount of metallic material was present in the area of disturbed soil to the west of the pits.

The results from a total of two hundred twenty-six (226) soil gas survey points and three geophysical techniques were used to bias the position of the seventeen soil borings in areas where anomalies occurred. This was done in order to target areas with the highest potential for contamination. Six soil samples were taken from each of the soil borings, for a total of one hundred and two soil samples. Samples were taken at the surface and while augering/drilling the soil borings. The contents of the pit were noted, when encountered. None of the borings encountered any containers (i.e., drums), liquid, sludge, or experienced a rod-drop that would indicate a drum or container being punctured. Only inert materials (i.e., wood, trash, lead wire, copper wire, metal, bottles, plastic, aluminum, rubble, foam, 1/2 inch cable, concrete, etc.) were encountered. Continuous OVA readings were also taken. At BRRP-12, a turpentine odor was noted at approximately 3 feet below the surface. The auger had a piece of wood in it when it was withdrawn. The wood also had a turpentine odor. Turpentine is a natural degradation product of pine wood.

CPT successfully provided lithologic, stratigraphic, potentiometric, and water quality data and was instrumental in the placement of the downgradient monitoring well cluster locations.

The groundwater assessment provided water quality data up-, down, and side-gradient of the waste unit which demonstrated that the BRRP was not the source of any elevated contaminant present in the groundwater. The presence of contaminants up-gradient as well as down-gradient suggest an up-gradient source.

3.2 Geophysical Investigation

Three geophysical survey techniques were used at the BRRP to determine subsurface characteristics of the area: electromagnetic survey, magnetic survey, and ground penetrating radar survey. The survey techniques are similar, but each technique has specific capabilities. The ground penetrating radar can detect disturbed areas of soil and buried objects. The electromagnetic survey detects metal objects. The magnetic survey detects ferrous metal objects.

3.2.1 *Electromagnetic Survey*

The electromagnetic (EM) survey was performed during October 6 -8, 1993. The objectives of the EM survey investigation were as follows:

1. To determine the boundaries of the BRRP Waste Unit,
2. To help identify buried tanks, drums, or other large metallic objects across the rubble pit area,
3. To help assess the natural geohydraulic conditions, and
4. To help map the potential contaminant plume.

EM methods measure the electrical conductivity of the subsurface. Conductivity is measured by inducing electrical currents into the earth with a time-varying primary magnetic field and measuring the amplitude and phase shift of the resultant secondary magnetic field associated with the induced currents. The amplitude and phase shift of the secondary magnetic field relative to the primary field are functions of the electrical properties of the earth materials near the transmitter and receiver. The effective depth of exploration of EM instruments is considered to be the depth of materials from which the majority (70 percent) of the instrument response is gathered.

The electrical conductivity of subsurface materials is primarily dependent upon the conductivity of the pore fluids, porosity, and the clay content of the soil and rock. There are two components of the induced magnetic field which can be measured. The first component is referred to as a "quadrature-phase" component that gives the bulk conductivity measurement. Bulk conductivity is expressed in terms of milli-mhos per meter (m-mhos/m). The second component is referred to as the "in-phase" component which is more sensitive to large metallic objects such as pipes, drums and tanks. The interpretation of the in-phase response is more qualitative than the bulk conductivity measurement. The interpretation of the in-phase response is based upon the variation in the in-phase component of the EM signal relative to a baseline or background response. By observing the response of the in-phase component of the secondary magnetic field, it is often possible to determine whether a change in conductivity (quadrature-phase) is due to the presence of buried metallic objects as opposed to clay or dissolved metals in the groundwater.

A Geonics EM-31 conductivity meter was used to collect ground conductivity values along the transect identified in Figure 3-1.

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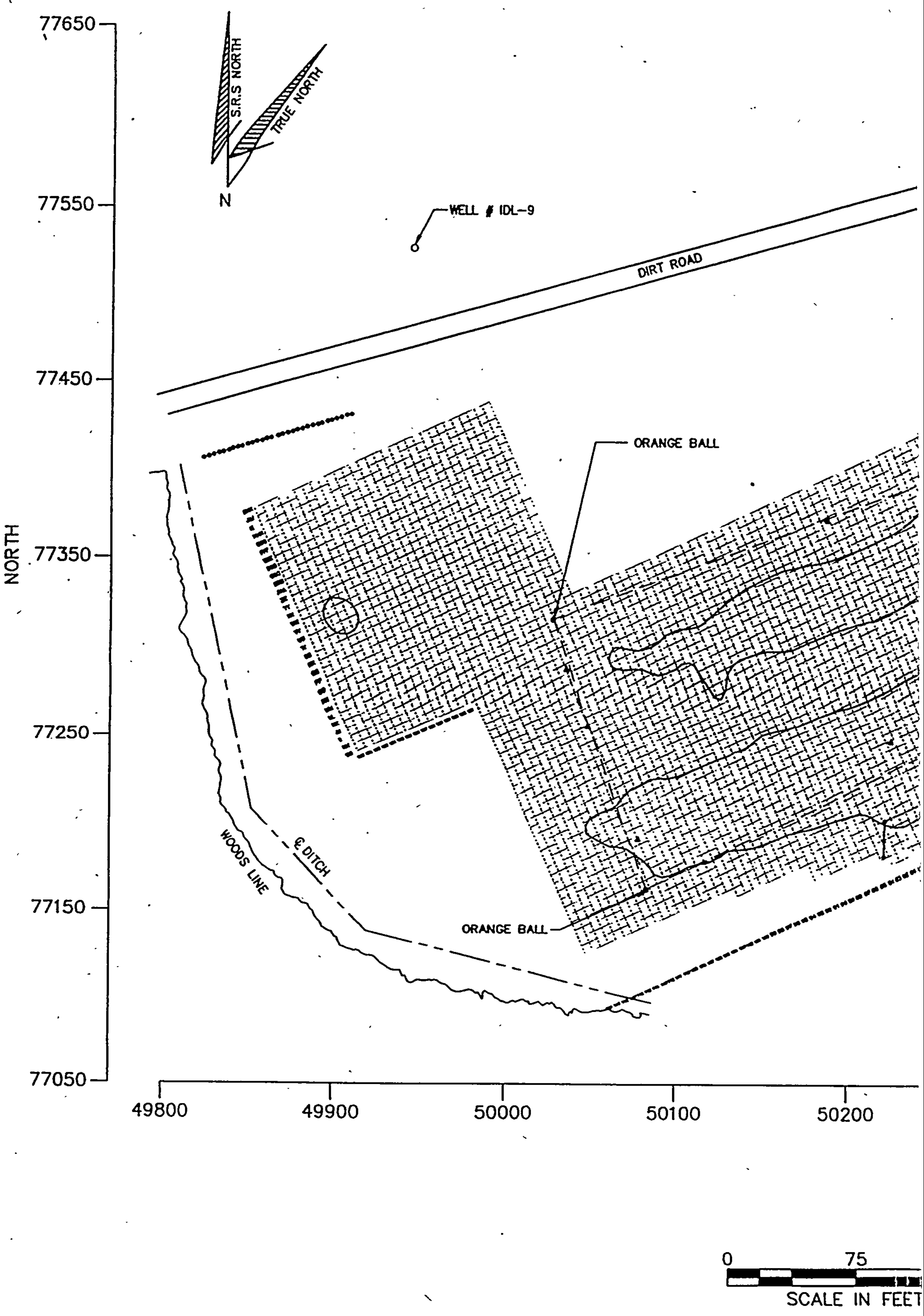

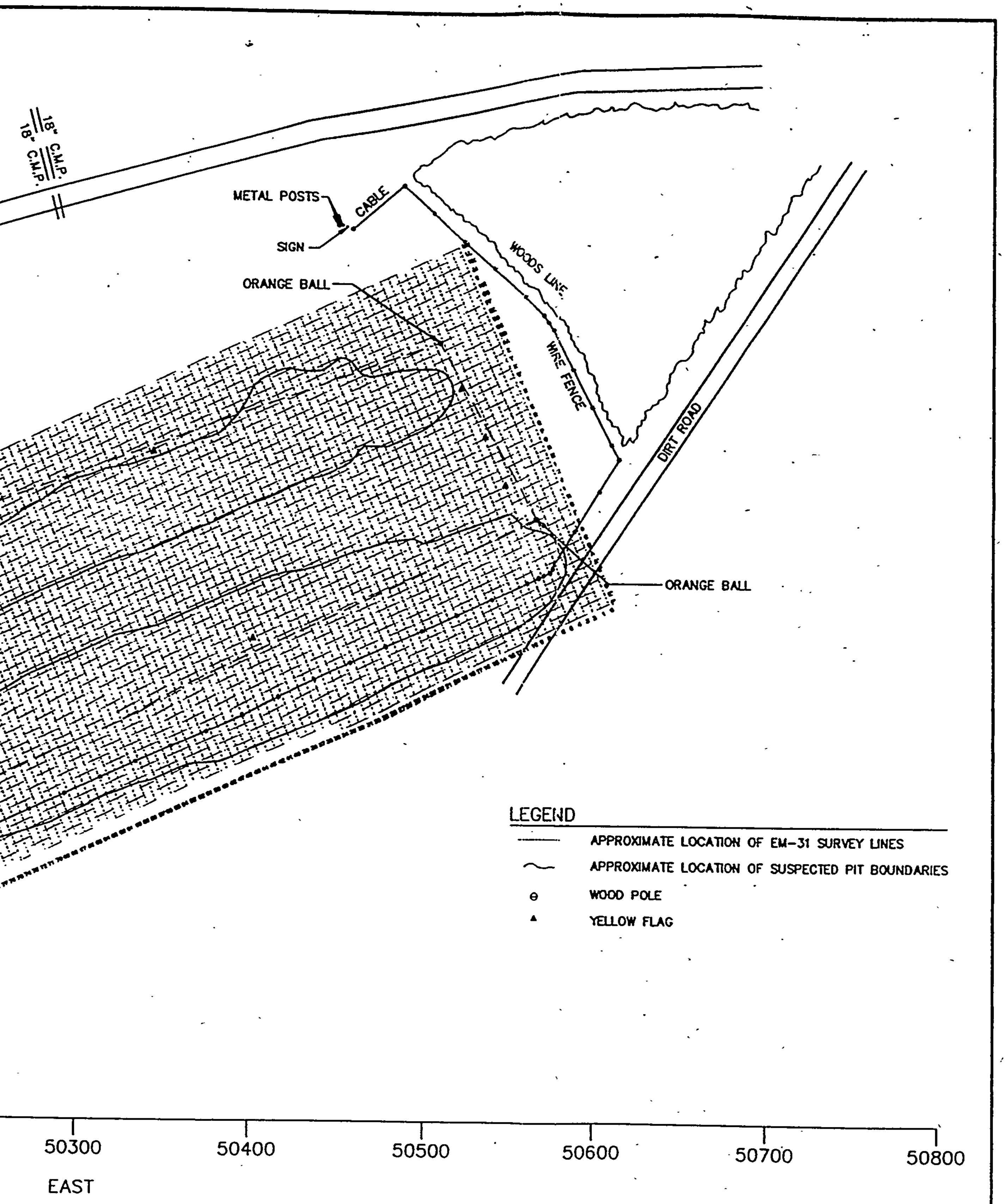

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SITE MAP SHOWING APPROXIMATE
LOCATION OF EM SURVEY LINES

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3–1

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The boundaries of the surveyed area was established by field personnel. As illustrated in Figure 3-1, the survey was performed along a 5-ft grid of perpendicular transects. The transects were established using a 300-foot fiberglass measuring tape. Bulk conductivity and in-phase response measurements were collected at survey stations which were spaced 5 feet apart along each transect line. The location of the survey stations were indicated using 24-inch survey flags. The survey flags were left at the project site after completion of the investigation to assist field personnel in locating identified anomalies (irregularities).

The EM-31 survey was performed by two people walking the EM-31 and data recorder along the previously established transect lines. EM data was collected using a data range scale of either 0 to 30 or 0 to 100 m-mhos/m. The effective depth of penetration of the EM-31 is approximately 20 feet below land surface. The instrument scale was varied to allow for increased accuracy in data interpretation. The location of the EM-31 instrument along the transect lines was electronically marked on the data on 5-ft intervals at each survey station. Continuous bulk conductivity and in phase data were recorded. Approximately 59,000 linear feet of EM survey were performed during the investigation.

3.2.2 *Ground Penetrating Radar Survey*

Field personnel performed a ground penetrating radar (GPR) survey at the BRRP during October 6 - 8, 1993. The objectives of the GPR survey were as follows:

1. Evaluate natural and disturbed soil conditions to delineate the pit boundaries,
2. Locate and delineate buried waste, including both bulk and drummed waste, and
3. Locate and delineate potential contaminant plume areas.

GPR systems are similar to EM systems in that a source and a receiver are needed. A radar antenna source emits an EM pulse several times a second. These EM impulses are then directed into the ground in the form of waves. As the waves penetrate deeper through the geologic material, contrasts (anomalies) cause some of the waves to be reflected back toward the surface, where it is received by the antenna, while some of the waves continues downward. When enough anomalies have been encountered, there is very little remaining of the signal (to be reflected); this condition is what is termed effective penetration depth. The time interval between the point when the signal is emitted to when it is reflected and received is dependent on the properties of the material and on the depth at which the signal is reflected. The radar impulse travels approximately 10 percent the speed of light in water; in dry sands, the radar impulse travels approximately 50 percent the speed of light.

The contrasts in electrical properties are a function of the composition of the materials and moisture contents. Generally, good conductors, such as metal drums, reflect the entire radar signal (EM wave), so there is no penetration below this point. Poor conductors (good resistors), such as unsaturated sands, will generally allow for a deeper radar signal penetration than good conductors such as saturated clays or saline water.

The GPR survey at the BRRP utilized velocities for the Upland Unit sediments based on a walkway noise spread performed in the undisturbed soils adjacent to the trenches. The variability of velocities associated with sediment dielectric values within Upland soils adjacent to the BRRP are consistent with values found elsewhere on site and as determined from other velocity measurement techniques (e.g., by direct arrival measurement to the water table). The walkway spread confirmed the values of 6-7 nanosecond per foot, two way time (0.28 to 0.33 ft/ns_{tt}) for the survey area of the BRRP.

GPR data was acquired on a total of 208 lines totaling 68,880 feet. GPR lines 1-37 were recorded twice using the 100 MHz high power antenna and again using the 300 MHz antenna. Grid lines were spaced at 5-foot intervals. Data were acquired in both directions (e.g., north-south, then south-north), but the data from all lines were plotted in the same direction, as displayed in Figure 3-2. Better results were generally obtained with the 300 MHz antenna.

3.2.3 *Magnetometer Survey*

A magnetic survey was conducted in June 1993 to accurately determine the locations of the trenches and to assess the prospects of additional buried objects at this waste unit. The survey consisted of a grid over and in the vicinity of the area where the trenches were known to occur.

Magnetometer surveys measure the strength of the earth's magnetic field. A proton nuclear magnetic resonance magnetometer is frequently used. This is a hand-held instrument in which one person can rapidly perform a survey over a site of a few acres in size. A grid system is set up and measurements are made of the magnetic field at each intersection of the grid. Areas with large amounts of buried metal, such as steel drums, will have magnetic anomalies associated with them. The strength of the anomaly will vary with the amount and depth of the buried metal. According to U.S. EPA

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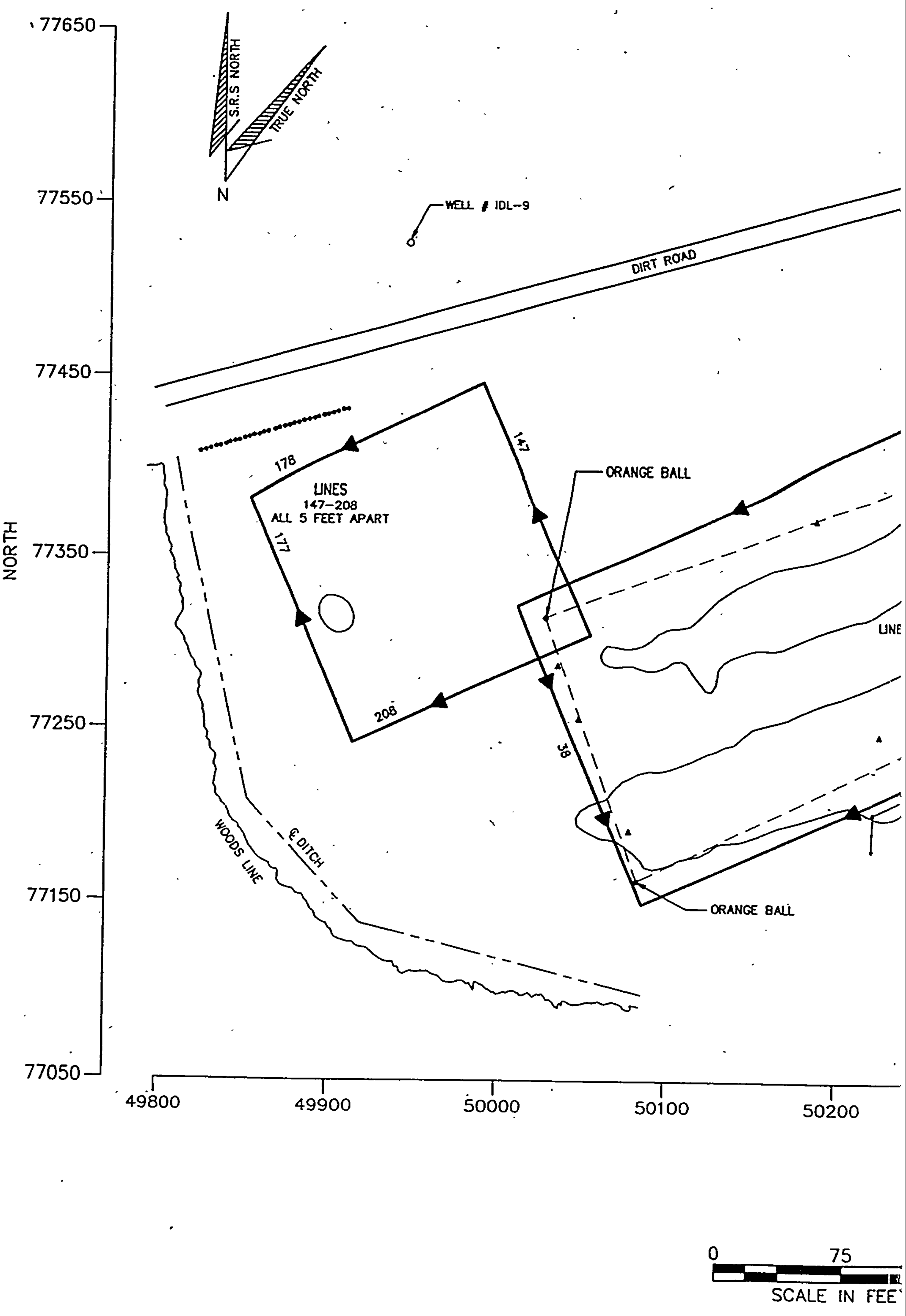

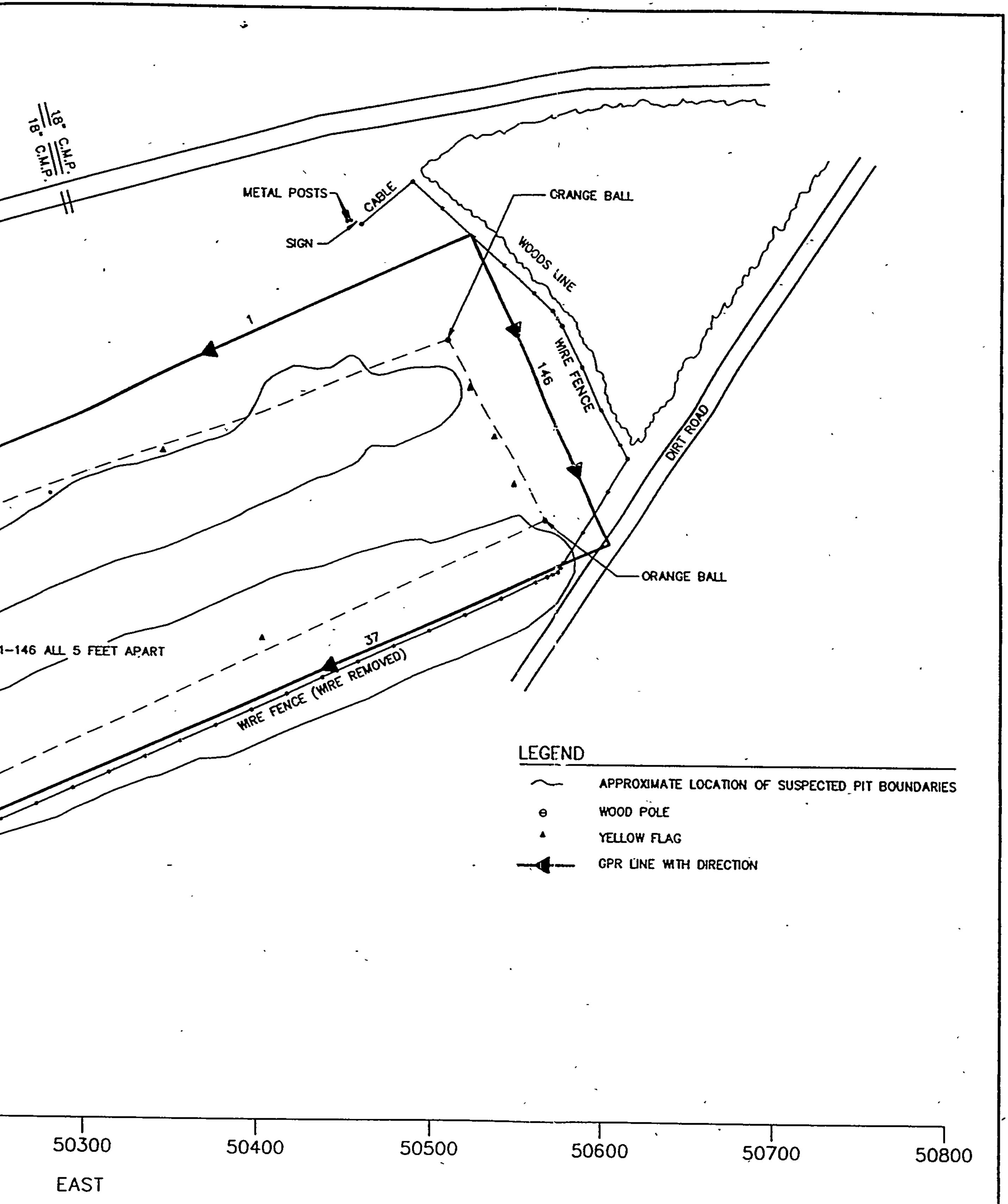

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BURMA ROAD 3–D SURVEY
GPR SURVEY

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3–2

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documents, a single drum can typically be detected at distances up to 20 feet, while a cache of drums can be detected at distances up to 67 feet or more.

At the BRRP, magnetic data was collected with an EG&G Geometrics G-856 Gradiometer. This is a proton magnetometer operated in the gradiometer mode, with a nominal accuracy of 0.1 nano-Tesla (nT). The proton precession magnetometer uses the precession of spinning protons to measure the total intensity of the earth's magnetic field independent of orientation. This scalar value is representative of the total field intensity. The gradiometer is equipped with two sensors which allow for measurement of both the total intensity and vertical gradient of the magnetic field. The vertical gradient is used because it can provide greater resolution of shallow anomalies. Because the gradient is the difference in total magnetic fields, it removes the variations in background readings by design. The negative aspect of using the gradiometer is that in the process of being more sensitive, it is also more sensitive to magnetic interference (e.g., surface metal). As identified in the WSRC Report titled "Magnetic Survey of the Burma Road Rubble Pit Waste Unit" (Cumbest et al, 1994), the grid established for most of the magnetic survey was defined by 5-foot station intervals placed on a square pattern. The grid covered the area between and immediately surrounding the orange waste unit marker balls that indicated the corners of the waste unit and the areas within the trenches. In addition to this area, coverage was extended to investigate the area of disturbed soil that occurred near the southern corner of the site. The grid for this extended area was defined by 5-foot station intervals collected along lines 10 feet apart resulting in a 5-foot by 10-foot grid pattern. The station locations were positioned before the magnetic data were collected by using a transmit to establish 90 degree angles and straight lines and a cord marked at 5-foot intervals.

The area of the BRRP magnetic survey is removed from cultural features that generate noise within the data set. The F-Area wind tower and BRR monitoring wells, cultural features adjacent to the site might possibly affect the data, are fixed and constant and will cause no cyclical variability within the data set. Multiple re-occupation of a fixed site for drift calculations after every two-transects (each transect taking approximately 10 minutes) allows for a curve averaging that precludes temporal effects of sunspot activity. Micropulsations are generally less than 10 nano-Tesla in amplitude and fall well below the smoothes contoured intervals presented on the BRRP magnetic survey maps. Additionally, by nature, micropulsations occur at random and the chance of occurrence while the sensor is directly over a trench is minimal.

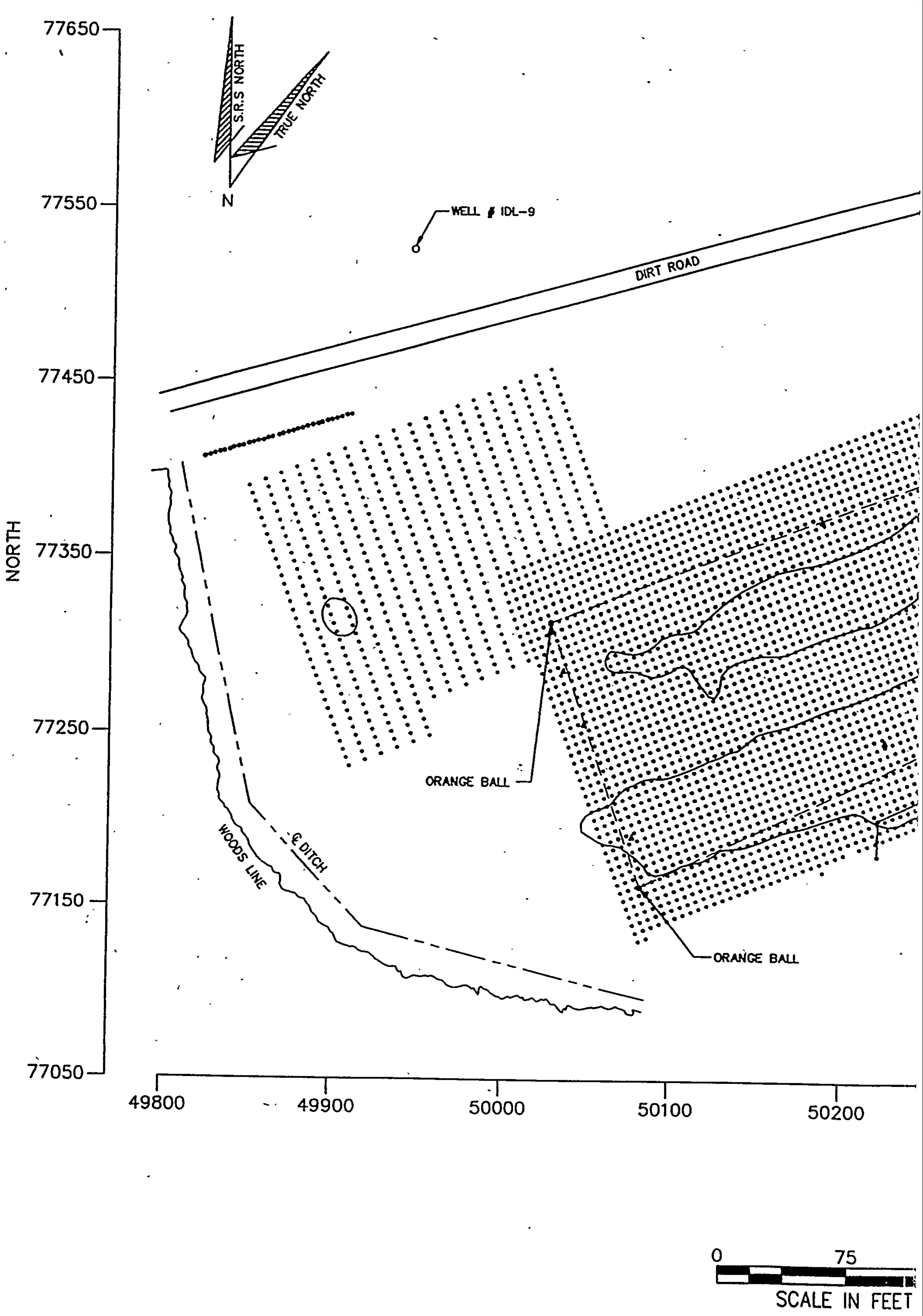
The magnetometer used has a nominal accuracy of 0.1 nT. However, high magnetic gradients [>600 nano-Tesla per meter (nT/m)] will cause the signal to sharply degrade. In most cases, this degradation will deteriorate the accuracy to 1 nT. More severe degradation can result in significant accuracy loss. With this consideration, the top sensor was placed 8 feet from ground level and the bottom sensor 6 feet from ground level for the survey conducted over the 5-foot square grid. This configuration was used to optimize the gradiometer function because of the short distance between the sensors relative to any possible anomaly sources. This configuration was also used to avoid the extreme magnetic gradients that were expected from the material in the trenches. This configuration was modified for the survey over the disturbed soil in the 10-foot by 5-foot grid. In this area, the top sensor was placed 4 feet above the surface and the bottom sensor 2 feet above the surface to maximize sensitivity and detect small or deeply buried objects. As a quality assurance/quality control check and to account for diurnal variation, a single station, located on the northwest corner of the grid, was surveyed regularly during data acquisition.

The data was downloaded from the magnetometer through an RS-232 port to an IBM PC Model 80. After downloading, the data was assigned coordinates and diurnally corrected with MAGLOC software. Further data display and processing, including gridding and contouring, were accomplished with GEOSOFT software. Gridding of the data was accomplished with BIGRID, which is specifically designed to gridline data and enhance trends. Before gridding, the data was low-passed filtered with a 10-foot wavelength cutoff. After gridding, the data was also directionally filtered to remove line-to-line leveling errors. All data was gridded at 2.5-foot node spacing. Magnetic gradients were calculated by subtracting the top sensor reading from the bottom sensor and dividing by their separation. Since the top and bottom readings are taken at a relatively short-time scale (approximately 3 seconds) relative to diurnal variations, the gradient is calculated from the data before diurnal correction.

The station locations for the survey are illustrated in Figure 3-3. The survey over the area delineated by the orange waste unit marker balls and the locations of suspected trenches (5-ft by 5-ft grid pattern) was rectangular in shape and oriented so that the short dimension was approximately perpendicular to the long dimension of the trenches. For this area, data was collected along traverse parallel to the short dimension. The survey conducted over the area of disturbed soil (5-ft by 10-ft grid pattern) consisted of 20 lines along which data were collected in the same manner ass the 5-ft by 5-ft grid.

3.3 Soil Gas Survey

The following accounts of soil gas surveys conducted at the BRRP Site were taken from the May 1993 report titled "An Investigation of Soil Gases at Depths of 3-25 Feet at the Burma Road Rubble



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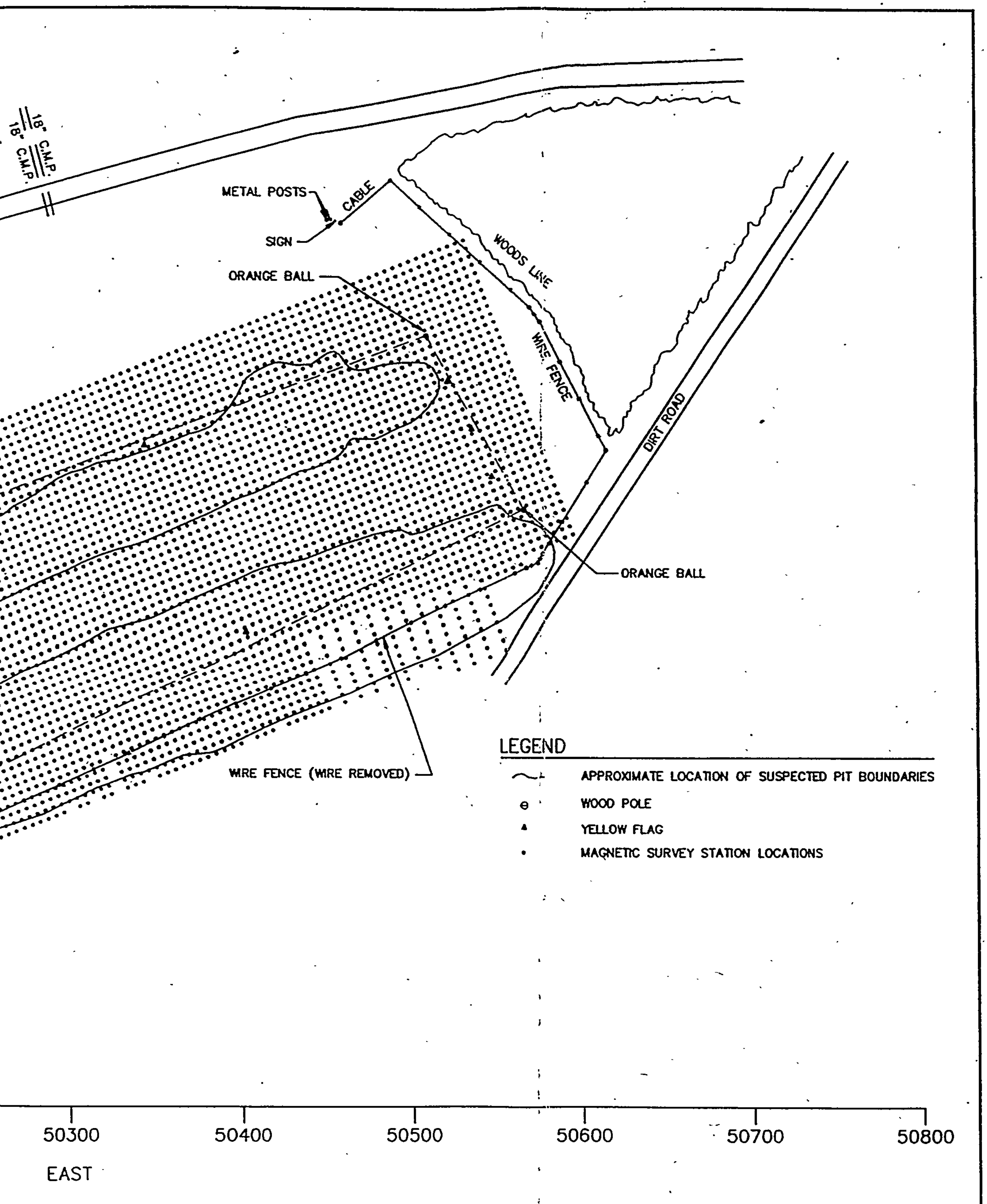

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MAGNETIC SURVEY
STATION LOCATIONS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3–3

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Pits" (Pirkle and Masdea, 1993) and the July 1993 report titled "A Soil Gas Survey at Depths of 3 and 20 Feet at the Burma Road Rubble Pits" (Pirkle and Masdea, 1993).

Four separate soil gas surveys were completed at the BRRP in October 1990, July 1991, September 1992, and July 1993. The objective of all soil gas surveys was to determine the presence and extent, or absence of contamination in soil gases in and around the burial pits. The most recent survey extended the coverage of prior surveys.

In the first two surveys (Sites 1 - 91), soil gas sample depths were 3 feet, except for Sites 85 - 88 which were 6 feet. In the third survey, Sites 92 - 133 were sampled using the Geoprobe hydraulic sampling system to depths up to 25 feet while Sites 134 - 150 were sampled at 3 feet using a manual sampling technique. In the most recent survey, Sites 151 - 207 were sampled at 3 feet and Sites 208 - 226 at 20 feet. A soil sample was taken for mercury only at each 3-foot site. A map of the sample locations from all of the surveys at the BRRP site is presented in Figure 3-4.

The Geoprobe procedure utilized to collect the soil gas samples specified driving the probe to a depth of 20 to 25 feet or to refusal, whichever was achieved first. The probe was then withdrawn 0.5 feet and a sample was attempted. If a sample could not be taken at this depth, the probe was pulled up 1 foot and another attempt was made to take a sample.

During these investigations, soil samples for mercury analyses were also collected. In surveys I through III, soil samples were collected for mercury analysis from a soil core at a depth of one foot at a location approximately one foot away from the point of soil gas collection. In survey IV, soil samples for mercury analyses were collected at depths of three feet.

All quality assurance procedures for sample collection, sample documentation and analytical methods followed an approved Quality Assurance Manual. This manual was audited and approved by the Department of Energy for implementation at the Savannah River Site.

In all surveys, the light hydrocarbons, (C1 - C4); gasoline range aromatic hydrocarbons, (benzene, toluene,, ethylbenzene, and xylene (BTEX)); selected chlorinated organics, and mercury were monitored. In the third survey and the most recent survey, soil gas samples were additionally analyzed for the C5 - C10 saturated hydrocarbons and 1,1,1-trichloroethane. All analyses for the most recent survey, except for soil mercury, were conducted at the Microseeps laboratory located in Pittsburgh, PA. Soil mercury analyses were carried out in an on-site laboratory. Samples for the

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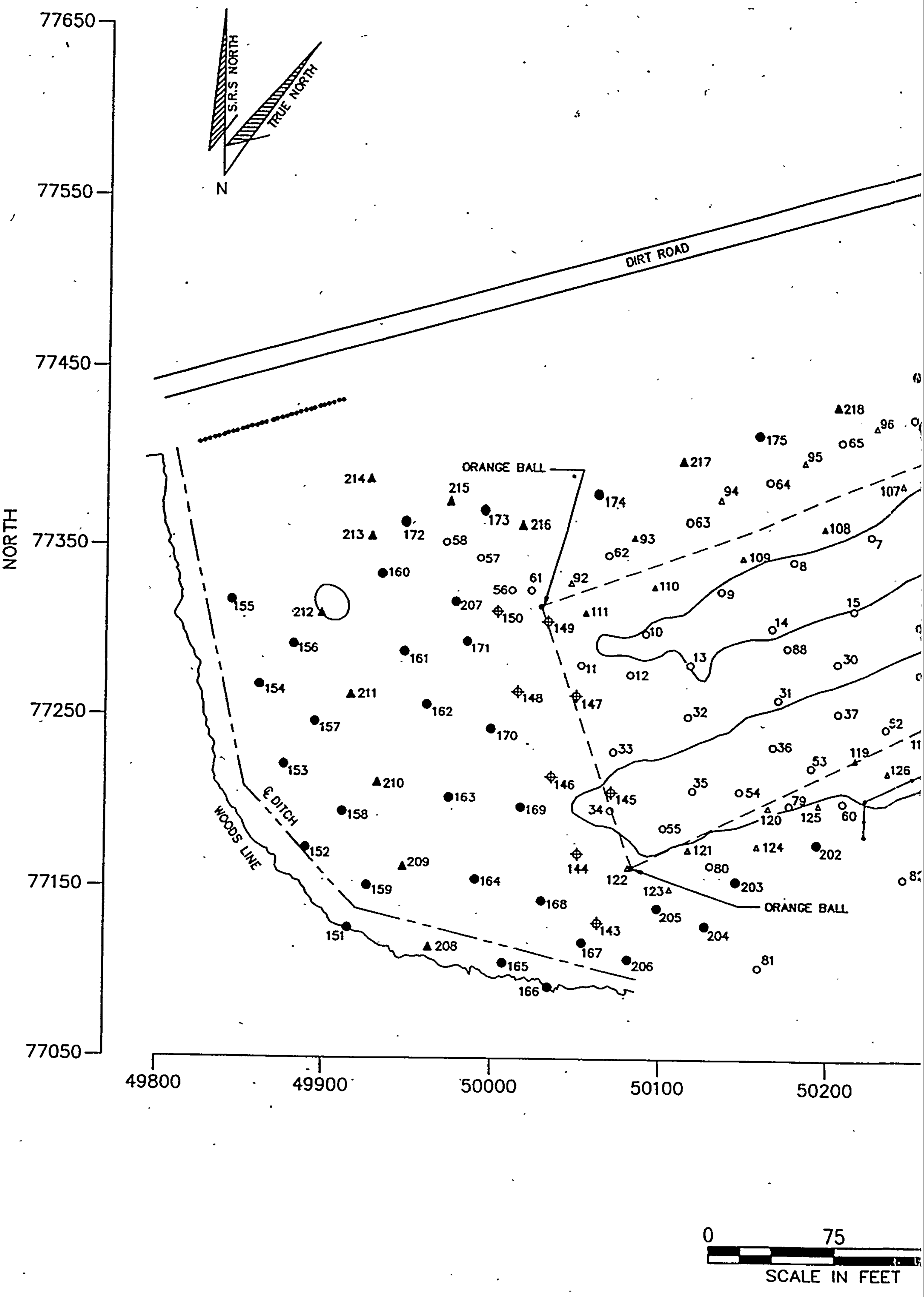

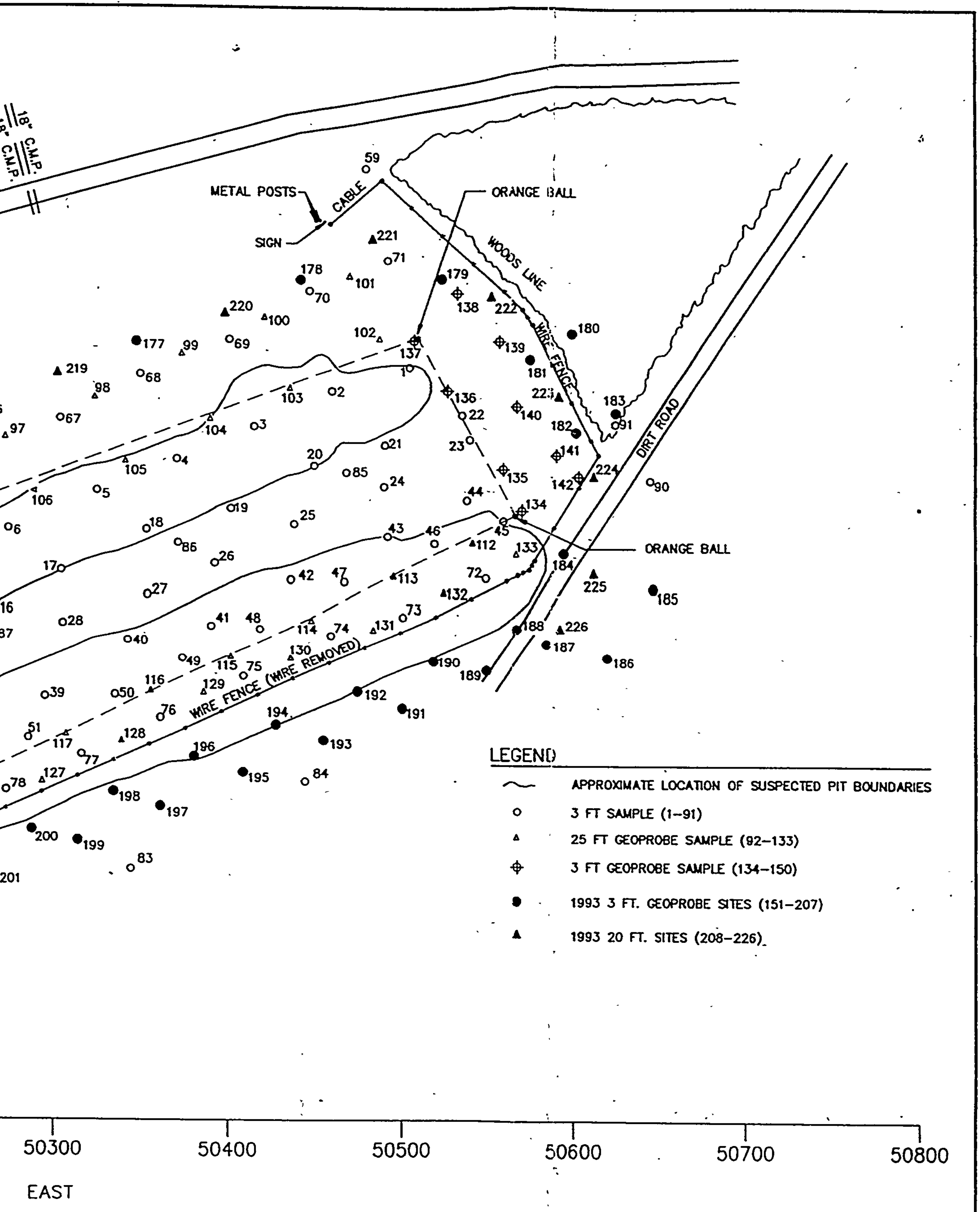

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SOIL GAS SURVEYS

SAVANNAH RIVER PLANT

AIKEN, SOUTH CAROLINA

FIGURE 3–4

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light hydrocarbon analyses were taken in previously evacuated 125 ml bottles. Samples for volatile organic compounds (VOC) analyses were taken in previously evacuated 22 ml bottles. A duplicate sample and a blank were taken for every ten samples. The duplicate samples were taken from a separate location which was approximately 1 foot from the original site. Blanks were collected after normal purging of the syringe sampler at each 10th sample location. The blanks were collected by drawing ambient air through the syringe into evacuated vials. The blanks were analyzed in the same manner as the other samples.

Table 3-1 lists the constituents analyzed in the soil gas samples taken in 1992 and 1993.

3.4 Surface and Subsurface Soil Sampling

Soil sampling was completed in two stages. Field personnel provided technical oversight during both of the sampling events. Surface and subsurface soil sampling within the areas of suspected contamination began on December 15, 1993 and was completed on January 11, 1994. Background soil samples were collected on January 17 and 18, 1994. The objectives of the soil sampling program were as follows:

1. To confirm the results of the soil gas surveys,
2. To determine if hazardous substances have contaminated the surface and subsurface soils within GPR Zones 1, 2, and 3 (see **Figure 1-3**), and
3. To gather background soil quantity data for statistical, comparative analyses with samples taken within the areas of suspected contamination.

Seventeen (17) borings (BRRP-1 through BRRP-17) were drilled in the area of suspected contamination. The boring locations were chosen after reviewing available results from the soil gas survey, the GPR survey, the EM survey, and the magnetometer survey. The primary studies used in determining the boring locations were the soil gas surveys and the EM survey. In general, the borings were located in areas where a soil gas anomaly was detected or adjacent to potential underground objects/areas of high metal concentration indicated by anomalies in the GPR, EM, or magnetometer surveys. Figure 3-5 shows the locations of the 17 borings. Table 3-2 lists the coordinates for these borings. Drilling and samples collection was performed with a hollow stem auger rig and a two or three inch diameter split spoon sampler. Prior to use, the split spoon sampler was decontaminated in accordance with the procedures listed in the Westinghouse Procedures Manual

Table 3-1 Constituents Analyzed in Soil Gas Samples

Benzene	Nonane
I-Butane	Octane
N-Butane	Pentane
Carbon Tetrachloride	Propane
Chloroform	Propylene
Decane	Tetrachloroethylene
Ethane	Trichloroethylene
Ethylbenzene	Toluene
Ethylene	trans-1,2-Dichloroethylene
Hexane	1,1,1-Trichloroethane
Heptane	Vinyl Chloride
Mercury	M & P Xylene
Methane	O Xylene
Methylene Chloride	

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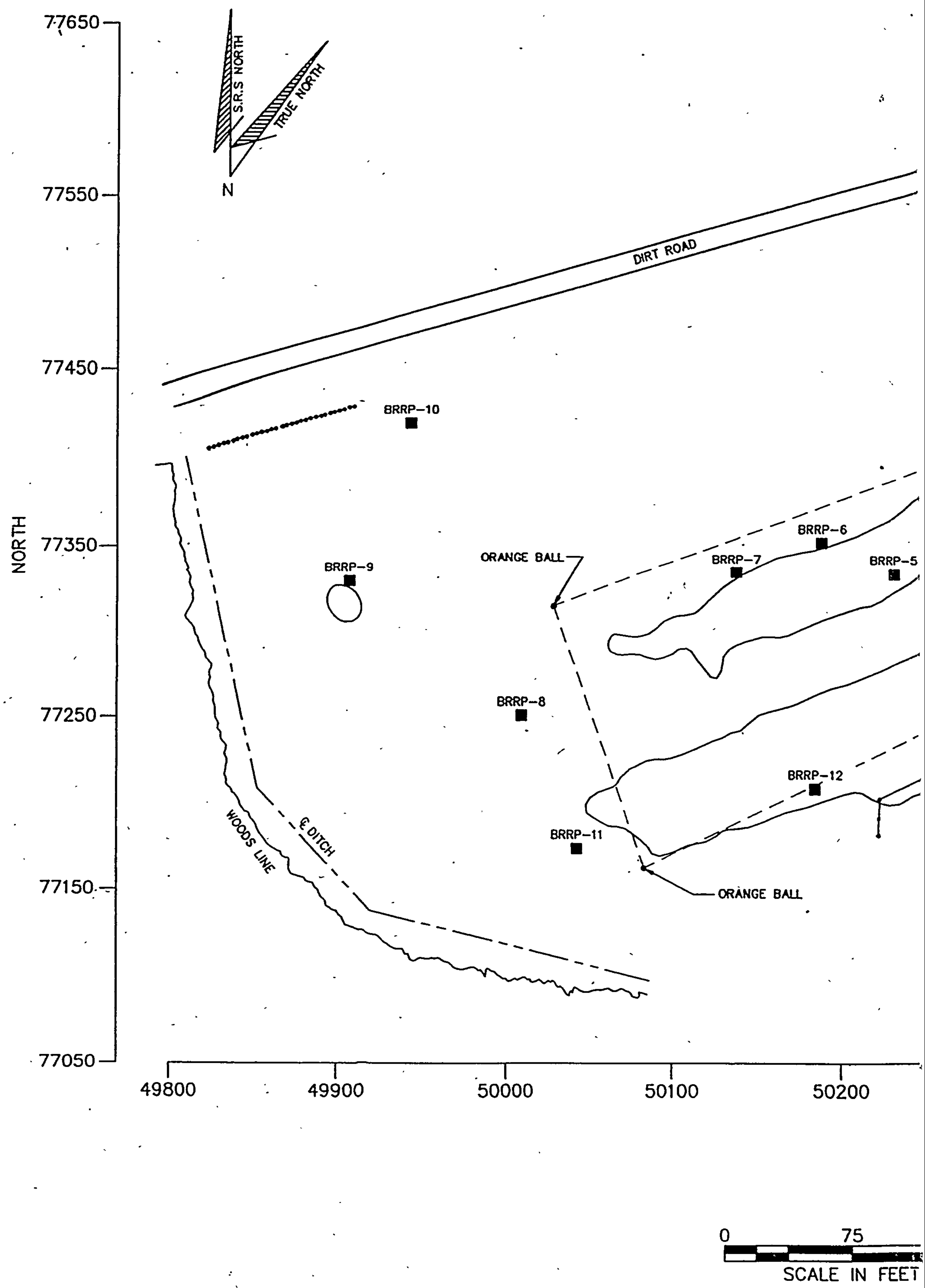

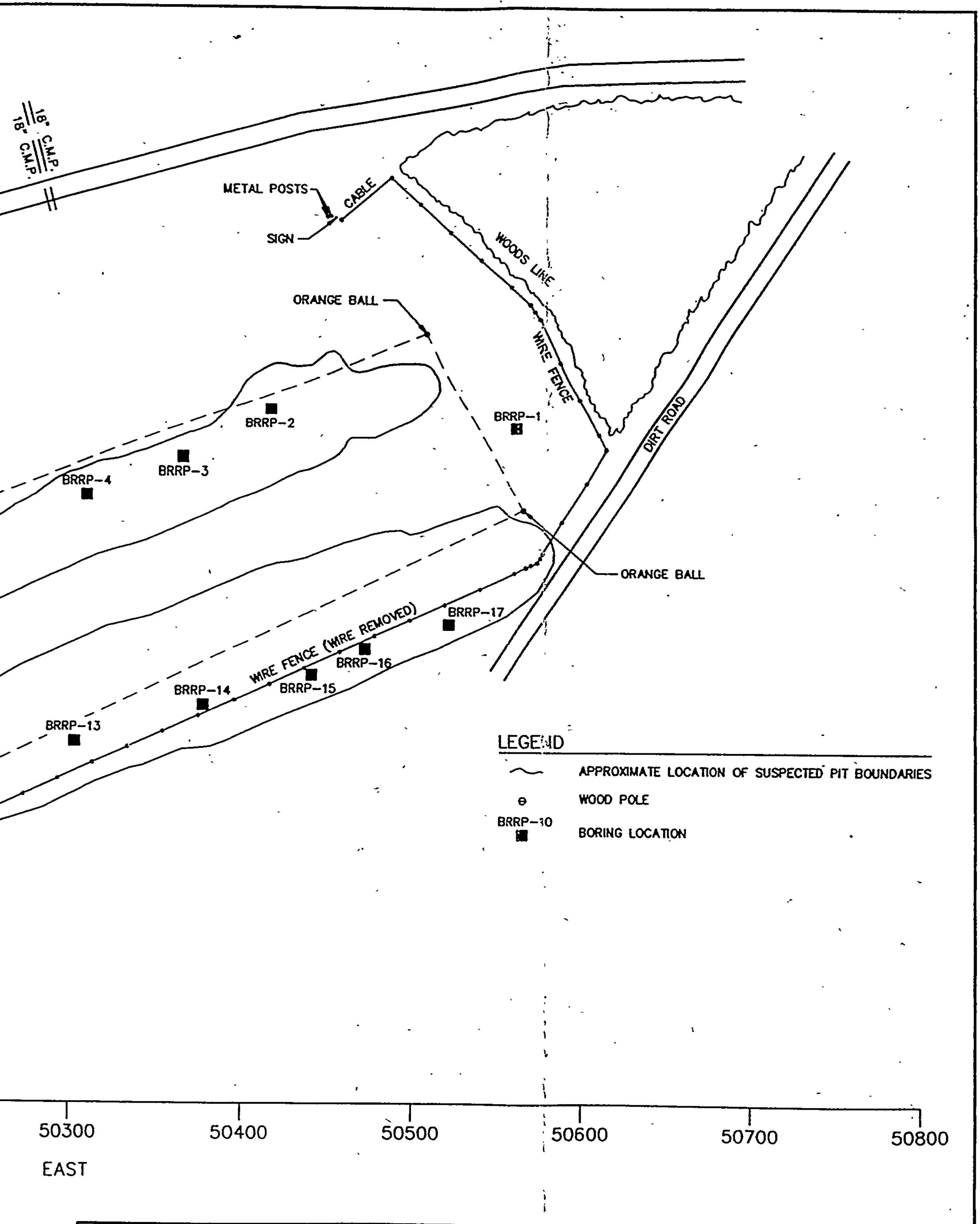

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LOCATION OF BORINGS DRILLED IN
AREAS OF SUSPECTED CONTAMINATION

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3–5

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Table 3-2 Coordinates for Soil Borings

Location	Latitude	Longitude
BRRP-1	33.2794974	81.6840004
BRRP-2	33.2792957	81.6844122
BRRP-3	33.2791545	81.6844965
BRRP-4	33.2790187	81.6846067
BRRP-5	33.2787551	81.6847035
BRRP-6	33.2787347	81.6848496
BRRP-7	33.2786150	81.6849536
BRRP-8	33.2782311	81.6851579
BRRP-9	33.2782454	81.6855674
BRRP-10	33.2785036	81.6856330
BRRP-11	33.2781096	81.6849338
BRRP-12	33.2784075	81.6846089
BRRP-13	33.2786934	81.6843766
BRRP-14	33.2788557	81.6842134
BRRP-15	33.2789954	81.6840757
BRRP-16	33.2790754	81.6840206
BRRP-17	33.2791830	81.6839123

3Q5, Hydrogeologic Data Collection Procedures and Specifications (WSRC, 1990). All samples were field screened with an Organic Vapor Analyzer (OVA) at the time of collection.

Split spoon samples were collected at the surface of each boring from 0.0 to 2.0 feet. The next sample was collected from approximately the base of the pit to two feet below the base of the pit. Two additional continuous two-foot split spoon were collected just below the base of the pit. Additional samples were collected at five foot intervals until the level of volatile organics detected in the headspace sample was 10 ppm or less in two consecutive samples. This sampling scheme is shown in Figure 3-6. Each sample was screened for volatile organics by using the following headspace procedure:

1. A sample from each undisturbed split spoon was placed in a wide mouth glass jar.
2. The glass jar was covered tightly with aluminum foil.
3. The jar was allowed to sit for approximately 20 minutes.
4. The aluminum foil was then punctured with the OVA probe and a reading taken.

The VOC screening method utilized in this field characterization allows time for volatile organic vapors to accumulate in the headspace of the sealed sample jar. This accommodates environmental factors (i.e., wind, rain, etc.) as well as eliminating inherent organic compounds contained in plastic bags that may provide a false positive reading by the screening tool. This procedure serves to minimize the potential for discontinuing sampling within a borehole before the vertical extent of contamination is determined. It also allows for characterization of the horizontal and vertical extent of contamination in one field sampling event.

The volatile organic sample vials were filled directly from the split spoon immediately after it was opened. The remaining soil in the split spoon was transferred to a decontaminated stainless steel bowl and homogenized. The remaining sample jars were filled with this homogenized soil.

At location BRRP-3, field personnel encountered metal objects at 8 to 9 feet during their first attempt. The drill rig was moved to a location 3 feet west of the original location and again met refusal at a depth of 9 to 10 feet. The rig was subsequently moved 5 feet east of the original location and the required depths were obtained at this spot.

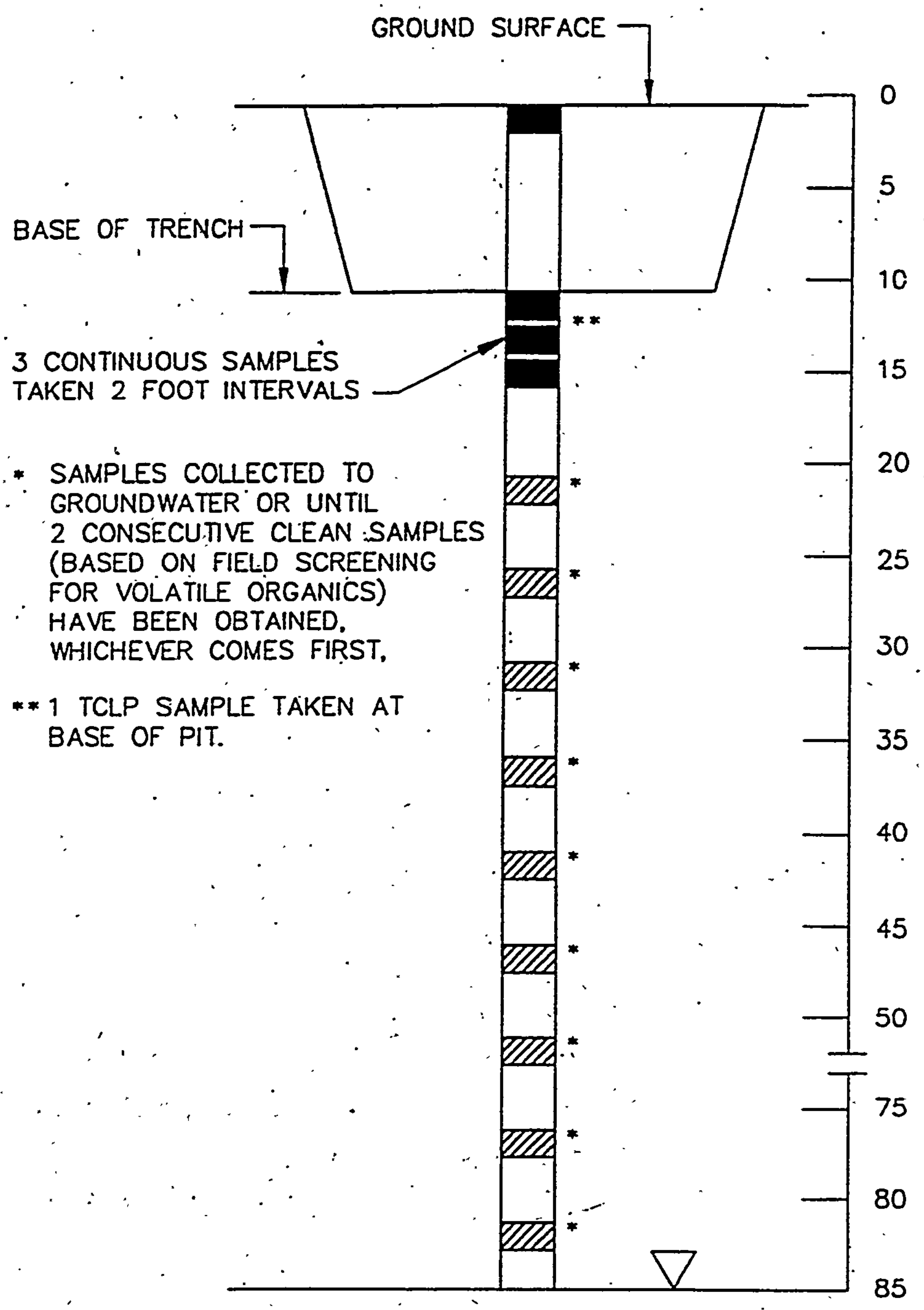

Figure 3-6 Sampling Scheme for Borings Conducted in Areas of Suspected Contamination.

Samples were collected at six depths for all locations. Table 3-3 summarizes the sample date, location, and analytical parameters for the samples collected from each soil boring. Soil boring logs are presented in Appendix A.

Analytical suites were determined by taking into account the unit history and the characteristics of the specific contaminants such as mobility within the soil matrix, potential fate and transport mechanisms as well as time and cost. Additionally, because the soil volumes obtained by the split spoon sampling device were often insufficient to fill all of the sample bottles (especially on duplicate samples), the analytes had to be prioritized based upon the unit history, contaminant mobility, and fate and transport mechanisms.

Two background surface samples were collected on December 28, 1993. These surface soil samples were collected with a hand auger from the surface to 2-foot depth. Background subsurface soil samples were collected on January 17 and 18, 1994. These subsurface samples were collected with a split spoon at a depth of 10 to 12 feet. Headspace readings were obtained from each sample using the procedure outlined above. All sampling procedures were conducted in accordance with WSRC 3Q5.

Figure 3-7 shows the locations from which all background soil samples were collected. Table 3-4 lists the coordinates for the background samples. Table 3-5 summarizes the field data for background samples collected.

3.5 Surface and Runoff Sediment Sampling

Two surface runoff sediment samples (BR-05-01 and BR-06-01) were collected on December 28, 1993. On February 22, 1994, one sediment sample (BRRP-101) was collected from the borrow pit located adjacent to the BRRP. Figure 3-8 shows the location of the surface runoff sediment samples. Table 3-6 lists the coordinates for the sediment samples. The objectives of the sediment investigation were as follows:

1. To determine if runoff from the pits has carried contamination to offsite areas.
2. To determine if the BRRP has impacted the quality of the water and sediments in the adjacent borrow pit.

Table 3-3 Soil Sample Field Data in Areas of Suspect Contamination

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BRRP-01-01	12/15/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-01-02	12/15/93	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-01-03	12/15/93	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-01-04	12/15/93	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-01-05	12/15/93	Soil	20 - 22	VOCs, RCRA Metals
BRRP-01-06	12/15/93	Soil	25 - 27	VOCs, RCRA Metals
BRRP-02-01	12/16/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-02-02	12/16/93	Soil	8 - 10	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-02-03	12/16/93	Soil	10 - 12	TCL/TAL with TICs, Radionuclides
BRRP-02-04	12/16/93	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-02-05	12/16/93	Soil	19 - 21	VOCs, RCRA Metals
BRRP-02-06	12/16/93	Soil	24 - 26	VOCs, RCRA Metals
BRRP-03-01	12/16/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-03-02	12/17/93	Soil	15 - 17	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-03-03	12/17/93	Soil	17 - 19	TCL/TAL with TICs, Radionuclides
BRRP-03-04	12/17/93	Soil	19 - 21	TCL/TAL with TICs, Radionuclides
BRRP-03-05	12/17/93	Soil	26 - 28	VOCs, RCRA Metals
BRRP-03-06	12/17/93	Soil	31 - 33	VOCs, RCRA Metals
BRRP-04-01	12/16/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-04-02	12/17/93	Soil	16 - 18	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-04-03	12/17/93	Soil	18 - 20	TCL/TAL with TICs, Radionuclides
BRRP-04-04	12/20/93	Soil	20 - 22	TCL/TAL with TICs, Radionuclides
BRRP-04-05	12/20/93	Soil	25 - 27	VOCs, RCRA Metals
BRRP-04-06	12/20/93	Soil	30 - 32	VOCs, RCRA Metals

TCL = Target Compound List
TAL = Target Analyte List
TIC = Tentatively Identified Compound
TCLP = Toxicity Characteristics Leaching Procedure
VOCs = Volatile Organic Compounds

Table 3-3 Soil Sample Field Data in Areas of Suspect Contamination (continued)

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BRRP-05-01	12/20/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-05-02	12/20/93	Soil	15 - 17	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-05-03	12/20/93	Soil	17 - 19	TCL/TAL with TICs, Radionuclides
BRRP-05-04	12/21/93	Soil	19 - 21	TCL/TAL with TICs, Radionuclides
BRRP-05-05	12/21/93	Soil	24 - 26	VOCs, RCRA Metals
BRRP-05-06	12/21/93	Soil	29 - 31	VOCs, RCRA Metals
BRRP-06-01	12/21/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-06-02	12/21/93	Soil	16 - 18	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-06-03	12/21/93	Soil	18 - 20	TCL/TAL with TICs, Radionuclides
BRRP-06-04	12/21/93	Soil	20 - 22	TCL/TAL with TICs, Radionuclides
BRRP-06-05	12/21/93	Soil	25 - 27	VOCs, RCRA Metals
BRRP-06-06	12/21/93	Soil	30 - 32	VOCs, RCRA Metals
BRRP-07-01	01/03/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-07-02	01/04/94	Soil	16 - 18	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-07-03	01/04/94	Soil	18 - 20	TCL/TAL with TICs, Radionuclides
BRRP-07-04	01/04/94	Soil	20 - 22	TCL/TAL with TICs, Radionuclides
BRRP-07-05	01/04/94	Soil	25 - 27	VOCs, RCRA Metals
BRRP-07-06	01/04/94	Soil	30 - 32	VOCs, RCRA Metals
BRRP-08-01	01/04/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-08-02	01/04/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-08-03	01/04/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-08-04	01/04/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-08-05	01/04/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-08-06	01/04/94	Soil	25 - 27	VOCs, RCRA Metals

TCL = Target Compound List

TAL = Target Analyte List

TIC = Tentatively Identified Compound

TCLP = Toxicity Characteristics Leaching Procedure

VOCs = Volatile Organic Compounds

Table 3-3 Soil Sample Field Data in Areas of Suspect Contamination (continued)

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BRRP-09-01	01/05/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-09-02	01/05/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-09-03	01/05/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-09-04	01/05/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-09-05	01/05/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-09-06	01/05/94	Soil	25 - 27	VOCs, RCRA Metals
BRRP-10-01	01/10/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-10-02	01/10/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-10-03	01/10/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-10-04	01/10/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-10-05	01/10/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-10-06	01/10/94	Soil	25 - 27	VOCs, RCRA Metals
BRRP-11-01	01/05/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-11-02	01/05/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-11-03	01/05/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-11-04	01/05/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-11-05	01/05/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-11-06	01/05/94	Soil	25 - 27	VOCs, RCRA Metals
BRRP-12-01	01/06/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-12-02	01/06/94	Soil	6 - 8	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-12-03	01/06/94	Soil	8 - 10	TCL/TAL with TICs, Radionuclides
BRRP-12-04	01/06/94	Soil	10 - 12	TCL/TAL with TICs, Radionuclides
BRRP-12-05	01/06/94	Soil	15 - 17	VOCs, RCRA Metals
BRRP-12-06	01/06/94	Soil	20 - 22	VOCs, RCRA Metals

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TAL = Target Analyte List
TIC = Tentatively Identified Compound
TCLP = Toxicity Characteristics Leaching Procedure
VOCs = Volatile Organic Compounds

Table 3-3 Soil Sample Field Data in Areas of Suspect Contamination (continued)

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BRRP-13-01	01/06/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-13-02	01/06/94	Soil	13 - 15	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-13-03	01/06/94	Soil	15 - 17	TCL/TAL with TICs, Radionuclides
BRRP-13-04	01/06/94	Soil	17 - 19	TCL/TAL with TICs, Radionuclides
BRRP-13-05	01/07/94	Soil	22 - 24	VOCs, RCRA Metals
BRRP-13-06	01/07/94	Soil	27 - 29	VOCs, RCRA Metals
BRRP-14-01	01/07/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-14-02	01/07/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-14-03	01/07/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-14-04	01/07/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-14-05	01/07/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-14-06	01/07/94	Soil	25 - 27	VOCs, RCRA Metals
BRRP-15-01	01/10/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-15-02	01/10/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-15-03	01/10/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-15-04	01/11/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-15-05	01/11/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-15-06	01/11/94	Soil	25 - 27	VOCs, RCRA Metals
BRRP-16-01	01/11/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-16-02	01/11/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-16-03	01/11/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-16-04	01/11/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-16-05	01/11/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-16-06	01/11/94	Soil	25 - 27	VOCs, RCRA Metals

TCL = Target Compound List
TAL = Target Analyte List
TIC = Tentatively Identified Compound
TCLP = Toxicity Characteristics Leaching Procedure
VOCs = Volatile Organic Compounds

Table 3-3 Soil Sample Field Data in Areas of Suspect Contamination (continued)

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BRRP-17-01	01/11/94	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BRRP-17-02	01/11/94	Soil	10 - 12	TCL/TAL with TICs, TCLP, Radionuclides
BRRP-17-03	01/11/94	Soil	12 - 14	TCL/TAL with TICs, Radionuclides
BRRP-17-04	01/11/94	Soil	14 - 16	TCL/TAL with TICs, Radionuclides
BRRP-17-05	01/11/94	Soil	20 - 22	VOCs, RCRA Metals
BRRP-17-06	01/11/94	Soil	25 - 27	VOCs, RCRA Metals

TCL = Target Compound List
TAL = Target Analyte List
TIC = Tentatively Identified Compound
TCLP = Toxicity Characteristics Leaching Procedure
VOCs = Volatile Organic Compounds

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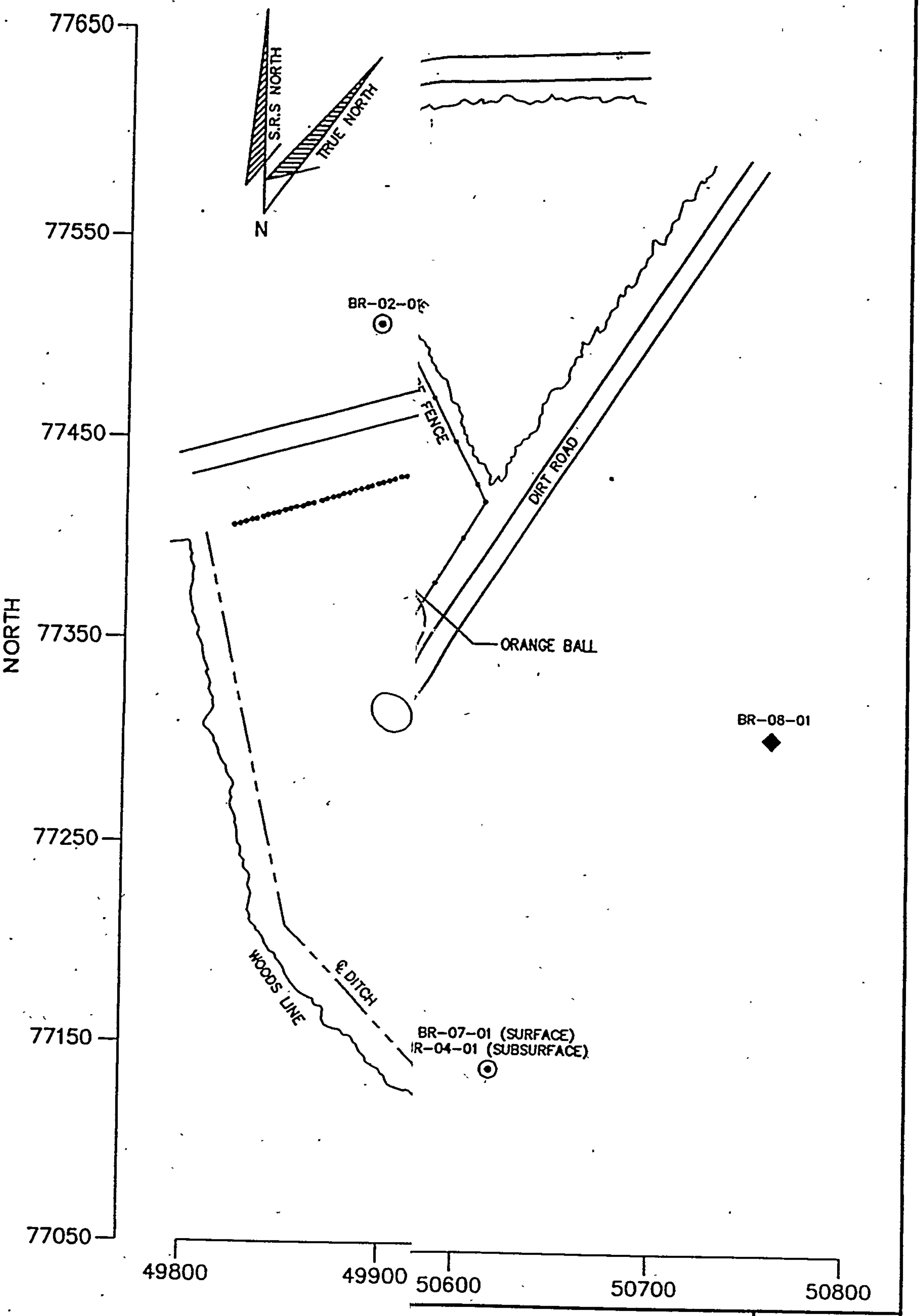

SUBSURFACE AND SURFACE
ROUND SOIL SAMPLES

NAH RIVER PLANT
, SOUTH CAROLINA

FIGURE
3-7

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DATE 09/22/94
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Table 3-4 Coordinates for Background Samples

Location	Latitude	Longitude
BR-01	33.2797815	81.6851442
BR-02	33.2786310	81.6859336
BR-03	33.2780389	81.6847243
BR-04	33.2789384	81.6833204
BR-07	33.2789384	81.6833204
BR-08	33.2795210	81.6832346

Table 3-5 Background Soil Sample Field Data

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BR-01	01/17/94	Soil	10 - 12	TCL/TAL with TICs, Radionuclides
BR-02	01/17/94	Soil	10 - 12	TCL/TAL with TICs, Radionuclides
BR-03	01/18/94	Soil	10 - 12	TCL/TAL with TICs, Radionuclides
BR-04	01/18/94	Soil	10 - 12	TCL/TAL with TICs, Radionuclides
BR-07	12/28/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides
BR-08	12/28/93	Soil	0 - 2	TCL/TAL with TICs, Radionuclides

TCL = Target Compound List
TAL = Target Analyte List
TIC = Tentatively Identified Compound

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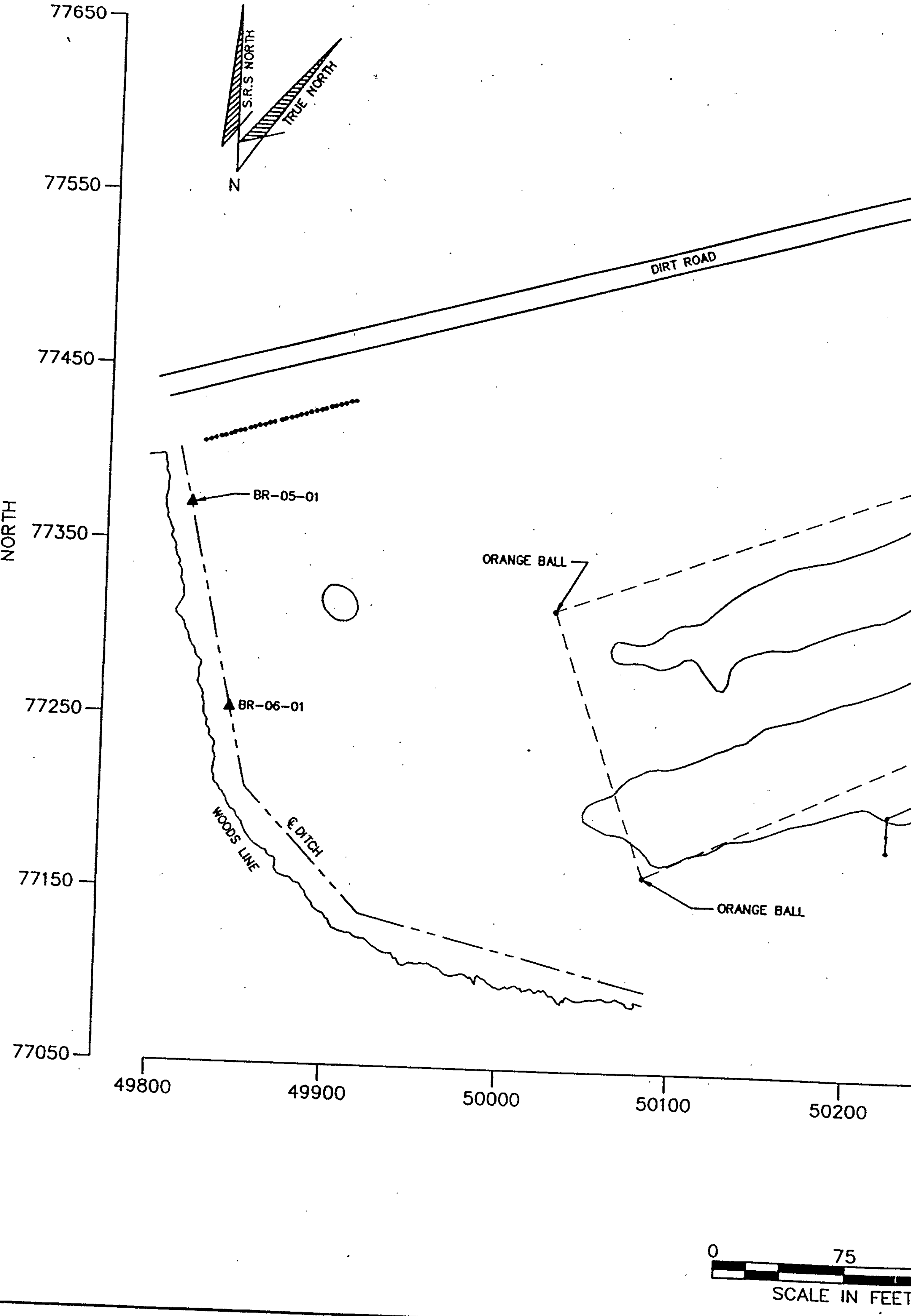

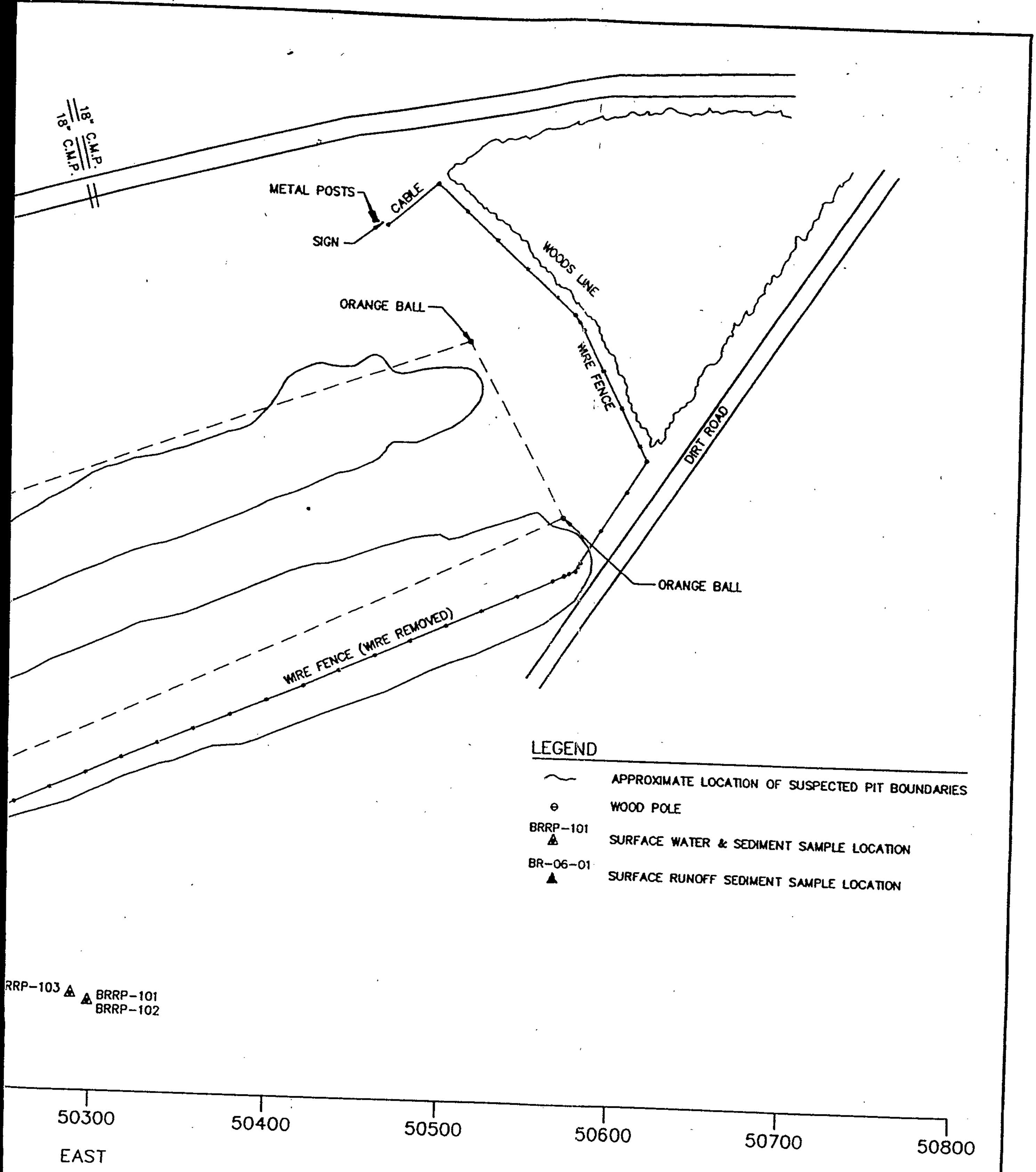

METCALF & EDDY

LOCATIONS OF SURFACE WATER AND
SEDIMENT SAMPLES

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3-8

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Table 3-6 Coordinates for Surface Runoff Sediment, Surface Water and Soil (Sediment) Samples

Location	Latitude	Longitude
BR-05	33.2781604	81.6859308
BR-06	33.2779857	81.6859308
BRRP-101	33.2783669	81.6841217
BRRP-102	33.2783669	81.6841217
BRRP-103	33.2783522	81.6841683

The surface runoff sediment samples, collected on December 28, 1993, were taken from a ditch located downslope of the unit. Each sample was taken at a depth of 6 to 12 inches using a hand auger and a stainless steel spoon. Samples were placed in glass jars and prepared for shipping. Sample preservation, shipment and handling followed WSRC protocol. Table 3-7 summarizes the sample date, depth, and analytical parameter information for the surface runoff sediment samples collected.

The sediment sample from the borrow pit was taken at a depth of 3 to 4 inches near the water's edge. A stainless steel spoon and a glass sampling jar were used to collect the sediment sample. **The VOC sample jars were filled first directly from the sampling device. The sample was then homogenized in a stainless steel bowl and the other sample jars were filled.** All samples were preserved, shipped and handled according to WSRC protocol. Table 3-8 summarizes the sample date, depth, and analytical parameter information for the sediment sample collected from the borrow pit.

3.6 Surface Water Sampling

On February 22, 1994, two surface water samples (BRRP-102 and BRRP-103) were collected from the borrow pit located adjacent to the BRRP. Figure 3-8 shows the location of the surface water samples. Table 3-6 lists the SRS coordinates for the surface water samples. The objectives of the surface water sampling investigation have been stated in Section 3.4, Surface Sediment Runoff Sampling.

One surface water sample was collected from near the water's edge while second surface water sample was collected from a high turbidity area within the pond. The surface water samples were collected using glass sampling jars. All samples were preserved, shipped and handled according to WSRC protocol. Table 3-8 summarizes the sample date, depth, and analytical parameter information for the surface water samples collected from the borrow pit.

3.7 Geological/Ecological/Hydrogeological Investigation

The geological/hydrogeological investigation began in November 1993 and was completed in February 1994. This investigation included:

1. The collection of lithology information and groundwater samples using cone penetrometer technology,

Table 3-7 Surface Runoff Soil (Sediment) Sample Field Data

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Feet)	Analytical Parameters
BR-05-01	12/28/93	Sediment	0 - 2	TCL/TAL with TICs, Radionuclides
BR-06-01	12/28/93	Sediment	0 - 2	TCL/TAL with TICs, Radionuclides

TCL = Target Compound List

TAL = Target Analyte List

TIC = Tentatively Identified Compound

Table 3-8 Surface Water and Soil (Sediment) Samples Field Data

Sample Location	Date Collected	Sample Type	Sample Depth Interval (Inches)	Analytical Parameters
BRRP-101	02/22/94	Sediment	3 - 4	TCL/TAL with TICs, Radionuclides
BRRP-102	02/22/94	Surface Water	0	TCL/TAL with TICs, Radionuclides
BRRP-103	02/22/94	Surface Water	0	TCL/TAL with TICs, Radionuclides

2. The collection of geotechnical samples,
3. The installation of nine groundwater monitoring wells in 3 three-well clusters, and
4. The performance of slug tests.

The specific objectives of this investigation were as follows:

1. To optimize the positioning of three new well clusters that would be placed upgradient, side gradient, and downgradient of the BRRP by using existing monitoring wells and hydrocone data,
2. To establish if hazardous substances have contaminated the aquifers below the water table aquifer by using water quality data obtained from the three new well clusters,
3. To gather background groundwater samples for statistical, comparative analyses with samples taken where contamination is confirmed or suspected, and
4. To gather other geological and geotechnical data needed for assessment and potential remedial design.

3.7.1 *Cone Penetrometer*

A cone penetrometer investigation was conducted at the BRRP beginning November 17, 1993 and was completed on December 5, 1993.

The scope of the field work included nine piezocone soundings to an approximate depth of 85 feet and five hydrocone groundwater samples collected from the top of the water table aquifer. Figure 3-9 illustrates the location of the soundings and samples.

The objectives of the cone penetrometer investigation were:

1. To characterize the subsurface lithology at the BRRP,
2. To collect groundwater samples using direct push technology, and
3. To supplement existing water table elevation data to aid in placement of the new well clusters.

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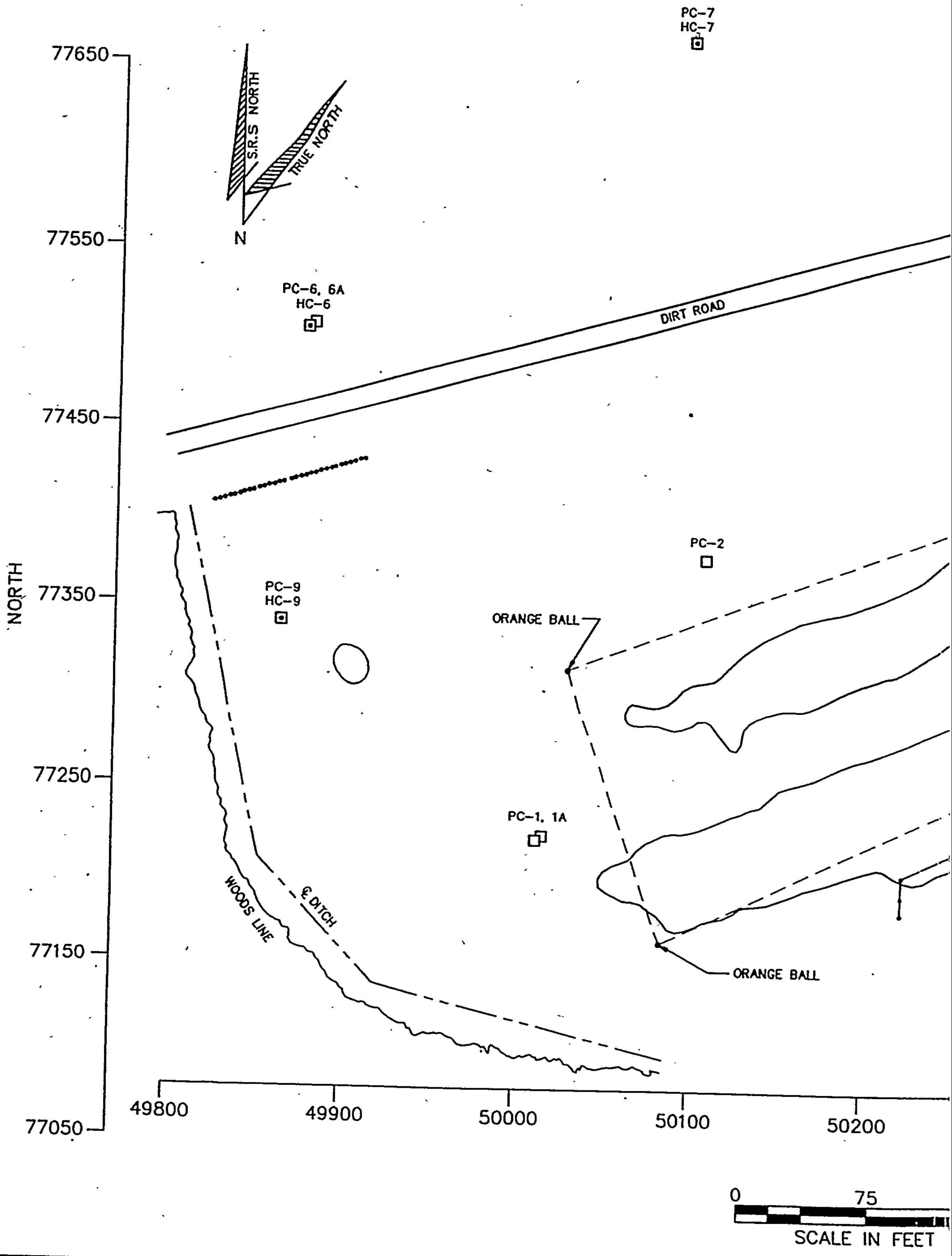

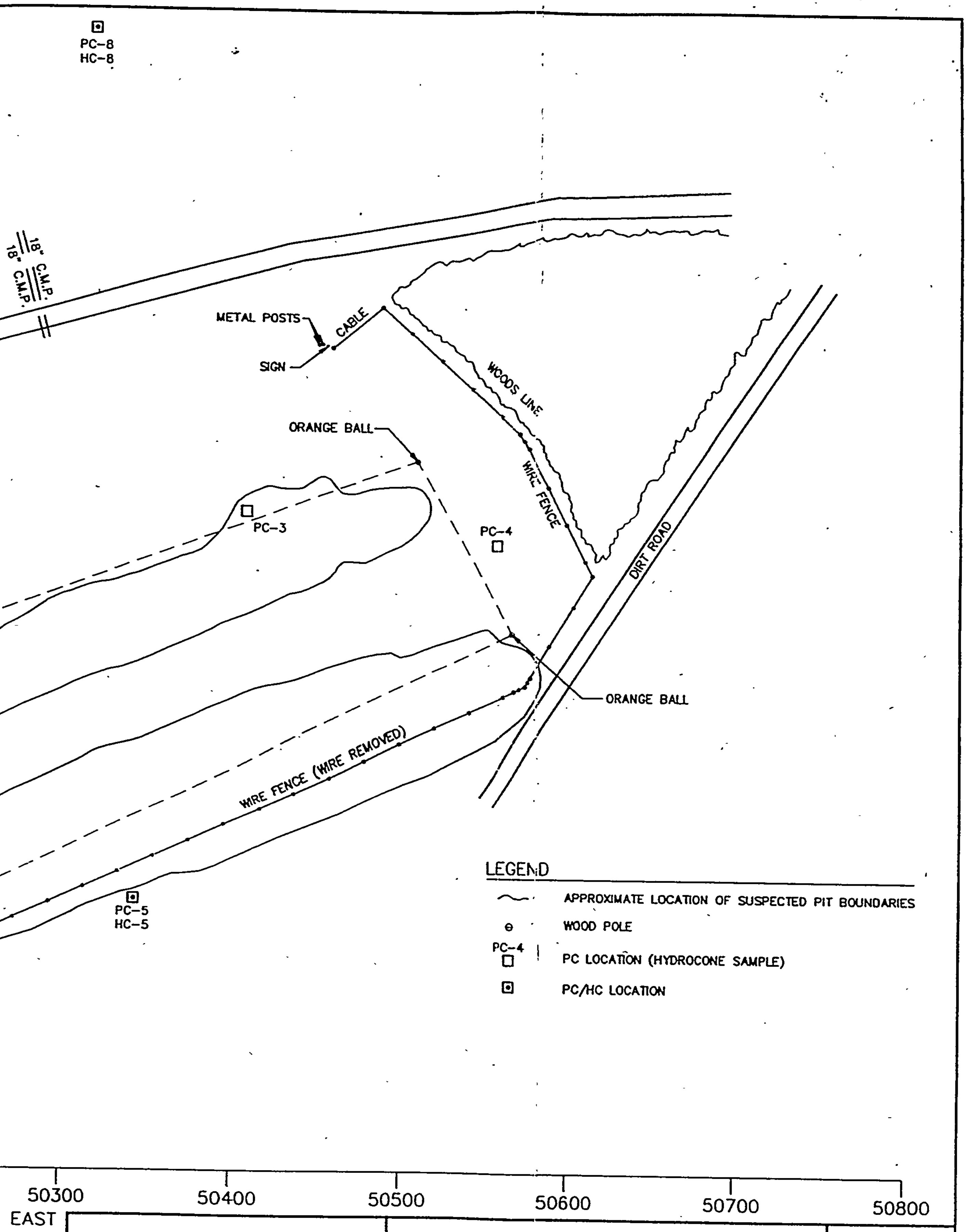

METCALF & EDDY

MAP OF PIEZOCONE/HYDROCONE LOCATIONS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE 3–9

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3.7.1.1 Piezocone

The Piezocone PC-1 is a direct push technology instrument which conforms to ASTM D-3441 and provides information on soil types and characteristics. Testing with the PC-1 is conducted by pushing the cone into the earth at a constant rate of two (2) centimeters per second. As the cone is advanced, data from pressure transducers and strain gages located inside the Piezocone are recorded and displayed in real time on the computer monitor. Recorded measurements include the stresses generated on a 60-degree conical point and on a 150 square centimeter cylindrical section (sleeve) located immediately behind the point. Pore pressure measurements are taken through a porous element located at the base of the tip of the point. These measurements are then correlated to soil type and various soil characteristics. These correlations can be used in determining groundwater sampling depths, confining units and in location perched water tables.

The point and sleeve pressures generated while the piezocone is being pushed are measured by strain gages which adhere to the piezocone in a Wheatstone Bridge formation. These strain gages conform to ASTM E-251. The pore pressure data is measured by a diaphragm pressure transducer, Data Instruments Model AB200 HP, and conforms to Mill Standard No. 45662.

Correlations exist between cone measurements and soil characteristics. The on-board computer determines soil characteristics and type during PC-1 soundings by relating point stress, sleeve friction, and the ratio of sleeve friction/point stress to equivalent soil parameters.

The PC-1 determines the following data:

1. Unified soil classifications,
2. Relative soil density (SPT blow count values),
3. Perched water table conditions,
4. Estimates of hydraulic conductivity,
5. Effective thickness of a confining unit.

In addition the pore pressure transducer can measure the following:

1. Induced pore pressure during thrusting,
2. Time rate of pore pressure decay when thrusting is stopped,

3. Hydrostatic or piezometric pressure within the aquifer which is obtained when all induced pore pressure is dissipated, and
4. Water table depth determined by correlations between instrument depth and hydrostatic head.

3.7.1.2 Hydrocone

The GS-1 Groundwater Sampler is used for obtaining groundwater samples (1300 cc volumes) without the need for monitoring wells.

The GS-1 sampler is constructed completely of stainless steel and consists of a six foot sample chamber, an electronic "wand", a tip assembly consisting of a check ball housing and check ball, a #10 slot Johnson screen and a 60-degree conical tip. Sampling with the GS-1 begins with pushing the instrument to a predetermined sampling depth. When this sampling depth has been achieved, high pressure argon gas is applied to the sample chamber. The high pressure gas closes the check ball assembly and holds the tip assembly in place while the sample chamber is back-pulled one foot to expose the screen assembly. Once the screen assembly is exposed, the argon gas pressure is vented and natural hydrostatic pressure forces groundwater through the screen, past the check ball and into the sample chamber. When the sample chamber is full, argon pressure is again applied to the sample chamber sealing the check ball assembly and preparing the GS-1 to be retrieved to the surface. Once the entire GS-1 assembly is retrieved to the surface , the tip assembly is removed and the collected groundwater sample is decanted from the sampler chamber directly into the sample containers. The entire filling process is monitored, real-time on the computer screen and the filling data is stored in the computer for plotting analysis. A computer generated estimate of hydraulic conductivity (K-Value) is determined by applying the time rate of filling data to standard Bouwer and Rice rate of rise permeability models.

The GS-1 sampler is operated using the hydraulic load frame developed for the Piezocone, and data is stored within the on-board computer system via a Micro Switch 26PCBFA3D transducer. This down hole data allows the rig operator to "view" the sample collection, and provides information concerning the volume of water that is being collected and how rapidly the sample chamber is filling. The argon gas pressure is also monitored with the microtransducers.

At the BRRP, a Piezocone sounding was performed at each location to determine soil types and hydrostatic groundwater levels. Once the soil types and groundwater levels were determined, groundwater samples were collected, at specified locations, using the Hydrocone. These groundwater samples were collected approximately five feet below the hydrostatic groundwater level at each location.

3.7.1.3 Grouting Procedures

Boreholes were abandoned by removing the probe and tools from the borehole. Temporary steel casing was placed in the borehole. Grout was then pumped through the steel casing to fill the borehole from the greatest depth achieved at the location to ground surface with a 5% bentonite powder/Portland type I-II cement mixture.

After the grout settled in the test hole for 24 hours, the grout was checked for collapse and if necessary the grout was brought up to ground surface at all borehole locations.

Grout consisted of a slurry of pure sodium bentonite, mixed with Portland type I-II cement, in a 5% bentonite to 95% cement ratio (dry weight basis). Water was provided from the potable water supply source used for equipment decontamination.

3.7.1.4 Decontamination

All test equipment, including the rig, were steam cleaned prior to arrival at the site. Decontamination operations consisted of thoroughly washing all equipment using a high-pressure steam wash. All equipment, and items in the immediate vicinity of the soundings were clean of oil and dirt. No grease, oil or other petroleum-based material were applied to any threads.

Decontamination was performed at each location upon completion of all sampling at that location. The hydrocone rig and all downhole equipment was decontaminated in accordance with procedures described below. All downhole drilling and hydrocone equipment was decontaminated before each sampling location as follows:

1. The equipment was thoroughly rinsed with potable water immediately following use.
2. The equipment was washed and scrubbed with a high pressure, hot water sprayer delivering a solution of potable water and Alconox.
3. The equipment was thoroughly rinsed with a high pressure, hot water sprayer delivering potable water.

4. The equipment was thoroughly rinsed with deionized water.
5. The equipment was rinsed twice with pesticide-grade isopropanol and allowed to air dry.
6. The equipment was thoroughly rinsed with organic-free water and allowed to air dry as long as possible.
7. The equipment was completely wrapped in aluminum foil so that no portion of the equipment was exposed. A tag was taped to the foil for identifying the equipment as clean.
8. When caked mud, rust and/or paint was present that could not be removed with steam or high pressure wash, the downhole equipment was sandblasted prior to step number 1 above, and prior to arrival on site.
9. Printing and/or writing on well casings, screens, tremie tubing, etc. was removed with emery cloth and or sandpaper prior to arrival on site. Where possible, materials without printing or writing were ordered.

Small downhole equipment was cleaned using the following procedures:

1. The equipment was thoroughly rinsed with potable water as soon as possible following use.
2. The equipment was washed and scrubbed in a solution of potable water and Alconox.
3. The equipment was thoroughly rinsed with potable water.
4. The equipment was rinsed twice with pesticide-grade isopropanol and allowed to air dry.
5. The equipment was thoroughly rinsed with organic-free water and allowed to air dry as long as possible.
6. The equipment was placed completely inside a plastic bag, wrapped in plastic, or wrapped in aluminum foil so that no portion of the equipment was exposed. A tag was taped to the plastic or foil for identifying the equipment as clean.

The Hydrocone Electronics Package was decontaminated utilizing the following procedures: The electronics package, "wand", of the Hydrocone cannot be exposed to high pressure cleaning or exceptionally high temperatures. Thus, decontamination of the wand consisted of a rinse with deionized/organic free water immediately followed by a complete wash and scrub, using bottle brushes, with an Alconox, deionized water solution. The wand was then rinsed with deionized/organic free water followed by two rinses with reagent grade isopropanol and allowed to air dry. Prior to the next use of the wand, it was rinsed with deionized/organic free water and allowed to air dry as long as possible.

All push rods for both piezocone soundings and hydrocone groundwater samples were decontaminated by utilizing an under chassis steam cleaner as the push rods were removed from the ground. **All decon rinse water was disposed of by pouring the water onto the ground surface of the waste unit.**

3.7.1.5 Unusual and Nonspecification Activities

The piezocone soundings at two locations, PC-1 and PC-6, were not able to penetrate a layer of cemented sands encountered in the subsurface. In these two instances, an augering system was utilized to open a pilot hole through the cemented areas and then continued to push with the piezocone. This method was successful at location PC-1. However, at location PC-6, the augers were lost in the hole and could not be retrieved. A drill rig was used to open a pilot hole.

CPT-5 was moved from the location shown in the RFI/RI Work Plan (with approval from SCDHEC). The geophysical data showed the original location to be within the pit boundaries.

The rate at which the Hydrocone filled at location CPT-6 was collected for the first trip down the hole; and therefore, only one K-value plot was generated. However, the K-value derived from this plot is suspect. An explanation of the sample collection procedures that occurred at CPT-6 is provided below.

The hollow stem augers used to predrill the hole were advanced to a depth of approximately 70 - 71 feet. The Hydrocone was advanced inside the augers to a depth of 68.5 feet. The Hydrocone was pushed into soils which had entered the augers. These soils compacted and made pushing difficult. On the first sampling attempt, water rushed into the Hydrocone and shorted the electronic circuits. The K-value obtained from this attempt is suspect because the Hydrocone was inside the augers and the soils around the Hydrocone were not characteristic of the conditions in the undisturbed aquifer. On subsequent attempts, the remaining water needed for analysis was collected using the Hydrocone with the argon pressure to open the tip and to seal it as the water sample was retrieved; however, the electronics were not operable and a K-value could not be obtained.

3.7.2 *Geotechnical Samples*

Subsurface samples collected for geotechnical analysis were obtained from the two locations (BRS-2 and BRS-6) shown in Figure 3-10. Location BRS-6 was sampled on December 13, 1993. Location BRS-2 was sampled on December 15 and 16, 1993. All soil samples were collected using a truck-mounted hollow stem auger drill rig. A 24-inch long, 2 inch outside diameter stainless steel split spoon sampler was used to collect these samples. A total of 32 samples were collected from the following depths from these two locations:

0 to 2 feet
5 to 7 feet
10 to 12 feet
15 to 17 feet
20 to 22 feet
25 to 27 feet
30 to 32 feet
35 to 37 feet
40 to 42 feet
45 to 47 feet
50 to 52 feet
55 to 57 feet
60 to 62 feet
65 to 67 feet
70 to 72 feet
75 to 77 feet

Each borehole was grouted after the sample was collected.

The samples collected from these two locations were taken to an outside laboratory for analysis for the following physical parameters:

- Moisture Content ASTM D2216
- Particle Size Analysis ASTM D422-63
- Atterberg Limits ASTM D4318-84
- Classification ASTM D2487-85

3.7.3 *Groundwater Well Installation*

Groundwater well installation began on November 4, 1993 and was completed on March 2, 1994. A total of nine wells were installed in 3 three-well clusters. Figure 3-11 shows the locations of these well clusters. Well cluster BRR-7 was installed first followed by well cluster BRR-6. Well cluster BRR-8 was the last well cluster to be installed. The location of BRR-8 was determined based on the results of

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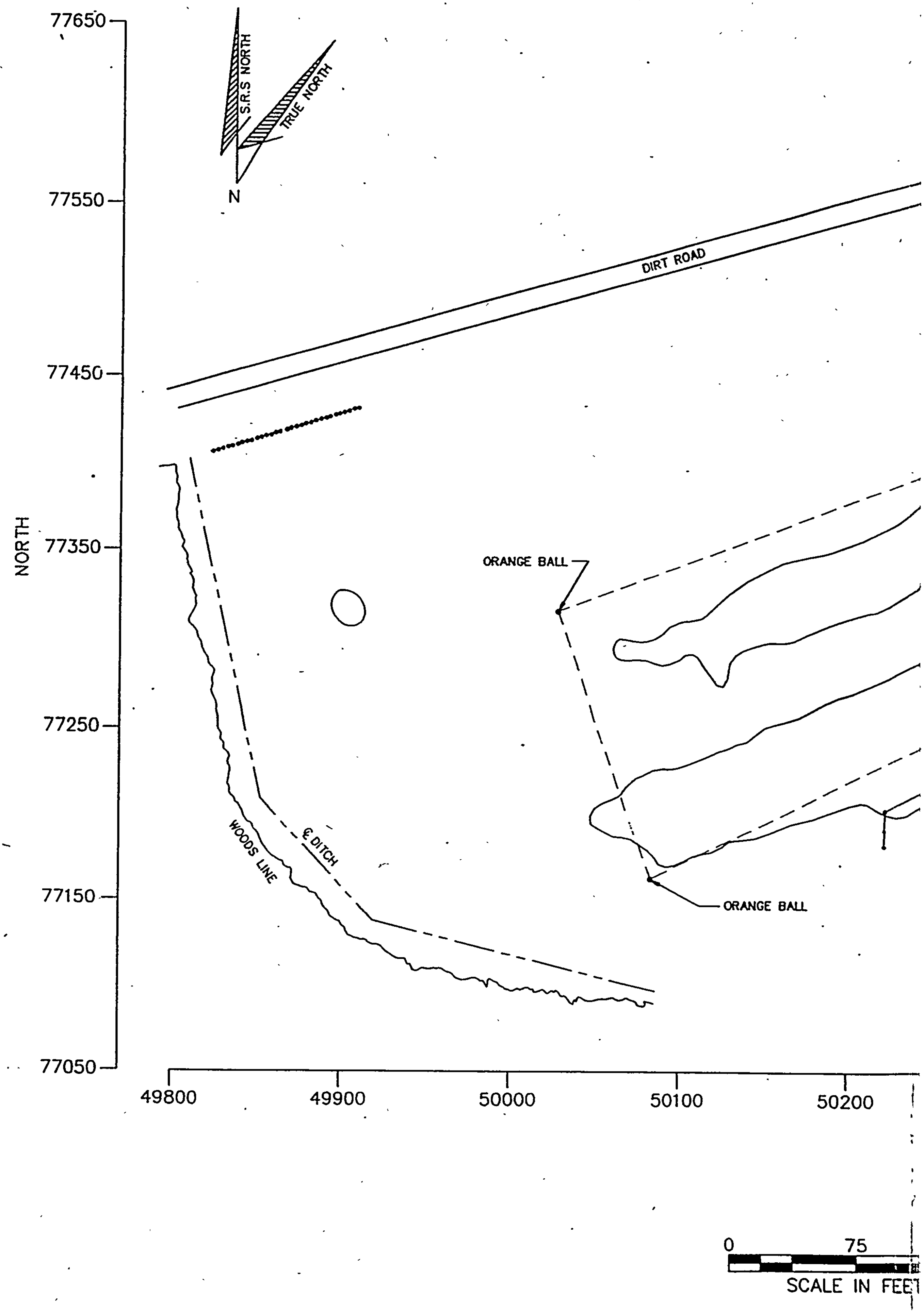

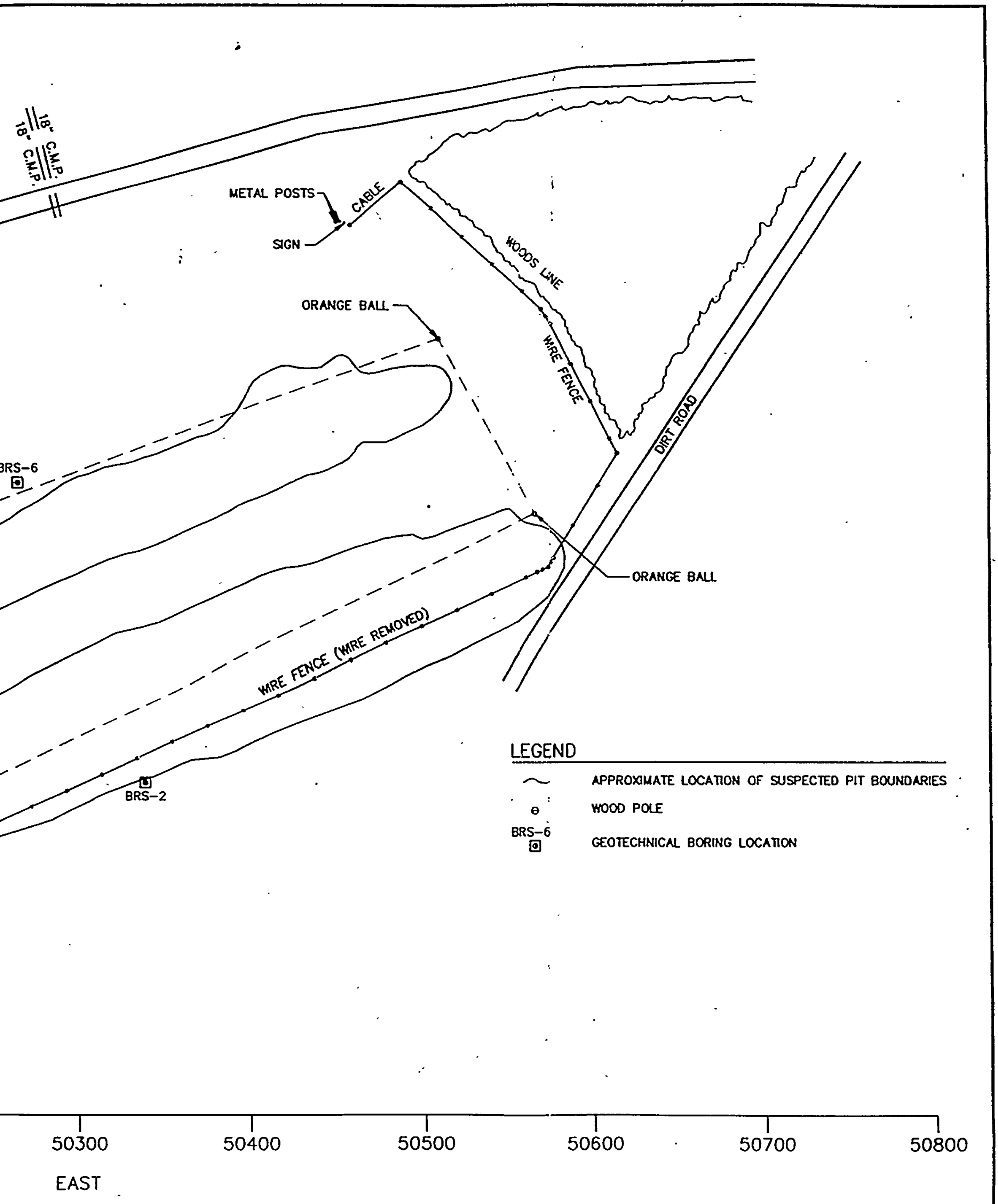

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METCALF & EDDY

LOCATIONS OF GEOTECHNICAL BORINGS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3-10

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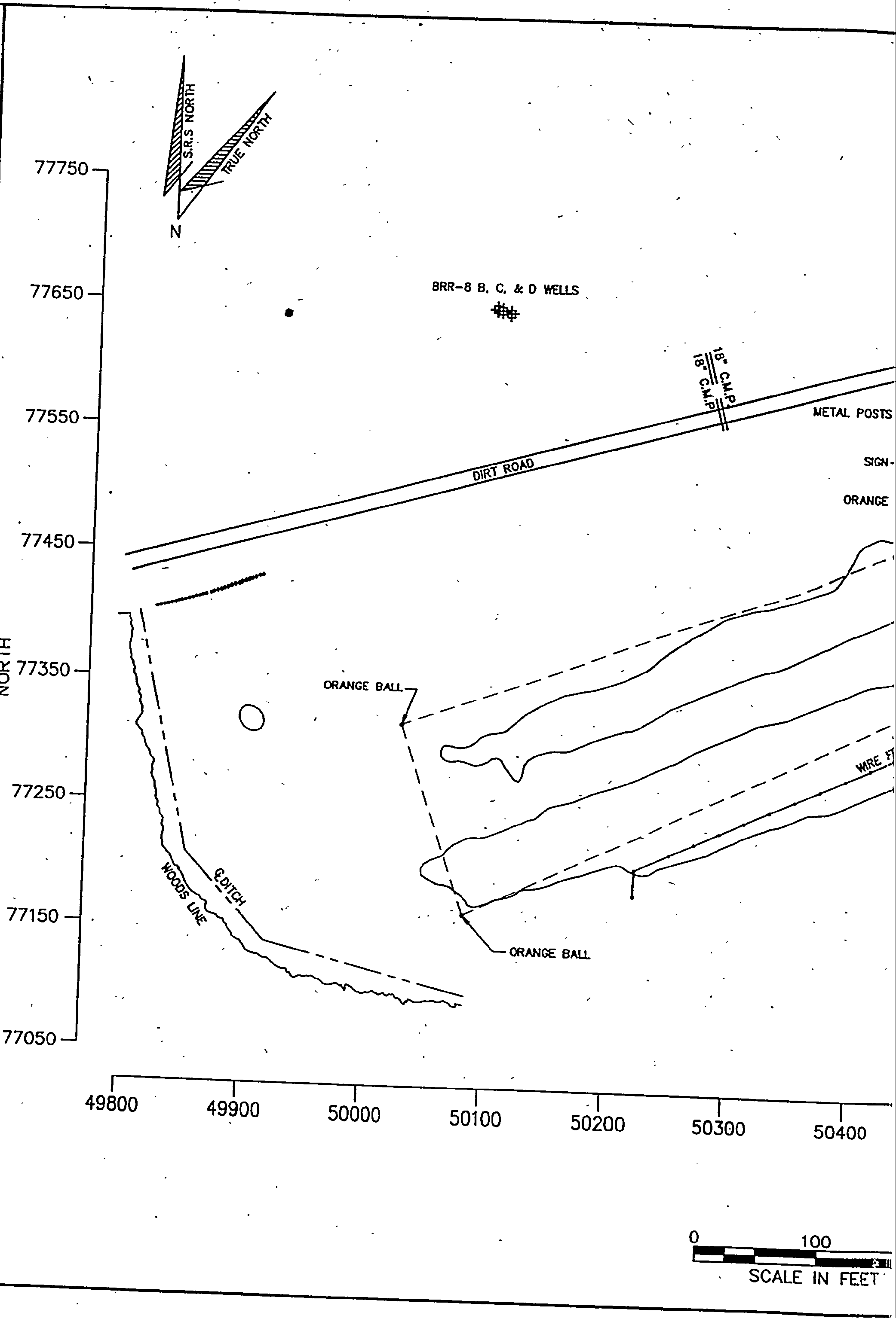

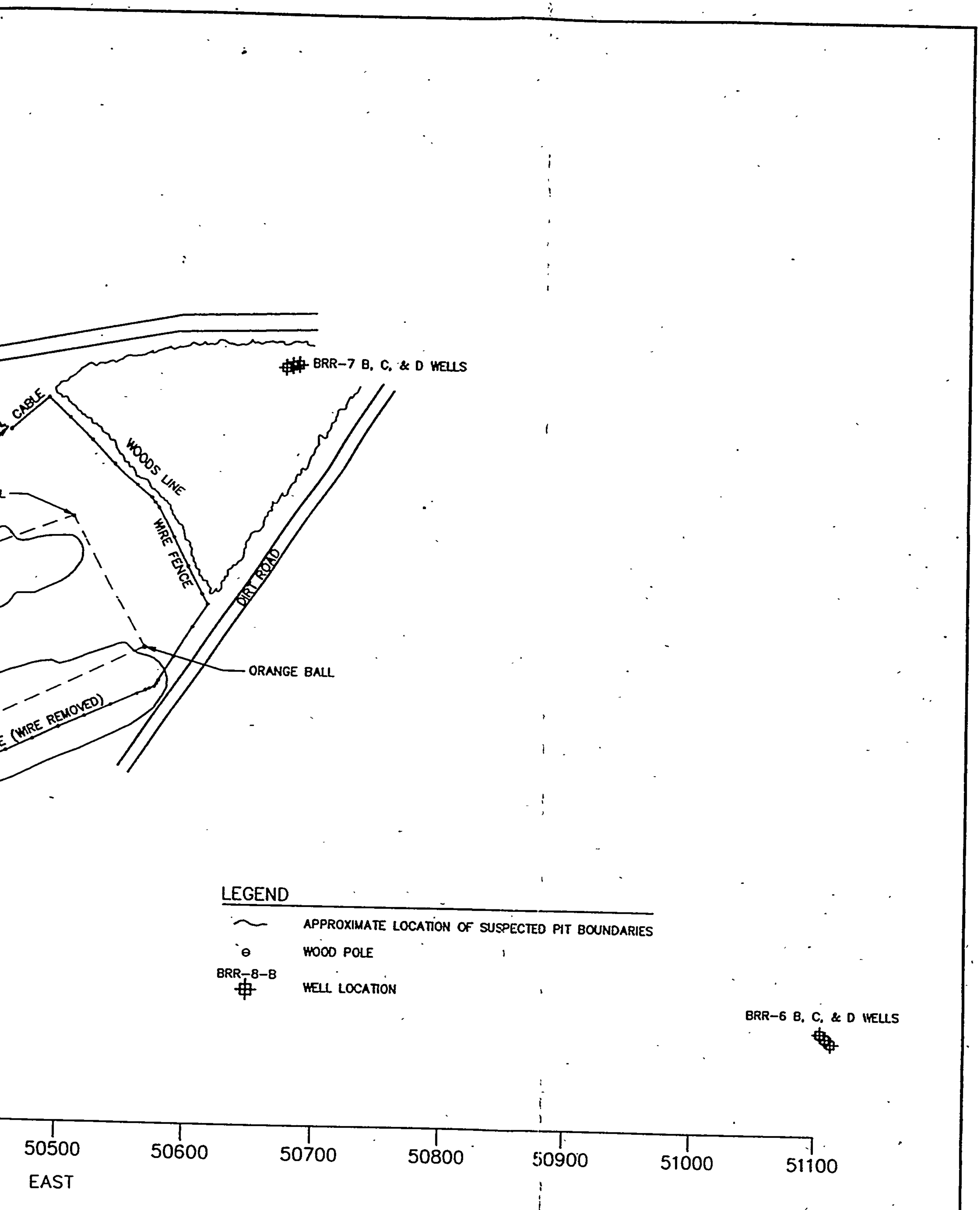

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LOCATION OF NEWLY INSTALLED
WELL CLUSTERS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
3–11

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the piezocone investigation. The water level measurements collected during the piezocone investigation were used to ensure that BRR-8 was placed downgradient of the pits.

Prior to drilling the pilot hole for each well, the drill rig and all tools to be inserted into the borehole were decontaminated by steam cleaning. The drill rig was stationed on plastic sheeting to prevent fluid leakage onto the ground. All new or reusable material and equipment for well construction were steam cleaned before insertion into the borehole. PVC tremie pipe was reused for each well but was decontaminated with pressure steam cleaning between wells. Tag lines and water level indicators were also steam cleaned between each well installation.

The well materials used are open at both ends and are thus subject to equilibrium with ambient atmospheric temperature and pressure. Although the water at the tip of the pressure washer nozzle is at a high temperature and pressure, these conditions are not sustained within the PVC pipe for any substantial amount of time. Rather, the jet of hot water/steam is used to rinse off the PVC pipe for only a few seconds. Therefore, it would not be expected that the collapse strength of the well materials would be decreased to any appreciable degree by the steam cleaning activities specified.

Technical oversight was conducted by hydrogeological field personnel during the drilling activities. **Because problems with flowing sands often cause hole cave-in problems for boreholes that are advanced below the water table, mud rotary drilling methods are generally used for all borings which are to be advanced below the water table. In accordance with this general practice, mud rotary drilling techniques were used for the installation of all of the BRR wells.** Borings that did not require sampling were advanced using 7-7/8" tricone bit. All pilot core holes in which core samples were collected were overreamed with a 7-7/8" tricone bit. Double-tube Christensen wireline coring was employed to collect continuous core samples for lithologic descriptions. These continuous cores were taken from the deepest well in each cluster. Cores were extruded on site into PVC troughs. Each core was immediately logged, wrapped in plastic, and stored in plastic-impregnated core boxes.

Each core was logged according to the procedure outlined in WSRC 3Q5. Procedures included descriptions of major sediment type, grain size distribution, color (Munsell color chart), texture, cement and matrix material (Appendix A). Descriptions would also note the presence of sedimentary structures, fossils and accessory minerals, and the degree of saturation.

Several methods were used to enhance sample recovery while coring under difficult conditions. These methods included varying the length of the core barrel shoes, shortening the core run, varying drill bit rotation speed, applying additional pull-down pressure, increasing drilling fluid weight, and using a "desander" to minimize sand content in drilling fluids. Horizons composed of gravel and interbedded loose sand and clay were difficult to recover.

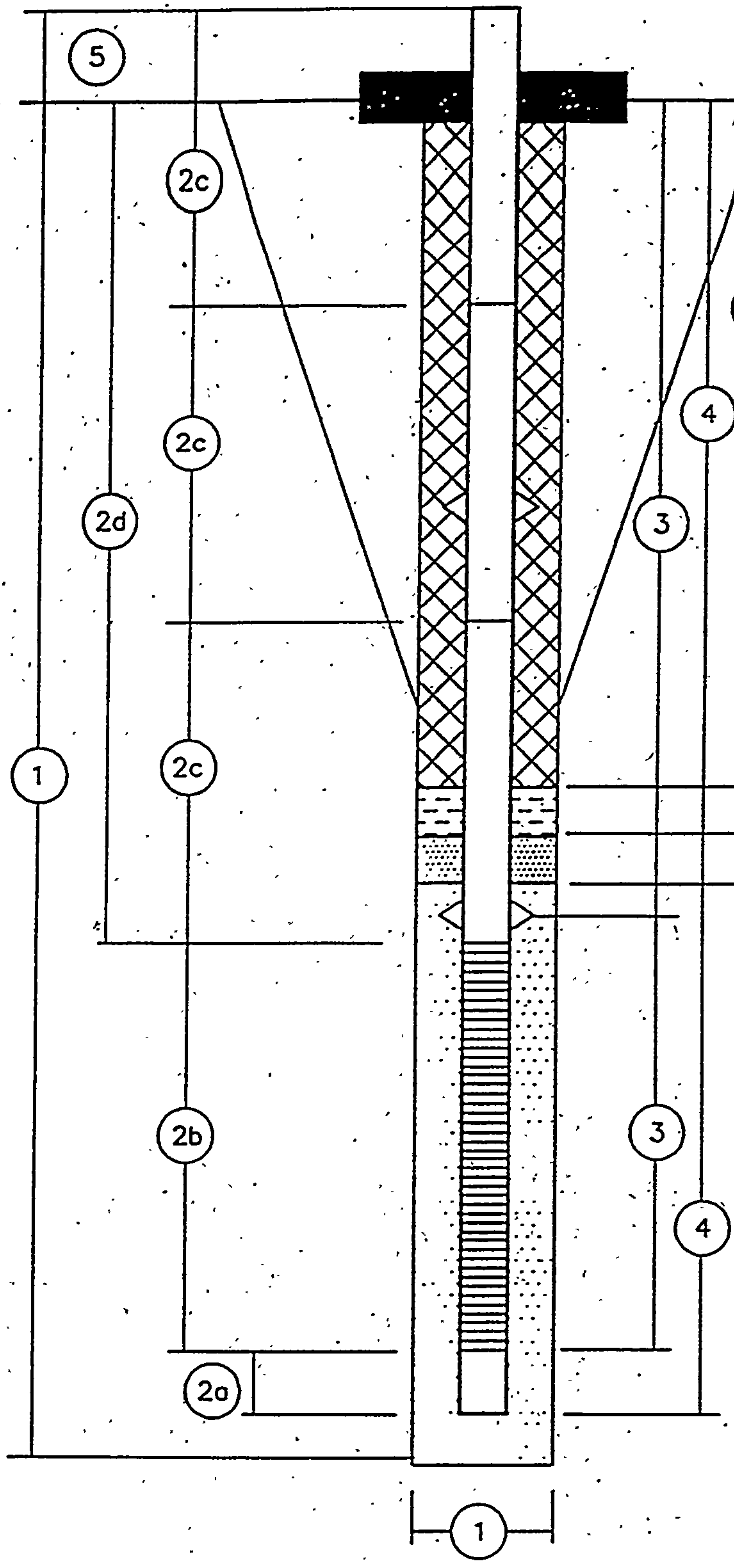
In general, bentonite-based drilling fluids (Quik Gel™) were used throughout the drilling program. Control of the drilling fluid weight and viscosity and minimization of sand in the fluid reduced the potential for excessive formation damage and loss circulation. However, lost circulation was a problem encountered at well cluster BRR-7 from 120 feet to 170 feet, where circulation was regained at the maximum depth of coring.

Upon completion of coring, each corehole was conditioned for geophysical logging by circulating clean drilling fluid until the sand content in the returning fluid was at a minimum. Geophysical logs were obtained by slowly raising the logging tool from the bottom of the borehole. Geophysical logging services were completed at BRR-6B, BRR-7B, and BRR-8B. Caliper, natural gamma, spontaneous potential, single point resistance, and long and short natural resistivity logs were run on core holes BRR-6B, BRR-7B, and BRR-8B. The geophysical logging equipment was capable of digital capture, minimizing the need for relogging and facilitating the merging and adjustment of data.

Field geologic logs, geophysical logs, sieve analysis, and drilling notes were used to identify target screen intervals. The appropriate screen intervals were identified in the field for all monitoring wells. A typical well construction diagram is identified in Figure 3-12.

All wells were constructed of 2-inch inside diameter (ID) Schedule 40 DSI Shur Seal PVC casing and screen. All screen sections, except BRR-7C, were 0.20 machine slotted. The screen section for BRR-7C was 0.10 machine slotted. All wells were installed according to procedures outlined in WSRC 3Q5. Monitoring well construction diagrams are found in Appendix C.

Monitoring wells designated with the prefix B and C were screened in the "Lower" aquifer zone of the Upper Three Runs Aquifer. Screened intervals were selected by field personnel using the geophysical information, field geologic logs, and correlation with nearby existing wells. All B and C wells consisted of approximately a 5-foot sump, a 10-foot screen attached, and attached casing which extended to the surface. PVC centralizers were installed one foot below the screen, one foot above



1) TOTAL DRILLED DEPTH/HOLE DIAMETER
2) CASING/SCREEN TALLY (MEASURED TO NEAREST 0.01 FOOT)
  (a) SUMP & PLUG LENGTH
  (b) SCREEN LENGTH
  (c) CASING JOINT LENGTHS (MEASURED IN UPHOLE SEQUENCE FROM TOP OF SCREEN)
  (d) DEPTH TO TOP OF SCREEN
3) DEPTHS TO CENTRALIZERS
4) TOTAL DEPTH OF INSTALLED WELL
5) CASING STICK UP (STANDARD 2.5' A.G.S.)
6) DEPTH TO TOP OF FILTER PACK
7) DEPTH TO TOP OF FINE SAND SEAL
8) DEPTH TO TOP OF BENTONITE SEAL
9) THICKNESS OF GROUT

Figure 3-12 Typical Well Construction Diagram.

the screen, and at approximately 40-foot intervals to the surface. Foster Dixiana FX50 filter pack sand (average particle size 0.50 mm) was installed via tremie to a minimum level of four feet above the screen. Foster Dixiana BX30 fine sand seal (average particle size 0.30 mm) was subsequently installed to a minimum of two feet above the filter pack sand. A minimum of four feet of bentonite pellets were then installed above the fine sand seal.

The BRRP D wells were screened in the "Upper" aquifer zone of the Upper Three Runs Aquifer, below the Twiggs Clay. Surface casing were not installed as part of the monitoring well construction, because the Twiggs Clay has a localized small areal extent and can be considered a semi-confining unit. It is assumed that the well grouting will provide an adequate barrier to localized contaminant migration. The D wells were screened just above the Tan Clay Confining Zone. BRR-7D and 8D wells do not have sumps due to the close proximity of the screened to the Tan Clay Confining Zone. A 20-foot screen was installed in wells BRR-6D and BRR-7D. A 15-foot screen was installed in well BRR-8D. The screens generally straddle the water table surface, with 5 feet of screen above the water table surface and the remainder within the saturated zone. PVC centralizers were installed at approximately 40-foot intervals to the surface. Foster Dixiana FX50 filter pack sand was installed via tremie to a minimum level of two feet above the screen. Foster Dixiana BX30 fine sand seal was subsequently installed to a minimum of tow feet above the filter sand pack. A minimum of four feet of bentonite pellets was then installed above the fine sand seal. Depths and thicknesses of the sand and bentonite were verified by field personnel by tagging.

One to several stages of grout were installed in the well annulus from the bentonite seal to ground surface via tremie pipe for all installed wells. A maximum of 50 feet of grout was installed in the first stage. This maximum thickness for the first stage of grouting was designed to stabilize the well and prevent the collapse of the well casing. After a minimum of 12 hours curing time, grout was installed continuously to the ground surface. Grout weights were maintained in the range of 13.2 pounds per gallon (lbs/gal) to 15.0 lbs/gal.

All wells were developed by the drilling company which installed them. Wells were developed until the discharge became clear.

3.7.4 *Slug Tests*

Rising head and falling head permeability tests (slug tests) were performed in all nine new monitoring wells. These tests provide estimates of the hydraulic conductivity of the aquifer around the screened zone of the well. A slug constructed of one inch diameter PVC pipe filled with quartz sand and plugged at each end was used to perform the slug tests. The static water level and the total depth of each well were measured prior to introduction of the slug. Water level in the wells were allowed to stabilize after the introduction of the slug. After the water level had stabilized, the slug was removed from the wells and the water levels were recorded using a Northwest Instruments Aquistar DL-4A Data Logger. Recordings were continued until the water level had recovered at least 90% of the original static water level.

The Bouwer and Rice Method (Bouwer, 1976) was used to analyze field data collected from performing the slug tests in the unconfined and confined aquifers.

3.8 Ecological Investigation

The ecological unit reconnaissance was conducted at the BRRP on August 1 and 2, 1994. This investigation was conducted as part of the Baseline Risk Assessment (BRA) for this unit. The BRA assesses the potential endangerment to human health and the environment associated with this unit and will be used to evaluate remediation criteria if needed. The objectives of this investigation were as follows:

1. Assess the general characteristics of on-unit biological communities including mammals, birds, reptiles, amphibians, and any aquatic communities present,
2. Determine the location, extent, and characteristics of on-unit ecological resources, such as forested areas and wetlands that could serve as important wildlife habitat or provide other ecological functions, and
3. Identify any overt effects of contamination on biological communities.

The field investigation included mapping and describing all wetland and terrestrial habitats; recording wildlife observations of birds, mammals, and reptiles; and investigating ecological resources in nearby downgradient areas which could be affected by mobile contaminants or any future remedial actions.

3.9 Summary of Sample Locations

Figure 3-13 represents a compilation of locations completed for the RFI/RI Investigation at the BRRP Site - piezocone/hydrocone, soil, groundwater, surface water, and sediment.

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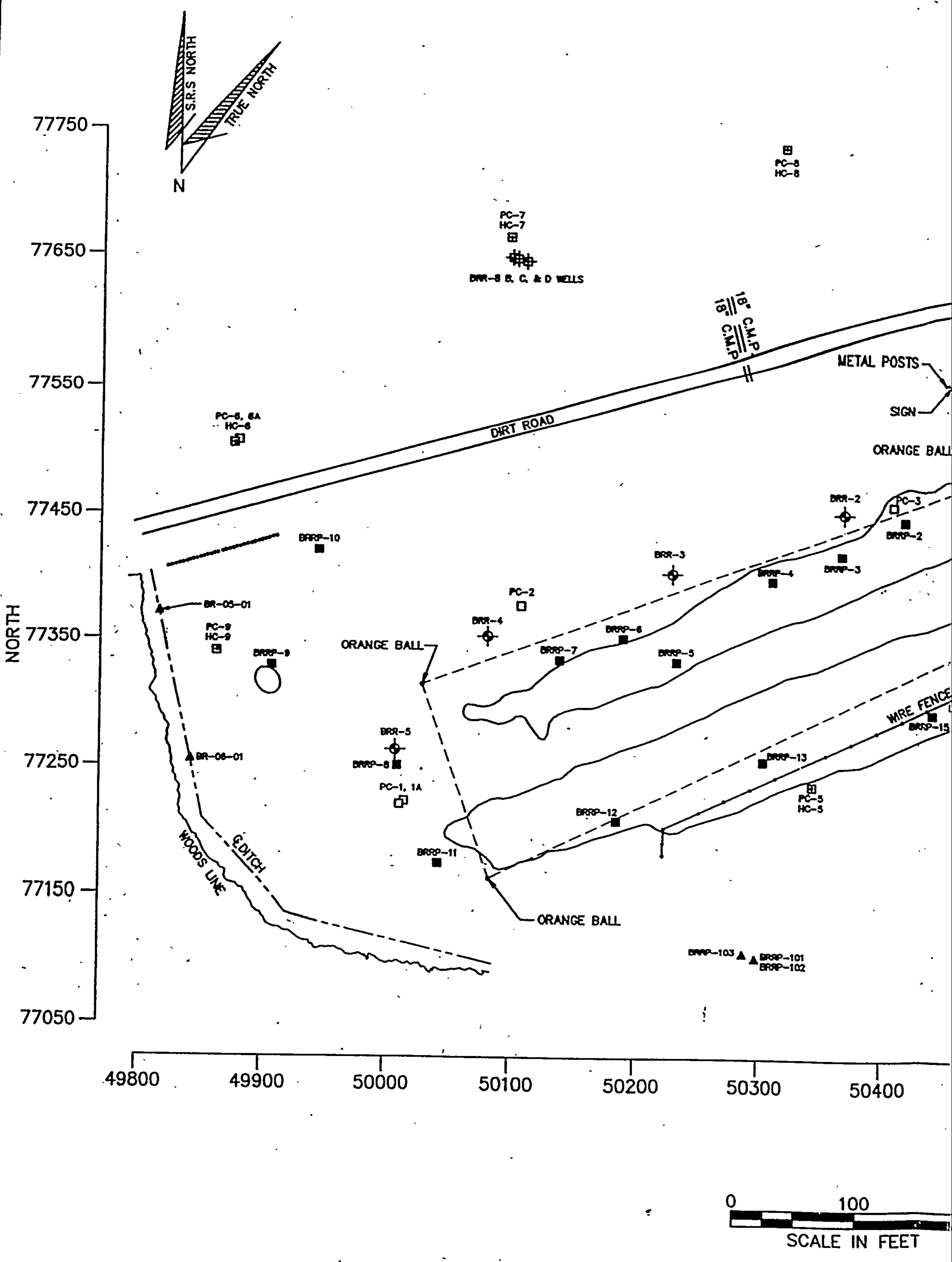

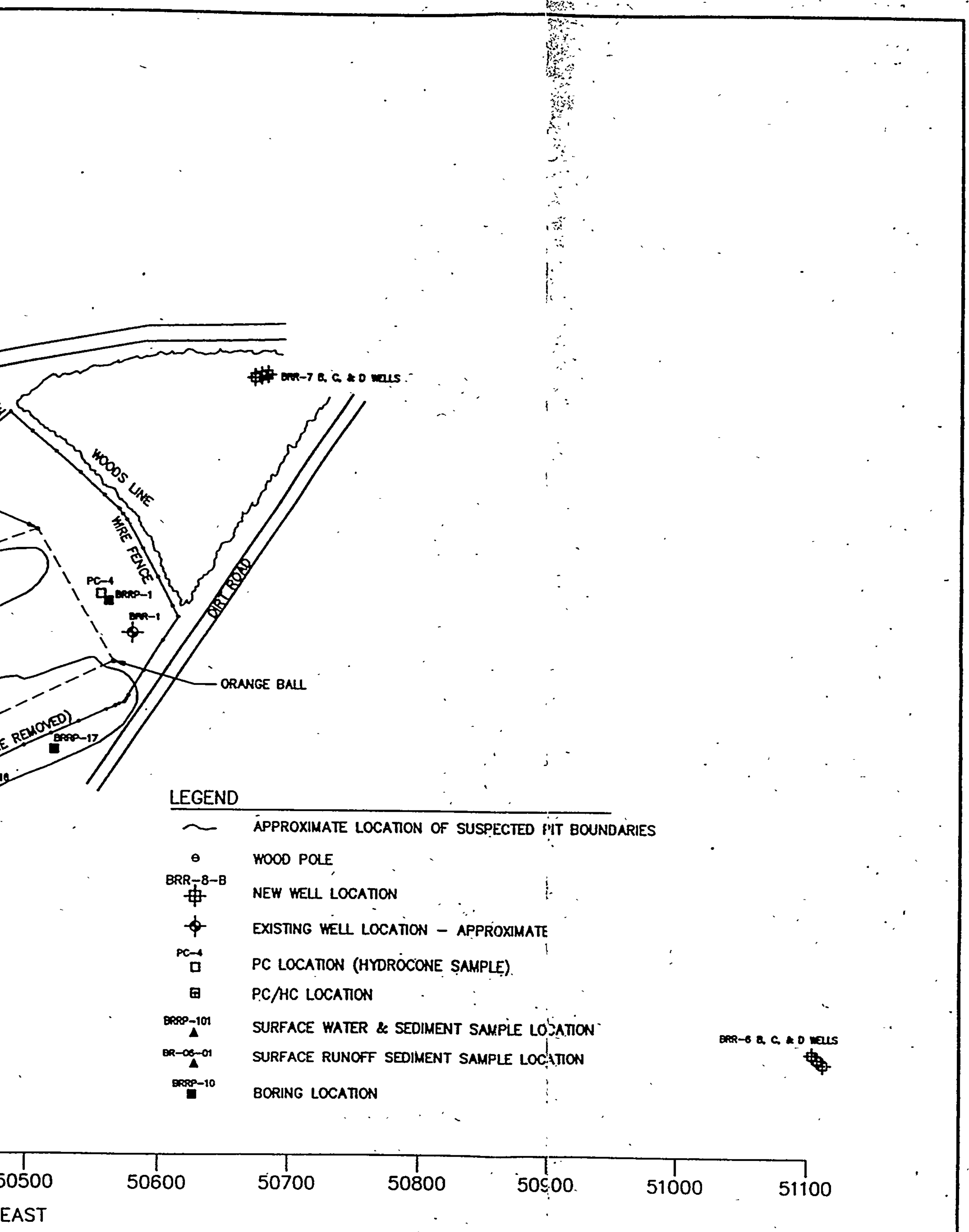

METCALF & EDDY

LOCATIONS OF PIEZOCONE/HYDROCONE, SOIL, GROUNDWATER, SURFACE WATER AND SEDIMENT SAMPLES

SAVANNAH RIVER PLANT

AIKEN, SOUTH CAROLINA

FIGURE

3–13

4.0 RESULTS AND DISCUSSION OF SITE INVESTIGATION

4.1 Geophysical Surveys

4.1.1 *Ground Penetrating Radar (GPR) Survey*

Field personnel conducted a 3-D GPR survey at the BRRP RFI/RI unit in 1993. Figure 4-1 illustrates the outline of the GPR survey grid. This survey supplemented an earlier GPR survey which indicated that not all of the BRRP unit was disturbed. The older survey had detected two parallel linear areas of disturbed soils within the unit as well as a third area of suspect disturbed soil that was believed to have been a source of soil for backfilling the other two areas. The following summary and use of selected GPR sections details the results of the most recent and more extensive GPR survey.

GPR sections clearly show disturbed soils and boundaries for two separate trenches. The trenches are parallel to each other and oriented in a northeast to southwest direction. The southern trench appears to extend beyond the orange ball markers on both ends of the site. On some sections trench bottoms and disturbed/undisturbed soil boundary contacts are apparent. The depth to the base of the trenches varied and was calculated for a representative set of sections. Depths ranged from 6 to 18 feet. Several sections show very strong reflectors suggestive of buried metallic debris. GPR coverage of a suspect mounded area in the northwest part of the unit revealed chaotic radar reflections indicative of disturbed soil. However, no strong reflectors were found in this area suggesting an absence of buried debris of any type.

The 3-D plots aid in the visualization of the BRRP. The 3-D figure (Figure 4-2) illustrates the linear alignment of the rubble pits. Figure 4-3 is a sample GPR cross section with labeled interpretive information including a vertical time scale in nanoseconds (ns), a horizontal scale of 5 meters between tick marks, maximum depth of the investigation and one buried object (utility). **Figures 4-4 through 4-7 represent data from the GPR survey of the Burma Road Rubble Pit. These figures are labeled with a line number in the upper left-hand corner of the text. These line numbers refer to the transects which are laid out in Figure 4-1.** The radar velocity at the BRRP site is given at 6-7 ns per foot. This velocity model was developed by taking GPR readings at four locations where the depth to a given object was known.

GPR section #1 is shown in Figure 4-4. This section is roughly parallel to and north of the northern trench at a bearing of S 68.29 . The relative continuity of the reflectors suggests that this section was

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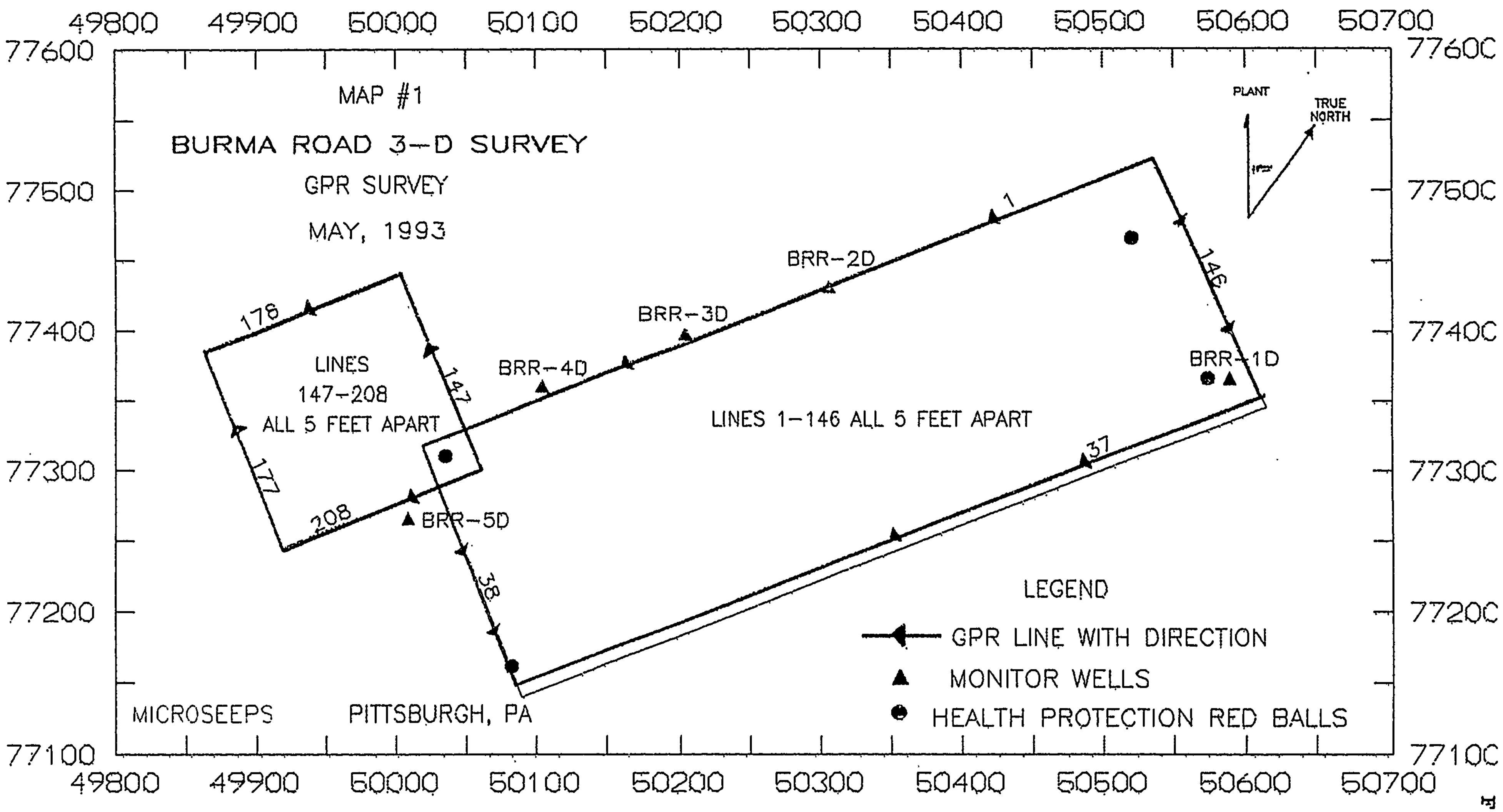

MAP #1
BURMA ROAD 3-D SURVEY
GPR SURVEY
MAY, 1993
PLANT
TRUE NORTH
1
146
BRR-1D
BRR-2D
BRR-3D
BRR-4D
BRR-5D
LINES 147-208 ALL 5 FEET APART
LINES 1-146 ALL 5 FEET APART
178
147
177
208
37
38
LEGEND
GPR LINE WITH DIRECTION
MONITOR WELLS
HEALTH PROTECTION RED BALLS
MICROSEEPS
PITTSBURGH, PA
49800
49900
50000
50100
50200
50300
50400
50500
50600
50700
77600
77500
77400
77300
77200
77100
7760C
7750C
7740C
7730C
7720C
7710C

Figure 4-1

BURMA ROAD RUBBLE PIT

3-D GPR SURVEY

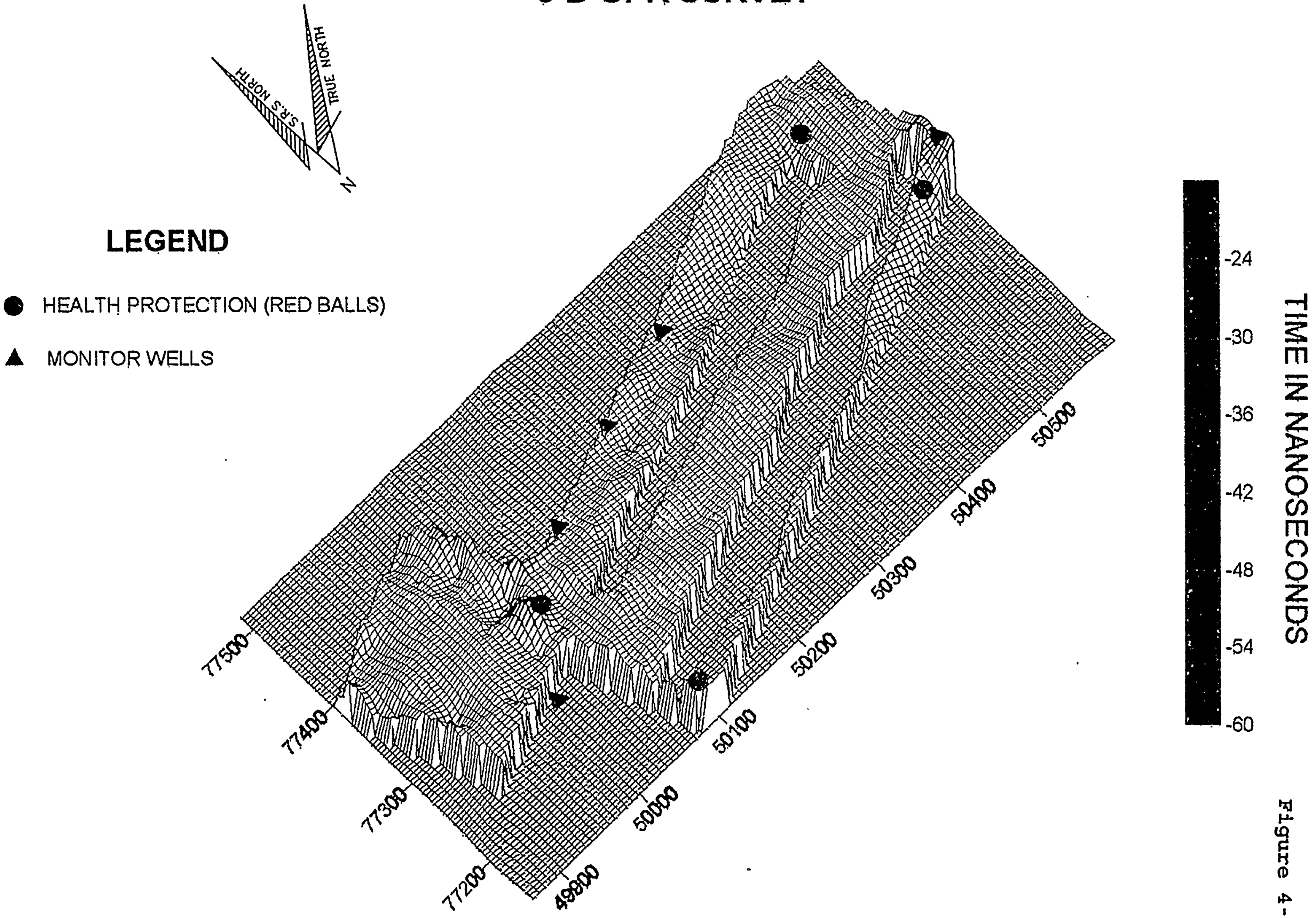
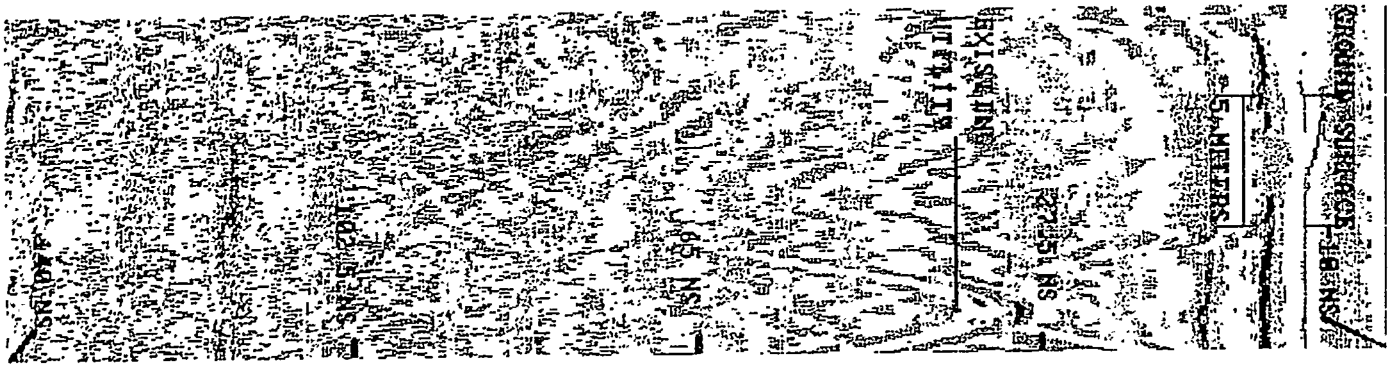


Figure 4-2

INTER Created Feb 15,1994 11:05 Modified Apr 8,1994 12:13
512 samples/scan 30.0106 scans/sec position: -5 nS range: 150 nS
Vert. IIR low pass N=2 F=80
Vert. IIR high pass N=2 F=11

Figure 4-3

BURMA ROAD 3D SURVEY
SAVANNAH RIVER SITE



obtained over undisturbed soils. The very strong reflector located approximately three horizontal tick marks from the left edge of the section may be due to a metallic object on the surface or in the shallow subsurface. GPR section #85 is shown in Figure 4-5. This section is roughly perpendicular to the BRRP at a bearing of S21.56 E and is located at the approximate midpoint of the long axis of the Rubble Pit unit. This section shows two primary areas of disturbed soils corresponding to the two trenches and an apparent contact between disturbed and undisturbed soil. On the section, the midpoint of the northern trench is located approximately at the fourth tick mark from the left edge of the section; the midpoint of the southern trench is located approximately at the second tick mark from the right edge of the section. On this section, the approximate width of the northern trench is 10 meters (approximately 30 feet) and the approximate width of the southern trench is 15 meters (approximately 50 feet). The distance between the trenches is approximately 18 meters (approximately 60 feet). Note that the south edge of the southern trench lies beyond the southeast end of the section line. The contact between disturbed and undisturbed soil appears to extend from the left edge of the section to the third tick mark and is shown as an area of relative continuity of the radar reflections.

The two-way travel time corresponding to the base of the north trench is 93.75 ns which is equivalent to a depth of approximately 4 meters (approximately 15 feet). The travel time corresponding to the base of the south trench is 71.25 ns which is equivalent to a depth of 3 meters (approximately 11 feet). These depths agree well with the data presented in Appendix A for soil borings BRRP-5 and BRRP-13, which are located near transect number 85.

GPR section #121 is shown in Figure 4-6. This section is roughly perpendicular to the BRRP at a bearing of S 21.56 E and is located near the northeast end of the Rubble Pit unit area. The section shows numerous strong radar reflectors including four very strong reflectors which may be metallic debris.

GPR section #155 is shown in Figure 4-7. This section is located in the northwest part of the BRRP area and is over a mounded area suspected of containing buried debris. The section is typical of most of the sections for this area and shows disturbed soils characterized by chaotic radar reflections. The GPR survey did not detect buried metallic debris in this area.

Figure 4-8 is a two dimensional contour map of the GPR survey area with the trench areas blanked out. The time scale is a color plot with each color corresponding to a specific time in nanoseconds. Note that the southern trench boundaries extend beyond the orange marker balls.

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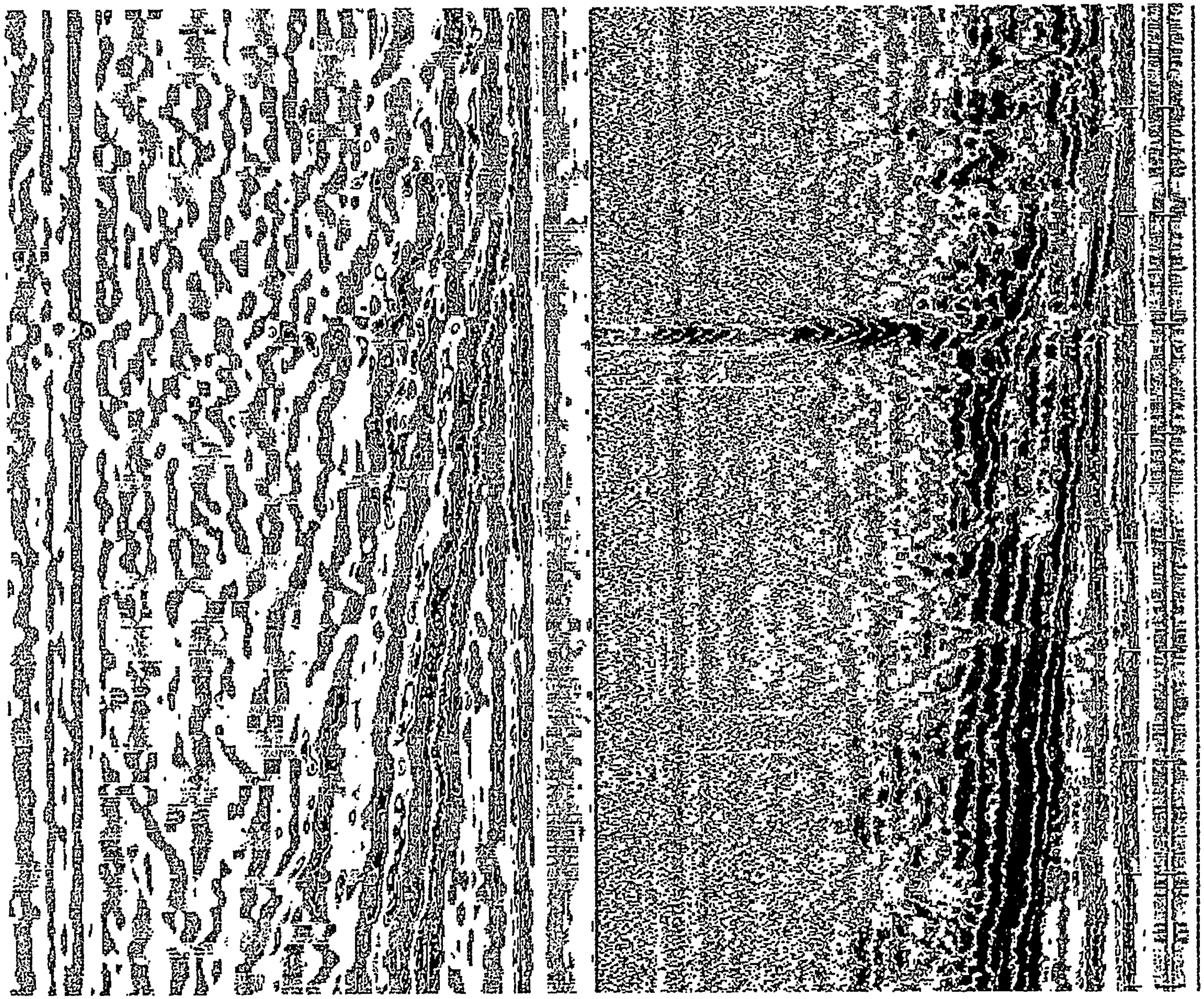
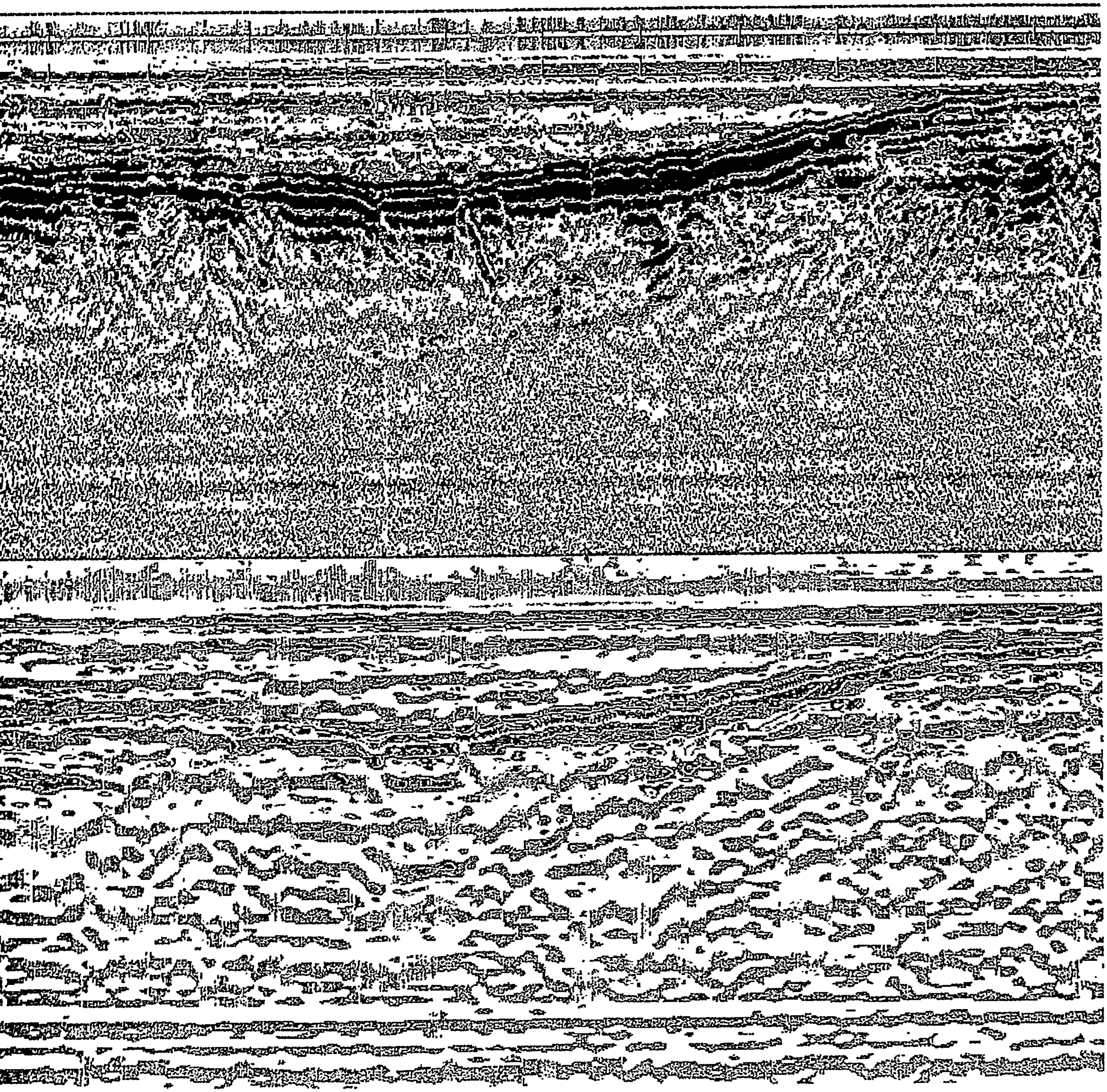
1 Created May 8,1993 07:54 Modified May 9,1993 00:30
512 samples/scan 30.0019 scans/sec position: -10 nS range: 150 nS
Vert. IIR low pass N=2 F=80
Vert. IIR high pass N=2 F=11

Figure 4-4   NE 1/2

BURMA ROAD 3-D GPR SURVEY
SAVANNAH RIVER SITE





85 Created May 8,1993 12:16 Modified May 9,1993 02:21
512 samples/scan 30.0019 scans/sec position: -10 nS range: 150 nS
Vert. IIR low pass N=2 F=80
Vert. IIR high pass N=2 F=11

Figure 4-5

BURMA ROAD 3-D GPR SURVEY
SAVANNAH RIVER SITE

Scale - 1" = 1.74 meters (5.77 feet)

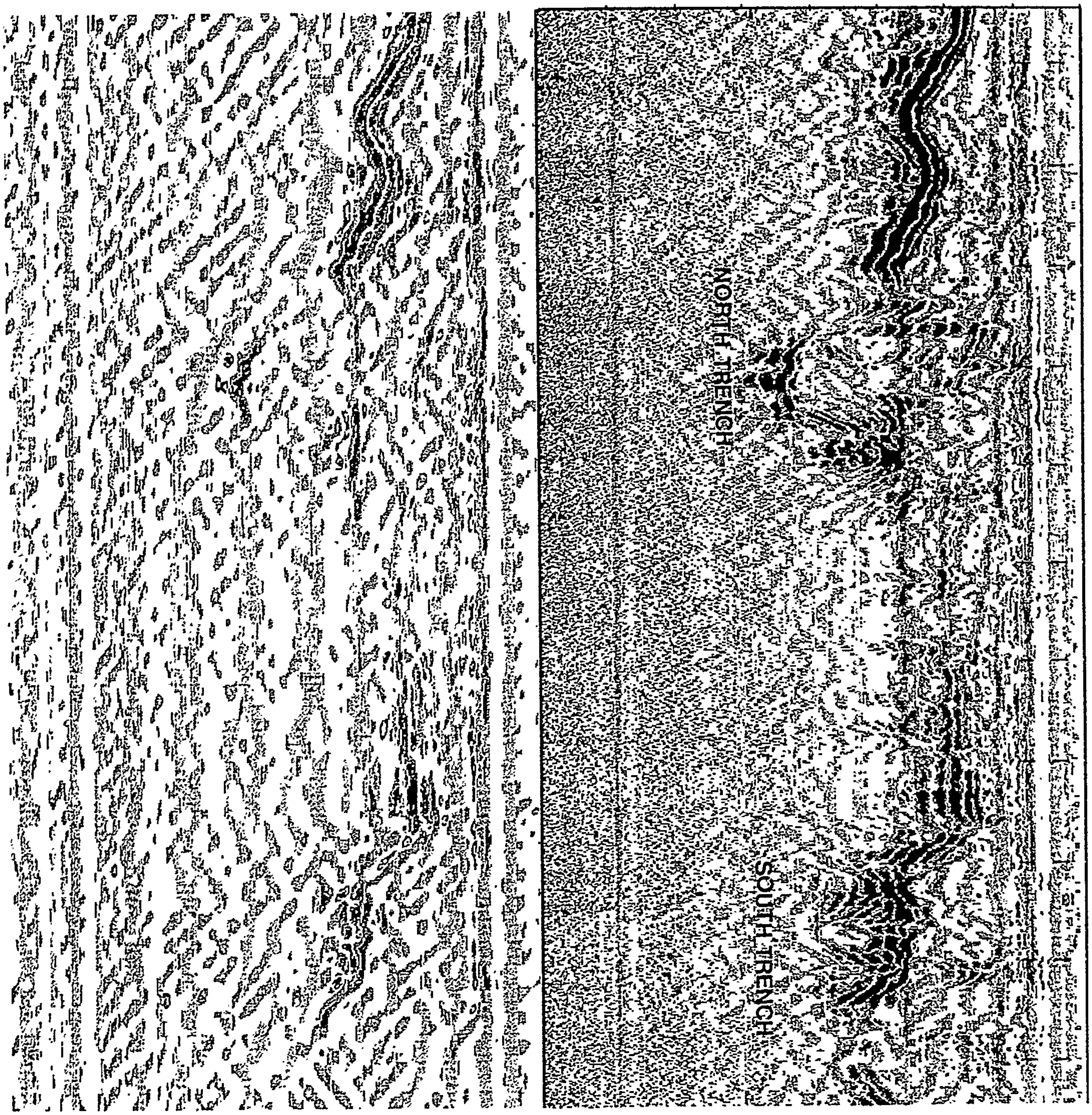


Figure 4-~~6~~ 5

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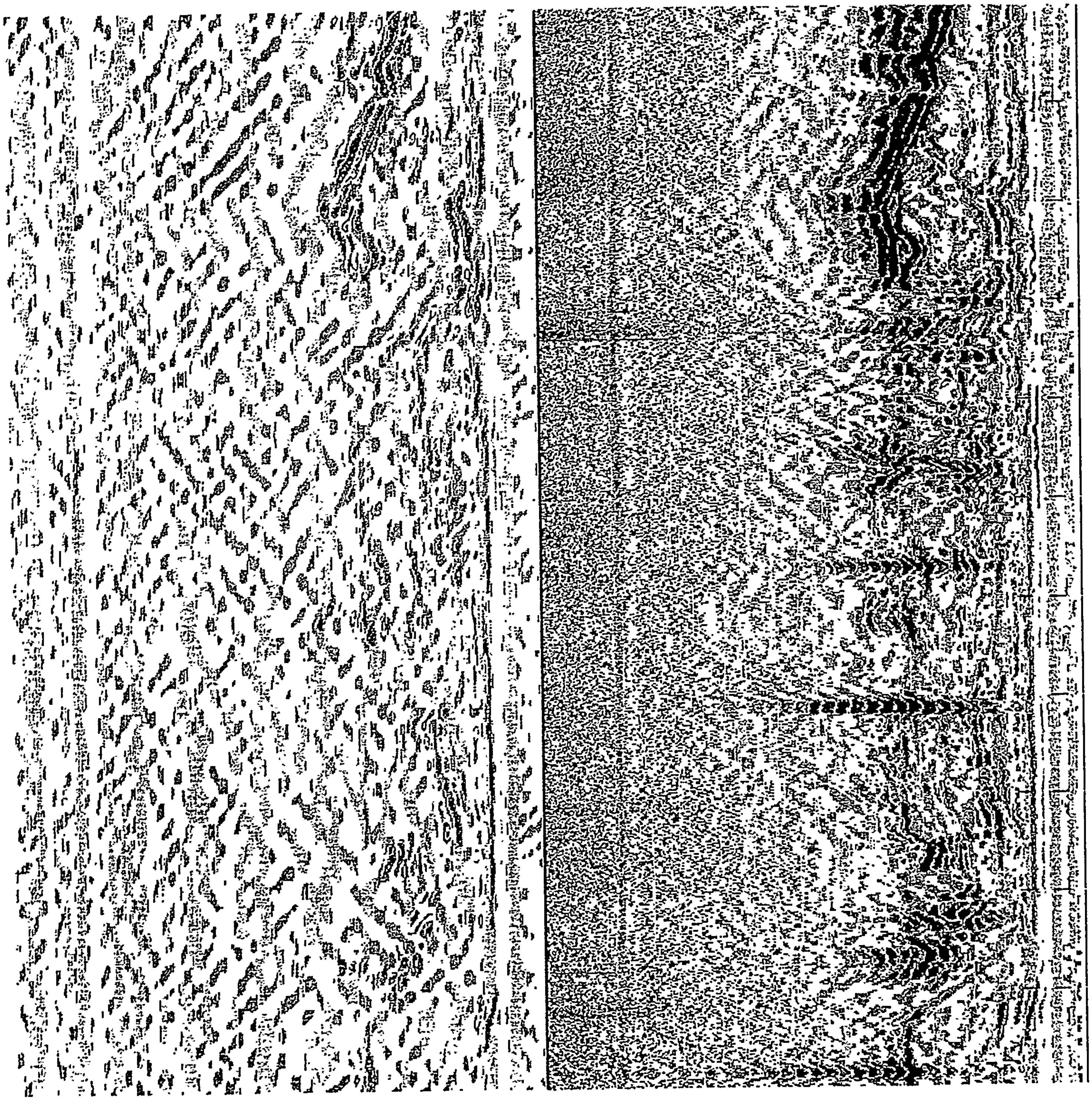
121 Created May 8,1993 13:51 Modified May 9,1993 02:53
512 samples/scan 30.0019 scans/sec position: -10 nS range: 150 nS
Vert. IIR low pass N=2 F=80
Vert. IIR high pass N=2 F=11

Figure 4-6

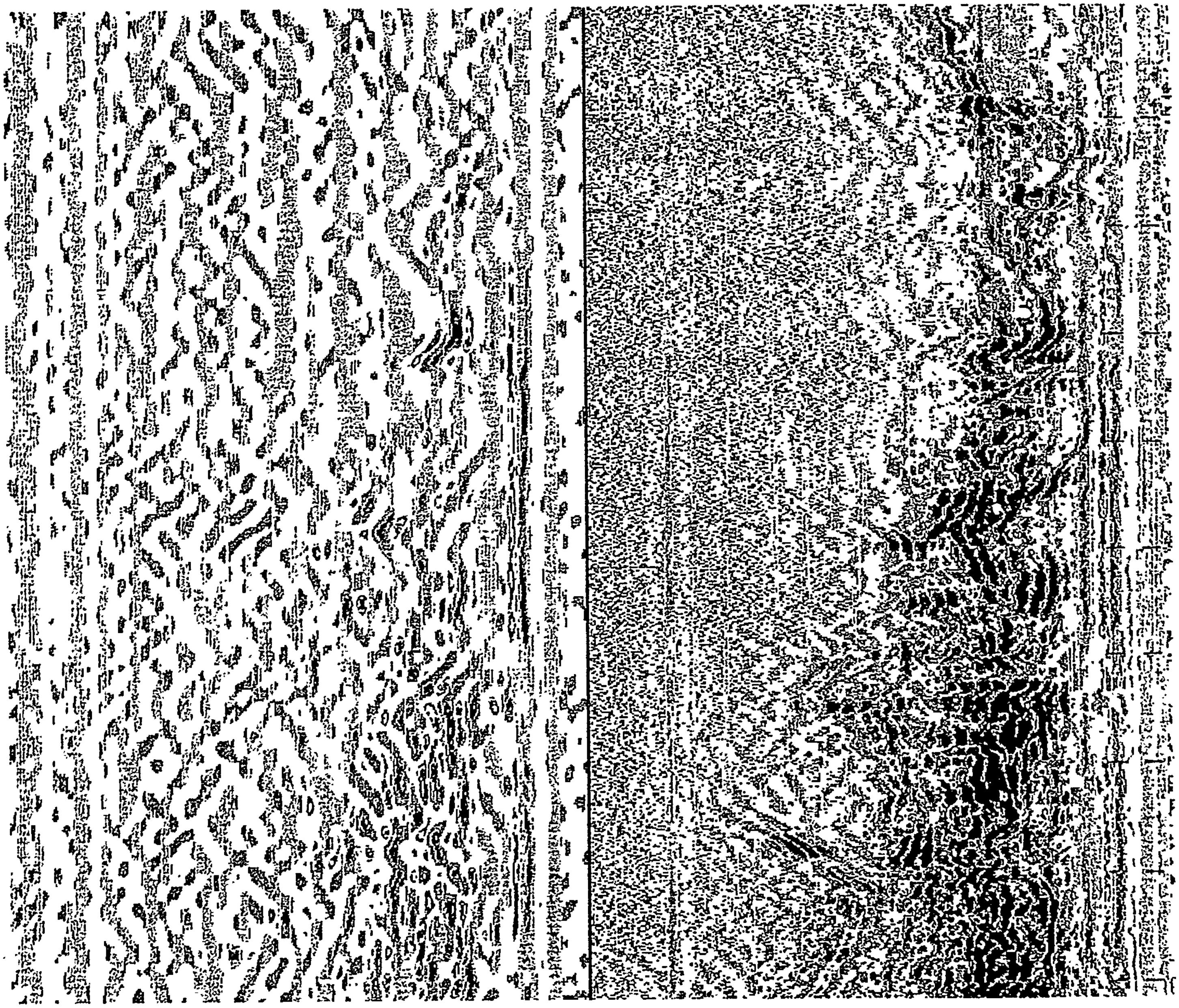
BURMA ROAD 3-D GPR SURVEY
SAVANNAH RIVER SITE



155 Created May 10,1993 07:54 Modified May 10,1993 20:48
512 samples/scan 30.0019 scans/sec position: -10 nS range: 150 nS
Vert. IIR low pass N=2 F=80
Vert. IIR high pass N=2 F=11

BURMA ROAD 3-D GPR SURVEY
SAVANNAH RIVER SITE

Figure 4-7



4.1.2 *GPR Survey Summary*

Three areas of disturbed soils at the BRRP unit have been defined using Ground Penetrating Radar. Two of the areas are well defined parallel northeast trending trenches. The southern trench extends beyond the orange-ball markers on both ends of the site. Numerous strong and weak radar reflecting anomalies are found within the trenches indicating the presence of buried debris including metal objects. Calculated depths of trench bottoms range from 1.8 meters (approximately 6 feet) to 5.4 meters (approximately 18 feet) at the site. A small area of disturbed soils characterized by chaotic radar reflections appears to be present in the west corner of the site. A lack of strong radar reflectors suggests that no debris is buried in this area.

4.1.3 *Electromagnetic Survey*

An electromagnetic (EM) survey was conducted at the BRRP site in 1993. Bulk conductivity values using the EM-31 ranged from 2 to over 100 m-mhos/m across the project site. A contour map of bulk conductivity values is presented in Figure 4-9. Bulk conductivity values were obtained by averaging two conductivity values of a particular transect point obtained from the north-south and east-west survey transects. In areas near the pit boundary, increased value weight was given to the EM-response values collected from transects performed perpendicular to the boundary of the pit.

Background conductivity values were obtained from the survey lines outermost from the pit area and along a dirt road east of the site. Apparent background conductivity values ranged from 2 to 3 m-mhos/m.

The suspected boundaries of the pit are also shown on Figure 4-9. These boundaries are characterized by a large variation in the in-phase component of the EM signal and, in general, by conductivity values elevated above apparent background levels. The large variation in the in-phase component indicates the presence of metal objects within the pit debris. The suspected boundary of the pit as defined by the bulk conductivity values was proximate to either the 5 or 10 m-mhos/m contour across the majority of the project site; however, the apparent boundary of the pit, as defined by a large variation in the in-phase component of the EM signal, extended outside the 5 m-mhos/m contour in several areas. The possibility exists that the suspected buried metal objects which created the variation in the in-phase response in these areas were not of a sufficient size to significantly elevate bulk conductivity values. Portions of the suspected boundaries of the pit fall outside an area defined by the orange ball markers.

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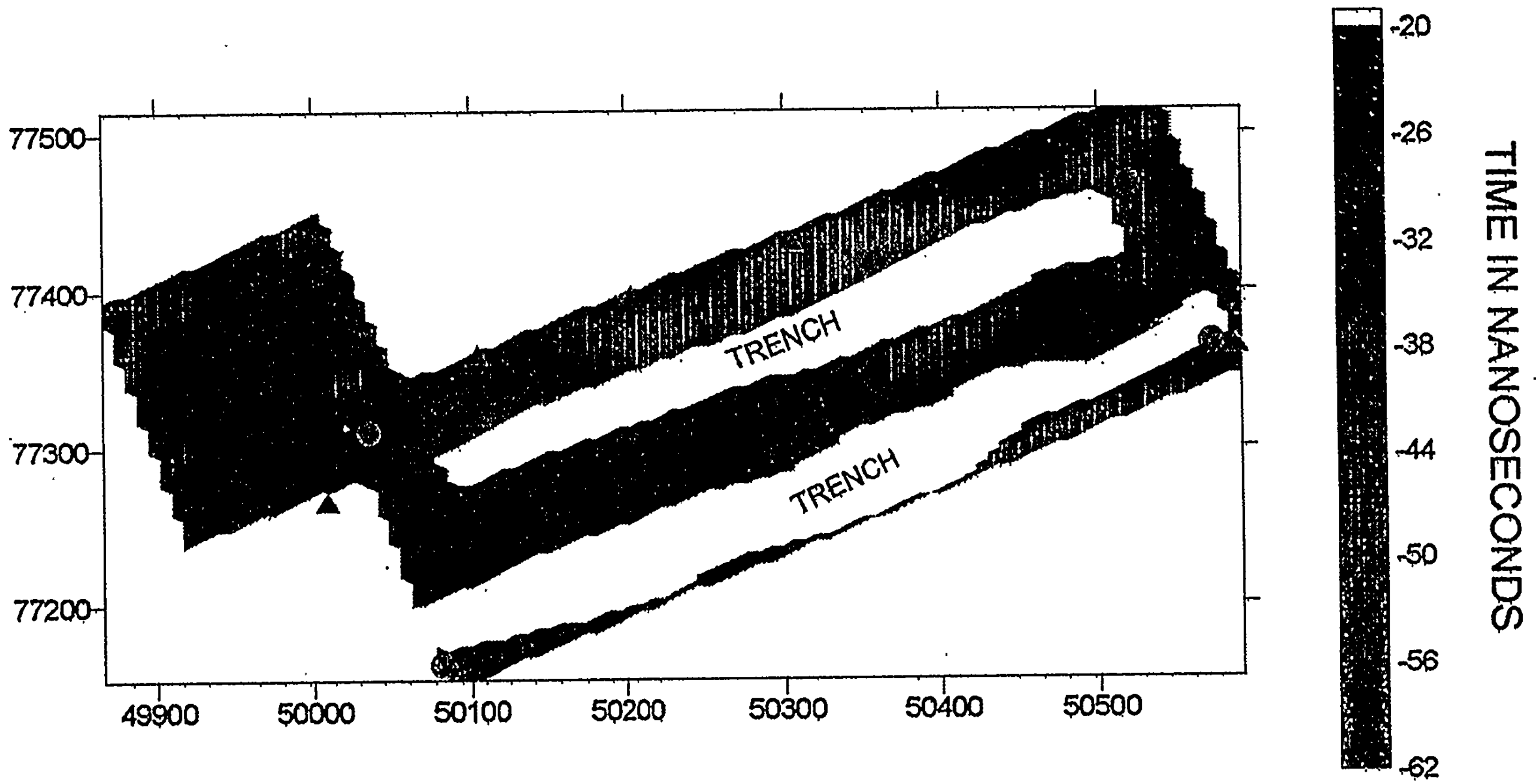
Figure 4-8

BURMA ROAD RUBBLE PIT

3-D GPR SURVEY

CONTOUR MAP



LEGEND

- ● HEALTH PROTECTION (RED BALLS)
- ▲ MONITOR WELLS

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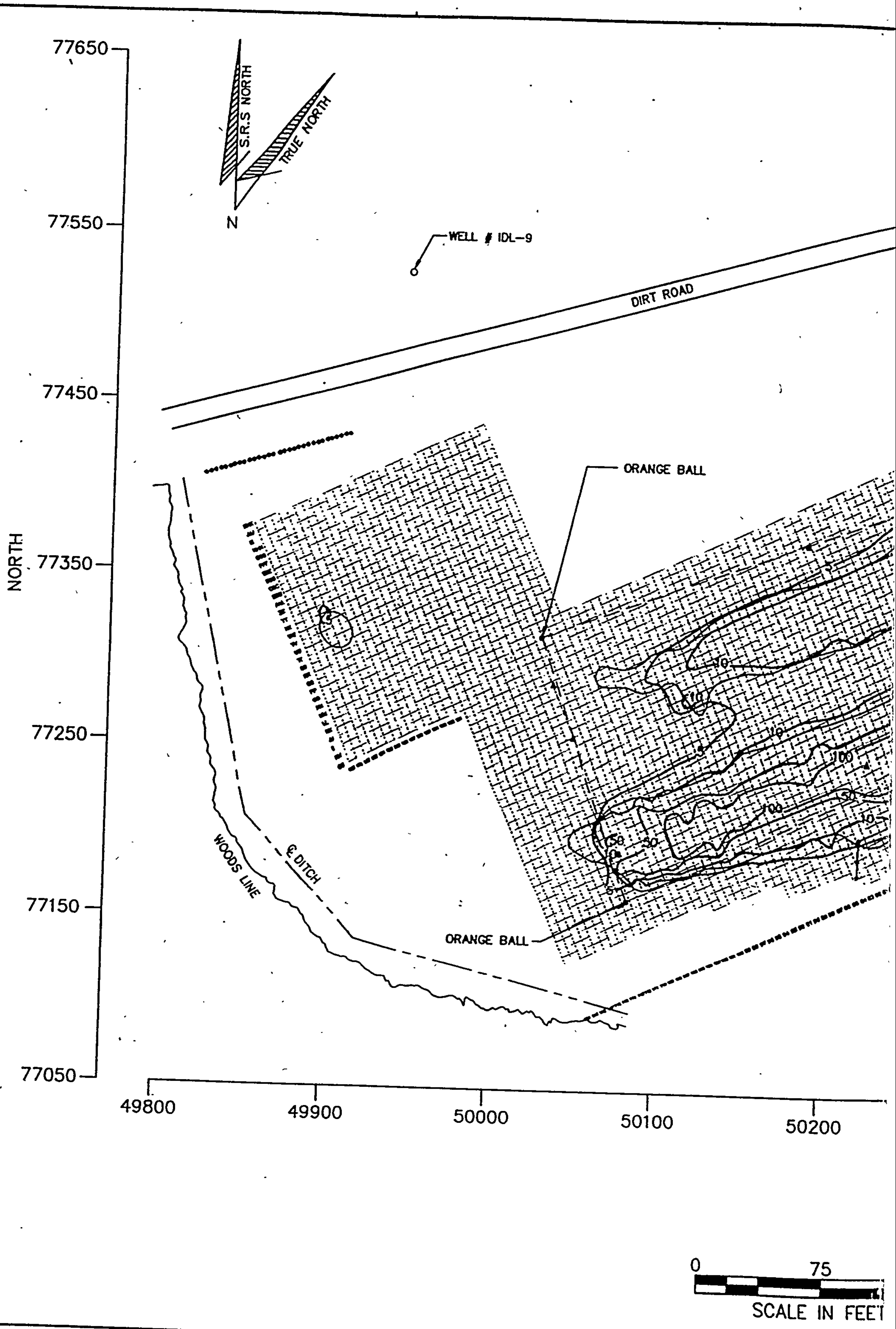

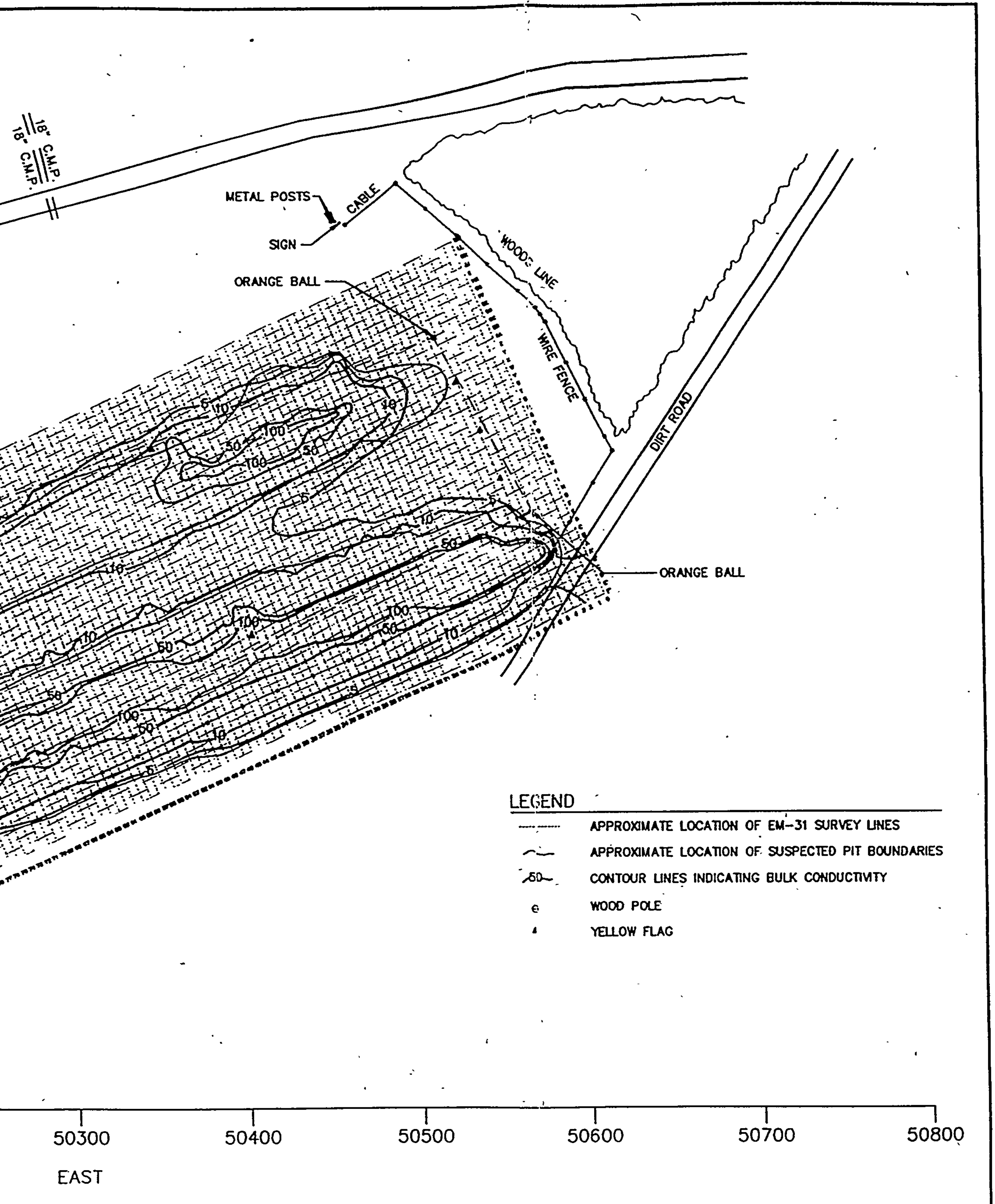

150

M&E METCALF & EDDY

SITE MAP SHOWING APPROXIMATE LOCATION OF EM SURVEY LINES, CONDUCTIVITY CONTOURS & SUSPECTED BOUNDARY OF PIT

SAVANNAH RIVER PLANT

FIGURE 4-9

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Within the suspected boundaries of the total BRRP unit are two separate linear anomalies which are defined by the 10 m-mhos/m contour. These two anomalies confirm the GPR survey conducted in May 1993 which outlined the presence of two generally parallel, northeast trending rectangular pits. The geophysical data indicated that the approximate dimensions of the rubble pits are each 400 feet long by 50 feet wide by 10 feet deep.

An area of bulk conductivity above background levels without a large variation in the in-phase response was present in the east corner of the site (Figure 4-9). This area is covered by a dirt road. The elevated bulk conductivity values may be associated with materials used in the road and not with the buried metal objects. Another small area of suspected buried metal debris was present inside the northwest corner of the surveyed area (Figure 4-9).

A large variation in the in-phase response was constant within the suspected boundaries of the pit. Accordingly, it was not possible to determine the size or the geometry of the metal objects which created the variations. Therefore, it was not possible to determine whether the variations were due to the presence of metal drums or tanks or were due to other types of metal debris. Note the high bulk conductivity values in the east part of the northern pit. This suggests a higher concentration of buried metallic objects in this area of the pit. This was confirmed with boring BRRP-3, where significant amounts of buried metal material caused the boring to be offset three times before the sampling depths could be reached. The bulk conductivity values collected across the project site are presented in Appendix D and displayed on a color-coded bulk conductivity map (Figure 4-10).

4.1.4 *EM Survey Summary*

The apparent boundaries of the BRRP have been defined using electromagnetic techniques. The pit boundaries appear to extend beyond an area defined by orange-ball markers at the site. Two parallel northeast trending linear anomalies can be defined within the overall pit boundary using the 10 m-mhos/meter contour. A small area of suspected buried debris appears to be present in the west corner of the site, away from the primary pit. Because of the apparent high-density of buried metal debris at the site, it was not possible to distinguish large metal objects such as drums or tanks from other metal debris within the pit.

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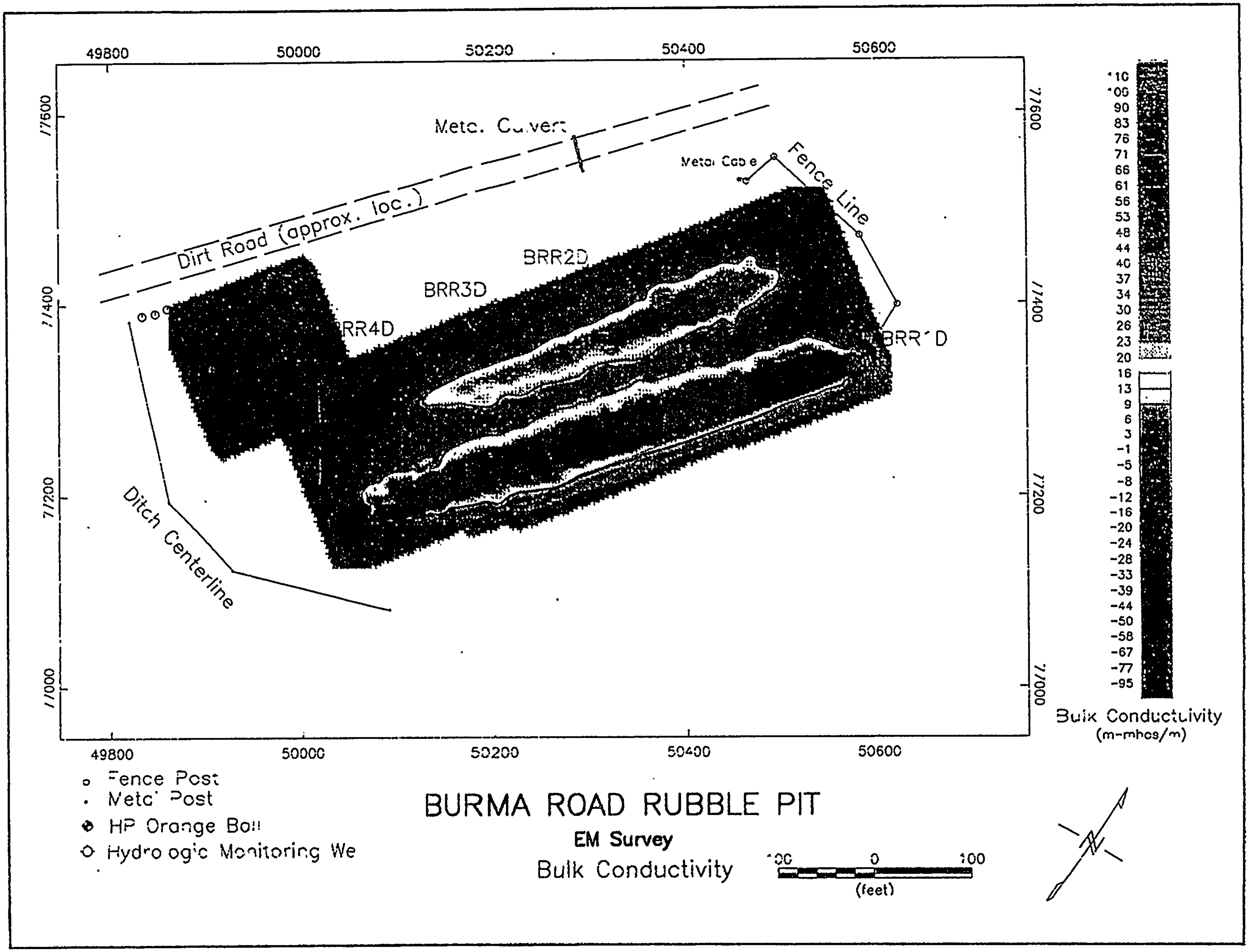

BURMA ROAD RUBBLE PIT

EM Survey

Bulk Conductivity

Figure 4-10

4.1.5 *Magnetic Survey*

A magnetic survey was conducted by WSRC at the BRRP unit in June 1993 (Figure 4-11). The following summary is taken from the WSRC magnetic survey report.

The survey data and the diurnal variation data are found in Appendix E.

Color contoured diurnally corrected maps of the magnetic data are presented in Figures 4-12 through 4-14 showing top sensor, bottom sensor and vertical gradient data. Prominent magnetic anomalies are associated with the monitoring wells (protective steel well covers), and the orange marker balls. The data also show two parallel, northeast trending dipole anomalies where the trenches are thought to be located. Additionally, an isolated magnetic anomaly occurs in the center of the disturbed soil area located in the west part of the BRRP unit.

The highest magnitude magnetic anomalies recorded are those located within the trenches and correspond with the electromagnetic survey anomalies. The maxima and minima in the magnetic vertical gradient data most closely coincide with the 10 m-mhos/m contour on the shaded image vertical magnetic field gradient map (see Figure 4-15).

The largest total field values and vertical gradients are found in the two linear (trench) anomalies particularly in the east end of the northern most anomaly indicating that these areas contain the most ferrous magnetic material. This confirms the EM survey bulk conductivity data, specifically the area outlined by the 10 m-mhos/m contour (see Figure 4-10).

The area in which the isolated magnetic anomaly occurs near the middle of the area of disturbed soil was searched for evidence of surface metallic objects. None were found so the anomaly is interpreted to represent a small buried ferrous metallic object at this location.

The other significant magnetic anomalies seen in the magnetic data are attributed to the presence of groundwater monitoring wells and the orange waste unit marker balls that mark the corners of the waste unit.

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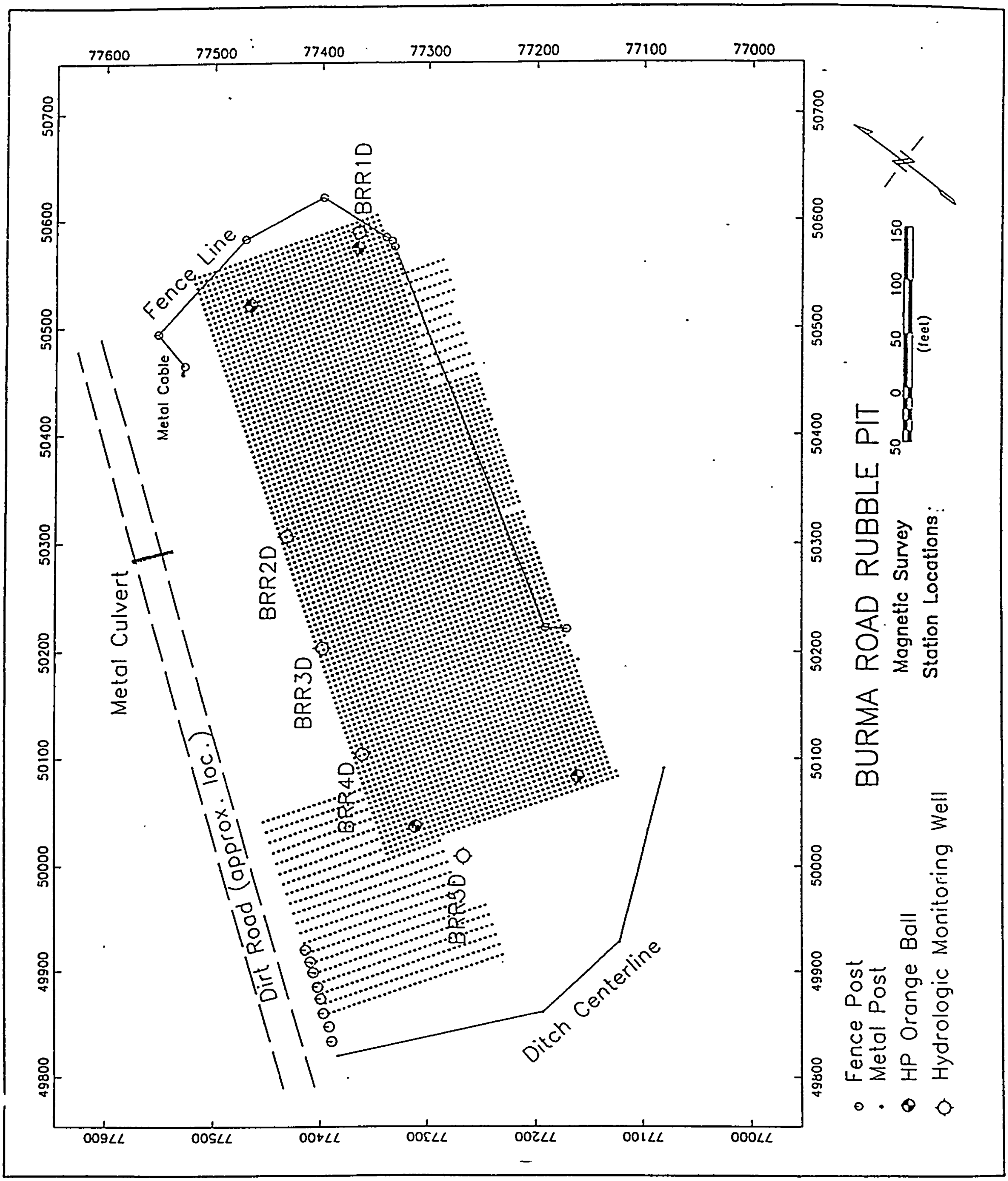
Figure 4-11


BURMA ROAD RUBBLE PIT
Magnetic Survey
Station Locations:
○ Fence Post
• Metal Post
⊕ HP Orange Ball
◇ Hydrologic Monitoring Well
0
50
100
150
50
(feet)
Fence Line
Metal Cable
Metal Culvert
Dirt Road (approx. loc.)
Ditch Centerline
BRR1D
BRR2D
BRR3D
BRR4D
BRR5D
77600
77500
77400
77300
77200
77100
77000
50700
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50500
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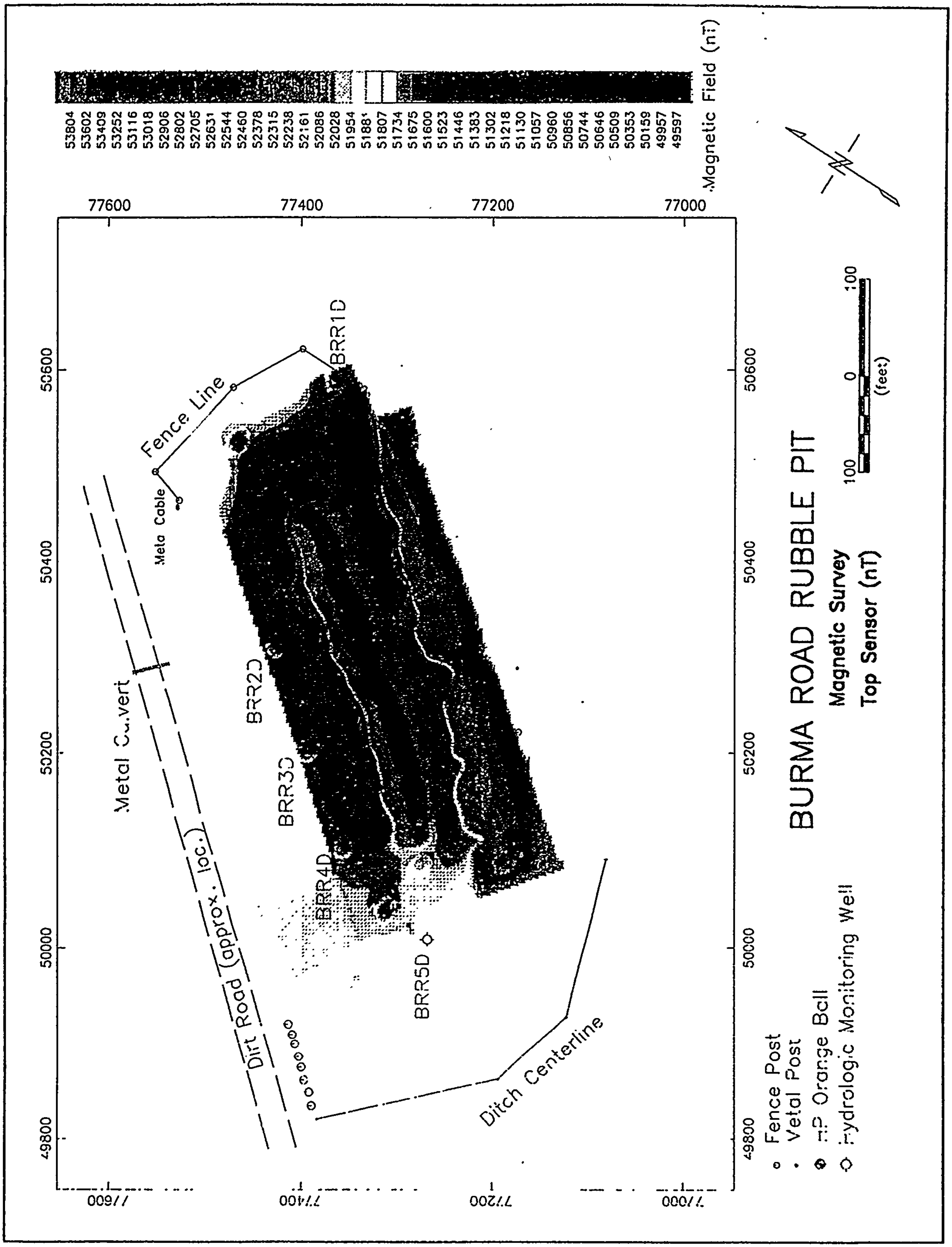
50200
50100
50000
49900
49800

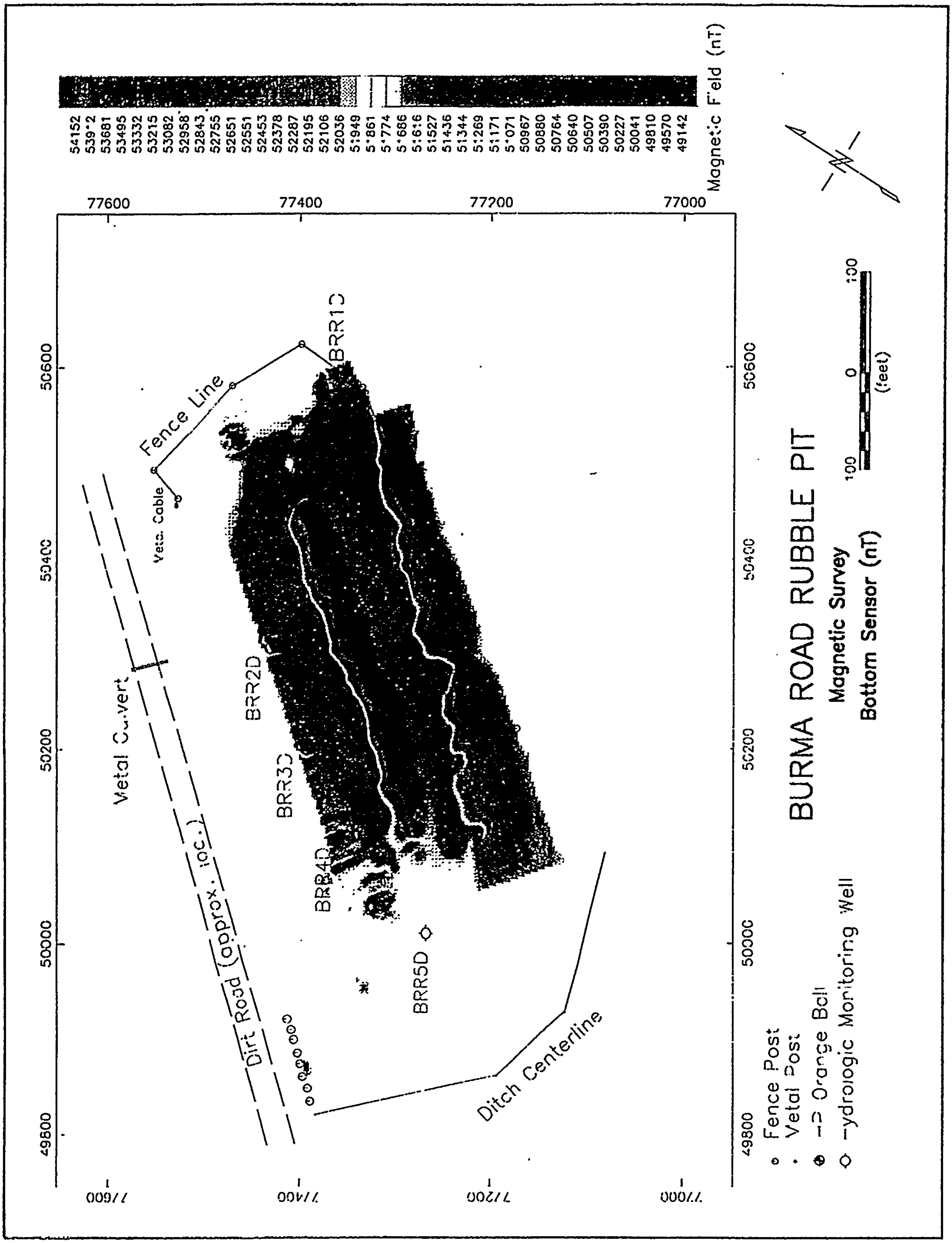


BURMA ROAD RUBBLE PIT

Magnetic Survey

Top Sensor (nT)

Figure 4-13



BURMA ROAD RUBBLE PIT

Magnetic Survey

Bottom Sensor (nT)

Figure 4-14

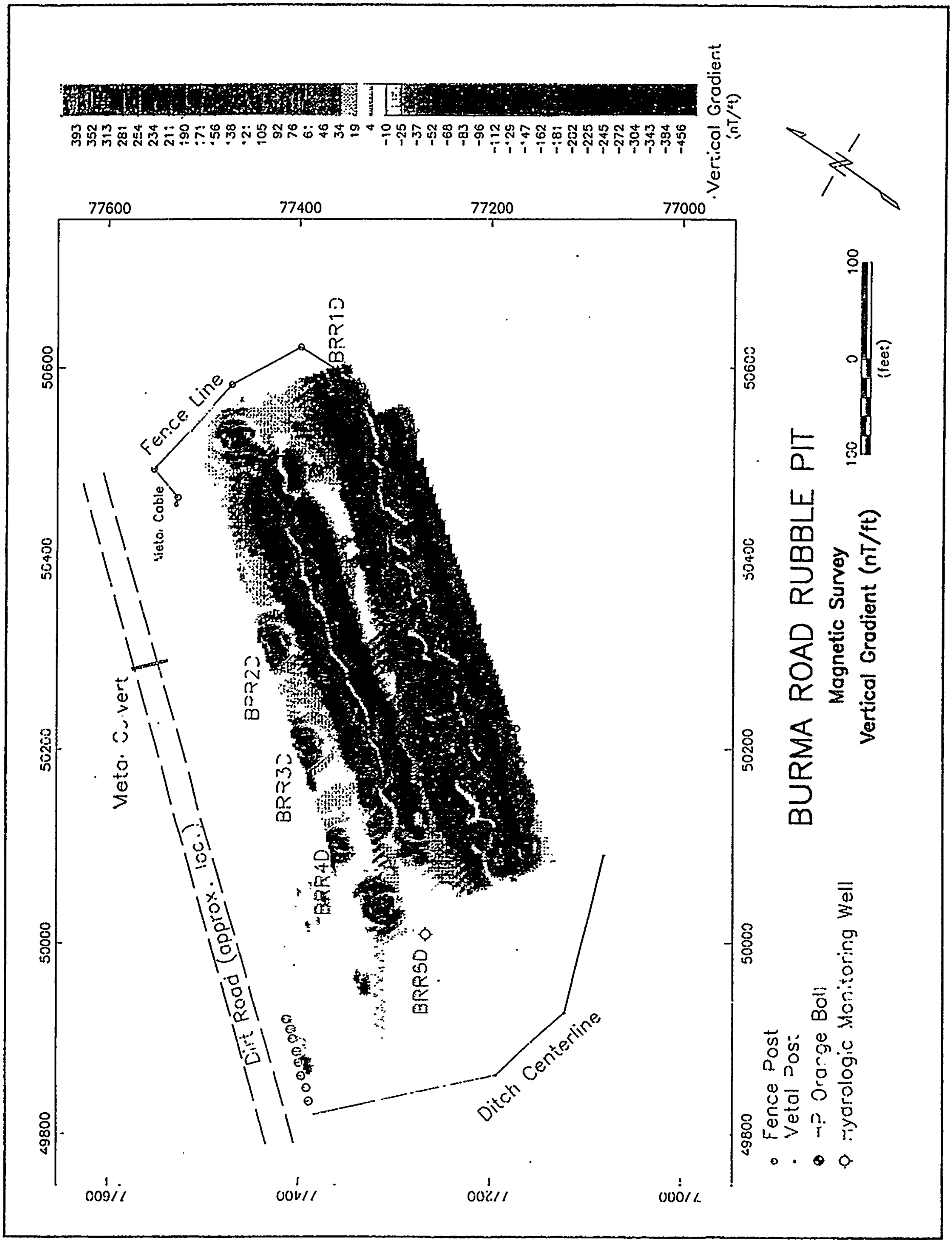
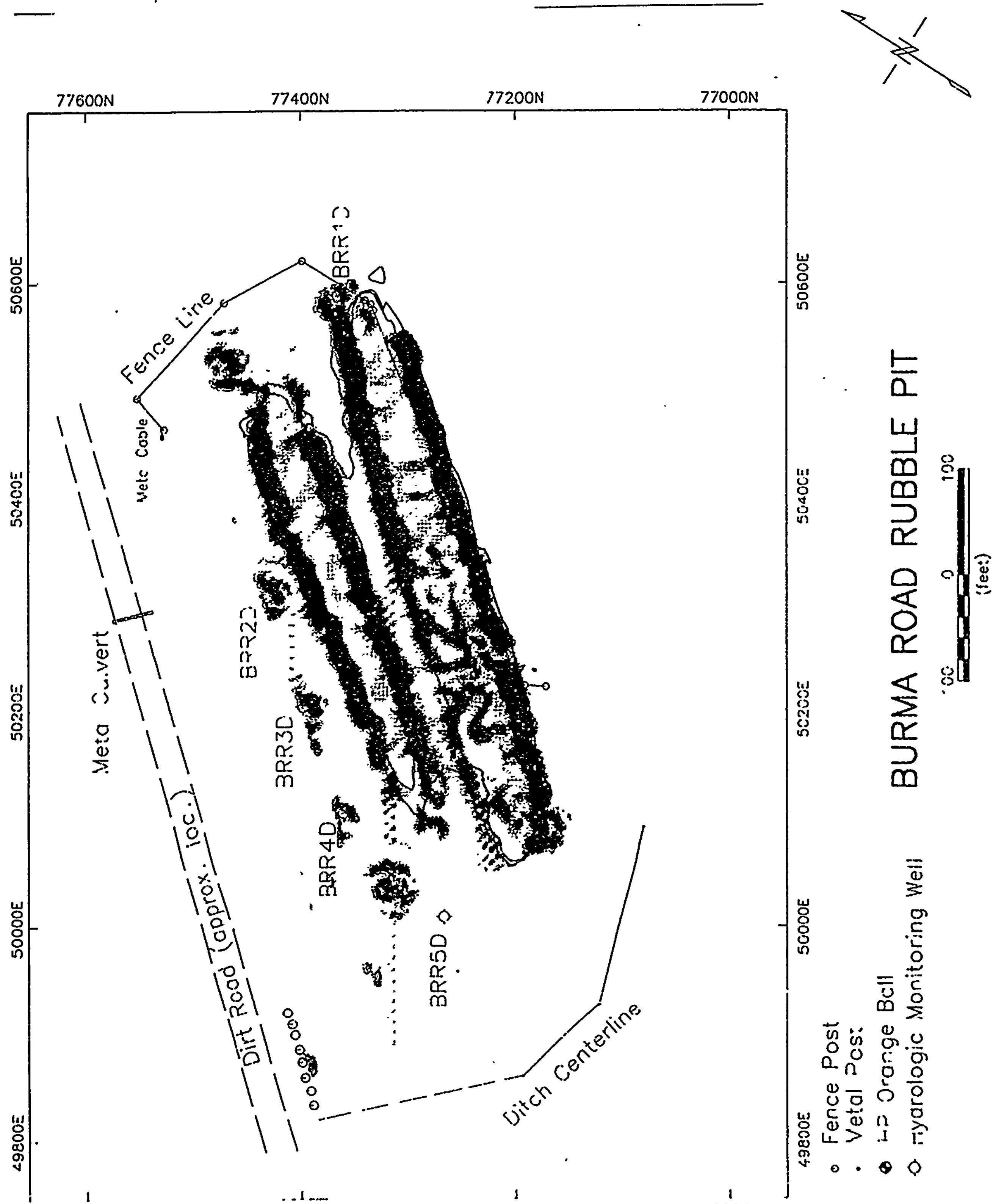

BURMA ROAD RUBBLE PIT
Magnetic Survey
Vertical Gradient (nT/ft)
Vertical Gradient (nT/ft)
393
352
313
281
254
234
211
190
171
156
138
121
105
92
76
61
46
34
19
4
-10
-25
-37
-52
-68
-83
-96
-112
-129
-147
-162
-181
-202
-225
-245
-272
-304
-343
-384
-456
77600
77400
77200
77000
49800
50000
50200
50400
50600
Fence Line
Metal Cable
Metal Culvert
Dirt Road (approx. loc.)
Ditch Centerline
BRR1D
BRR2D
BRR3D
BRR4D
BRR5D
100
0
100
(feet)
Fence Post
Metal Post
Orange Ball
Hydrologic Monitoring Well

Figure 4-15

5- and 10-m-mhps/m bulk conductivity contours overlain onto shaded relief image of vertical magnetic field gradient



4.1.6 *Magnetic Survey Summary*

Two major linear magnetic anomalies and one small isolated anomaly were identified in the magnetic survey. The linear anomalies correspond to the EM survey anomalies, (particularly the 10 m-mhos/m contour) and have been interpreted to correspond to the two northeast trending trenches. The highest magnetic values are found in the east area of the north trench which also corresponds to the highest EM survey values suggesting that the highest concentration of ferrous metallic objects is located in this area. A small isolated magnetic anomaly is present in the disturbed soil area located in the northwest part of the unit and corresponds to an EM survey anomaly in the same location. Other prominent magnetic anomalies found in this survey can be attributed to groundwater monitoring wells and the orange waste unit marker balls.

4.2 Soil Gas Surveys

A total of four soil gas surveys were completed at the BRRP site. Surveys I through III were conducted over the two burial trenches in October 1990, July 1991, and September 1992 respectively. Survey IV, conducted in July 1993, extended the coverage beyond the two burial trenches. In all cases, the purpose of the soil gas surveys was to determine the presence and extent or absence of contamination in soils around the site. The following information is taken from a report entitled "Final Report, An Investigation of Soil Gases at Depths of 3 - 25 Feet at the BRRP [Survey III]" and from another report entitled "Final Report, A Soil Gas Survey at Depths of 3 and 20 Feet at the BRRP [Survey IV]".

The results of all analyses from Surveys I through IV are shown in Appendix F and field locations are depicted in Figure 4-16. Five background samples for these surveys were collected 150 feet southwest of the site.

4.2.1 *Results of Soil Gas Surveys I - III*

Of the chlorinated hydrocarbons, only tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene, and trans 1,2-dichloroethylene are present in amounts exceeding the minimum detection level. Tetrachloroethylene and 1,1,1-trichloroethane are present in both trenches. Concentrations of both species are low: the highest observed concentration of tetrachloroethylene was 147 ppbv at 3 feet in the northern trench; the highest observed concentration of 1,1,1-trichloroethane was 164 ppbv in the southern trench. It is noted that 1,1,1-trichloroethane was observed above the minimum detection

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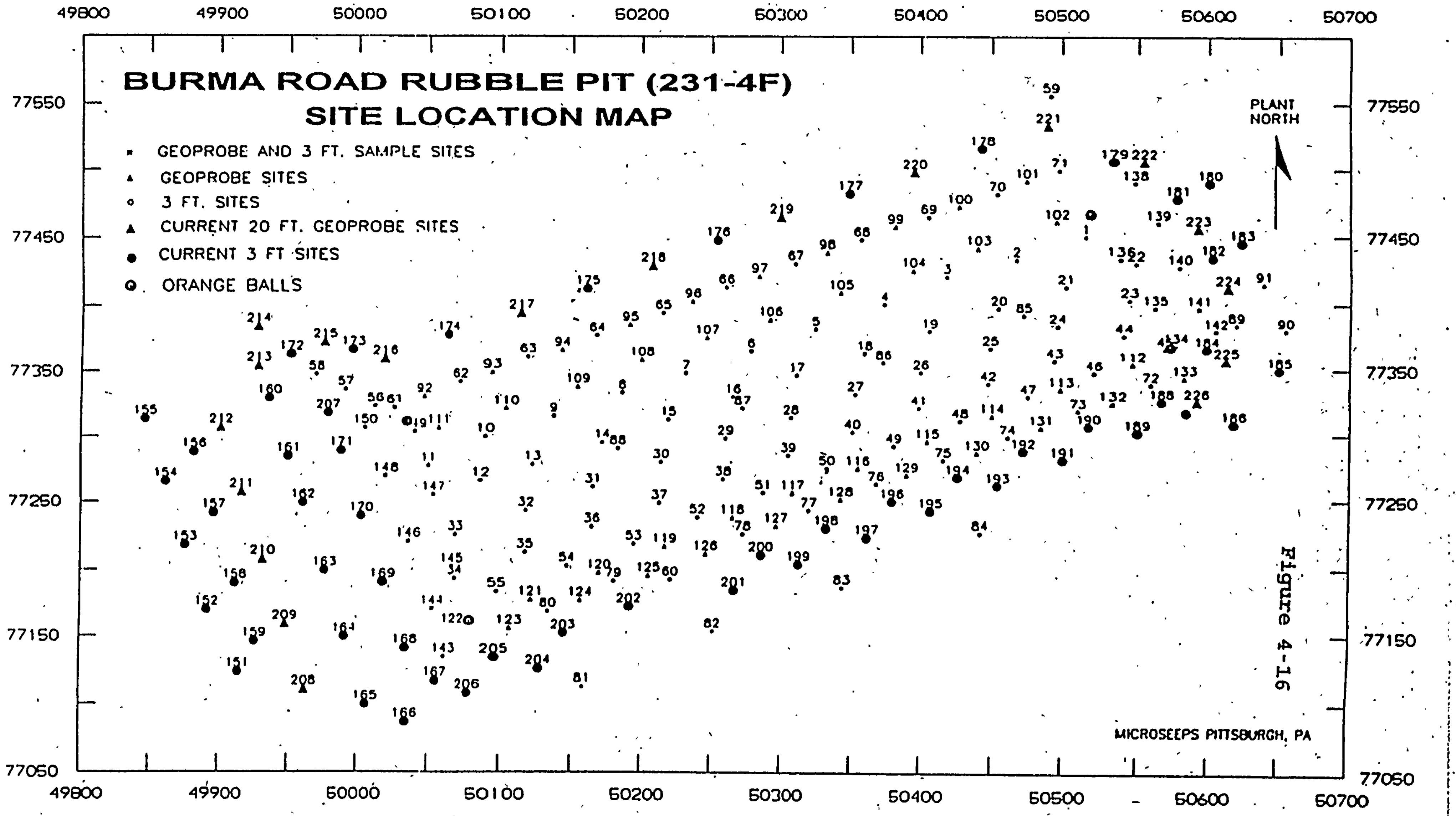

BURMA ROAD RUBBLE PIT (231-4F)
SITE LOCATION MAP

Figure 4-16

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level in virtually every sample while the occurrence of tetrachloroethylene was more restricted. It is also noted that the observed distribution of tetrachloroethylene at 3 feet as compared to the deeper samples is not highly correlated. The compound 1,1,1-trichloroethane was monitored only in Survey III which largely consisted of Geoprobe sites, thus a depth distribution comparison is not possible for this compound.

The compounds trichloroethylene and trans 1,2-dichloroethylene are found only in the southern trench and largely in the eastern end of that trench. Their distribution at 3 feet and at depth are well correlated, although the distribution of trans 1,2-dichloroethylene at depth is somewhat larger and at higher concentrations than the distribution at 3 feet.

The aromatic hydrocarbons, benzene, toluene, ethylbenzene and xylenes are present in anomalous amounts, particularly in the southern trench. These hydrocarbons could be due to the presence of gasoline or other light petroleum distillates as a part of the materials buried. In general, the observed concentrations of aromatic hydrocarbons are much larger than the chlorinated hydrocarbons.

The saturated hydrocarbons (C5-C10) are also found in anomalous concentrations particularly in the southern trench. The distribution of pentane, hexane, heptane and octane are for the Geoprobe sites since these hydrocarbons were only measured in Survey III. The distributions of octane and heptane are very localized and well correlated; both are similar to the distribution of the aromatics discussed above. The distribution of hexane is also similar, howwever small concentrations of hexane are observed outside the localized area of octane and heptane contamination. The distribution of pentane is much more general. It is probable that the observed distributions of hexane and pentane are comprised of two parts, the first and most prominent results from hydrocarbon fuel contamination in a restricted area of the eastern end of the southern trench. The second part results from the natural background of these species in the Savannah River Site area. **In support of the natural occurrence of hydrocarbons in the Central Savannah River Area (CSRA), recent geochemical investigations conducted on the late Eocene Griffins Landing Member (GLM) of the Dry Branch formation carbonate outcrop samples from Griffins Landing, Georgia, detected the presence of wet saturated hydrocarbons. When fractured, outcrop samples produced a petroliferous odor (Richers et al, 1994).** Only in the cases of pentane and hexane do the background concentrations exceed the minimum detection levels of the analytical methods.

Anomalous levels of the light hydrocarbons are clearly associated with the observed aromatic hydrocarbons in the southern trench. The presence of methane may be due to bacterial degradation of buried rubble. There appears to be an inverse correlation between the distribution of ethane and the distribution of methane. This is due to the fact that in the presence of very large methane concentrations, ethane is not well separated chromatographically and in these cases is not well determined. The remaining light hydrocarbons, are obviously correlated to the contamination in the eastern end of the southern trench, however these hydrocarbons are also mixtures related to the contamination and to the natural background as discussed above for pentane and hexane. It may be that the highest concentrations of the C2+ fraction are generated from the buried waste via microbial degradation.

Finally, the mobile mercury found in soils at the BRRP are very low and probably reflect background levels only.

4.2.1.1 Summary

The aromatic hydrocarbons, BTEX, the saturated hydrocarbons, C5-C10, and selected chlorinated organic compounds were observed in anomalous concentrations in soil gases at the BRRP. The aromatics and contamination related saturated VOC's were limited exclusively to the southern trench. Tetrachloroethylene and 1,1,1-trichloroethane were found in both the southern and northern trenches, while trichloroethylene and trans 1,2-dichloroethylene were found only in the southern trench. Light hydrocarbons were found in anomalous amounts which were well correlated with the saturated and aromatic VOCs in the eastern end of the southern trench. Only background levels of mercury were found at the BRRP.

4.2.2 *Results of Soil Gas Survey IV*

In Soil Gas Survey IV, the chlorinated hydrocarbons were found in trace amounts only. Hydrocarbon constituents, pentane and hexane, are clearly still associated with the area of the southern trench observed in prior surveys to contain a complex array of saturated and aromatic hydrocarbons. The aromatics and higher saturates are not observed in this area in this most recent survey, although one benzene value was observed in the southwestern area of the survey and several o-xylene values were observed in the southeastern area of the survey. The o-xylene values are associated with alpha-pinene peaks and may be derived from pine resin rather than a hydrocarbon fuel mixture.

In particular, hydrocarbon constituents pentane and hexane are observed at most sites in the extension of the survey to the southwest of the orange balls marking the presumed southwest extent of the trench boundaries. Both pentane and hexane are found in higher concentrations in the 3 foot sites in this area than in the 20 foot sites.

The light hydrocarbons, although not generally observed in high concentrations, have a distribution similar to the hydrocarbon VOCs (methane and pentane). **Location #188 (see Figure 4-16)** on the southeastern boundary was observed to have very high methane concentrations.

The distribution of mercury is suggestive of background concentrations in the Savannah River Site area as determined in the recent background survey report entitled "An Investigation of Background Soil Gas Concentrations at the Savannah River Site", June, 1993.

4.2.2.1 Summary

The observed levels of most hydrocarbons and chlorinated hydrocarbons have decreased from previous soil gas surveys. The exceptions are pentane and hexane which are associated with areas which have been found to contain complex mixtures of hydrocarbons, possibly petroleum derived fuels, in previous surveys. These hydrocarbons are also found in the area to the southwest of the probable trench boundaries and are found in larger concentrations in the shallow samples. Light hydrocarbons in general are similar in distribution to pentane and hexane. **Background levels of soil mercury were found in all the surveys.**

4.3 Field Environmental Investigation Results

The following information presents results of data from the field investigation.

4.3.1 *Geology*

Regionally, the geology of the BRRP consists of approximately 195 feet of Early to Middle Eocene to Late Eocene fluvial and marine depositional environments (shallow marine, lagoons, bays, neritic and mid-neritic, and fresh water/salt water interface sediments). A cross section utilizing the deep monitoring wells BRR-8B, **BRR-7BR**, and BRR-6B and **hydrocone (HC), piezocone (PC) numbers 6, 8, and 9 water level data** is illustrated in Figure 4-17. This cross section illustrates the lithology of the strata, the screened intervals within the Upper and Lower Three Runs Aquifer, the confining

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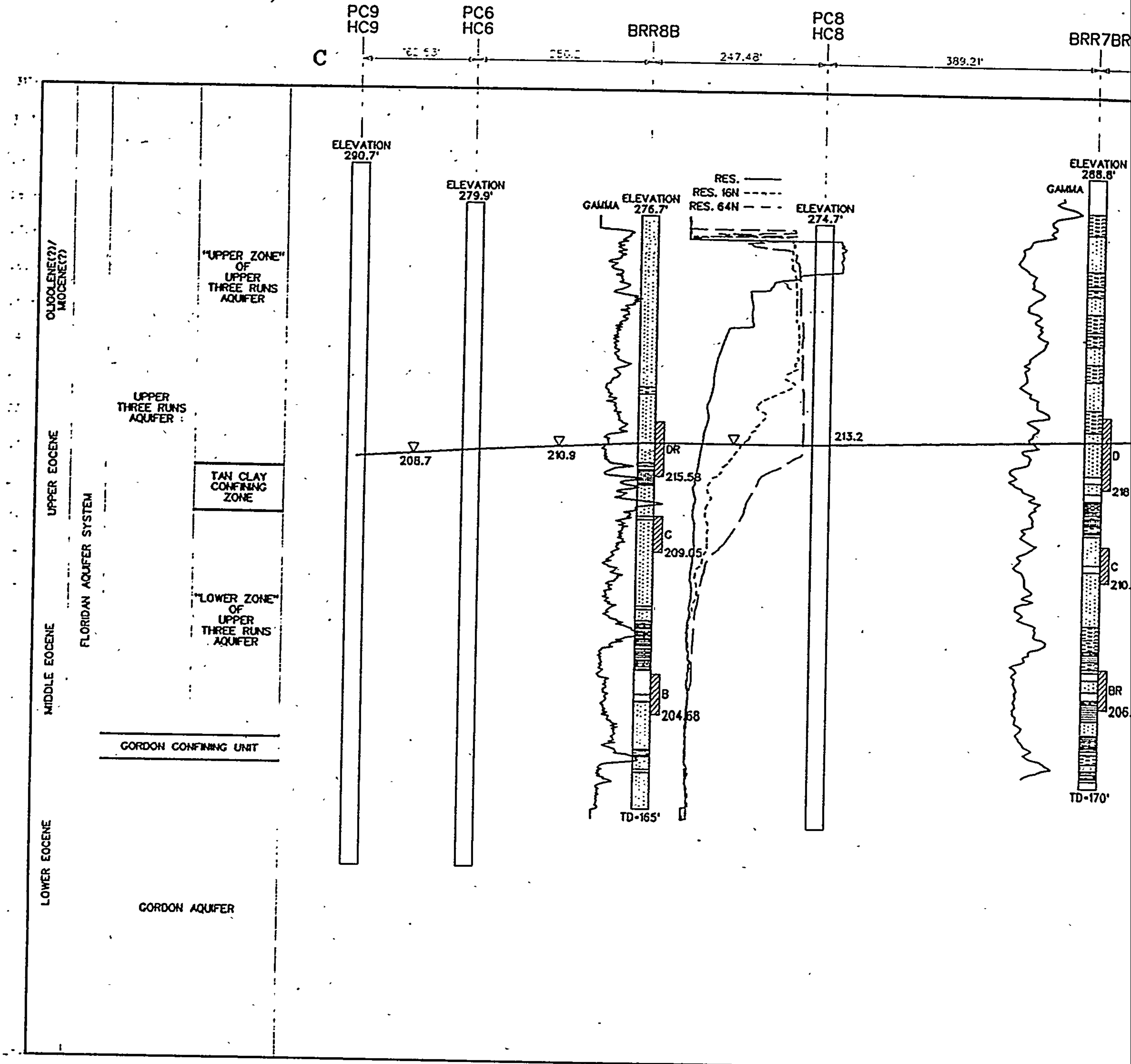
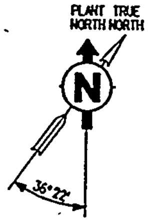
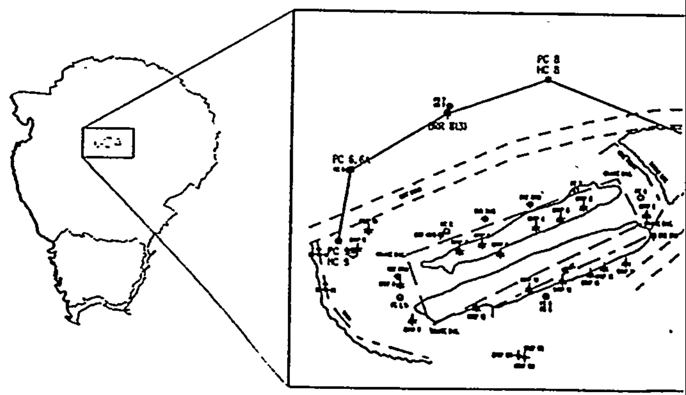
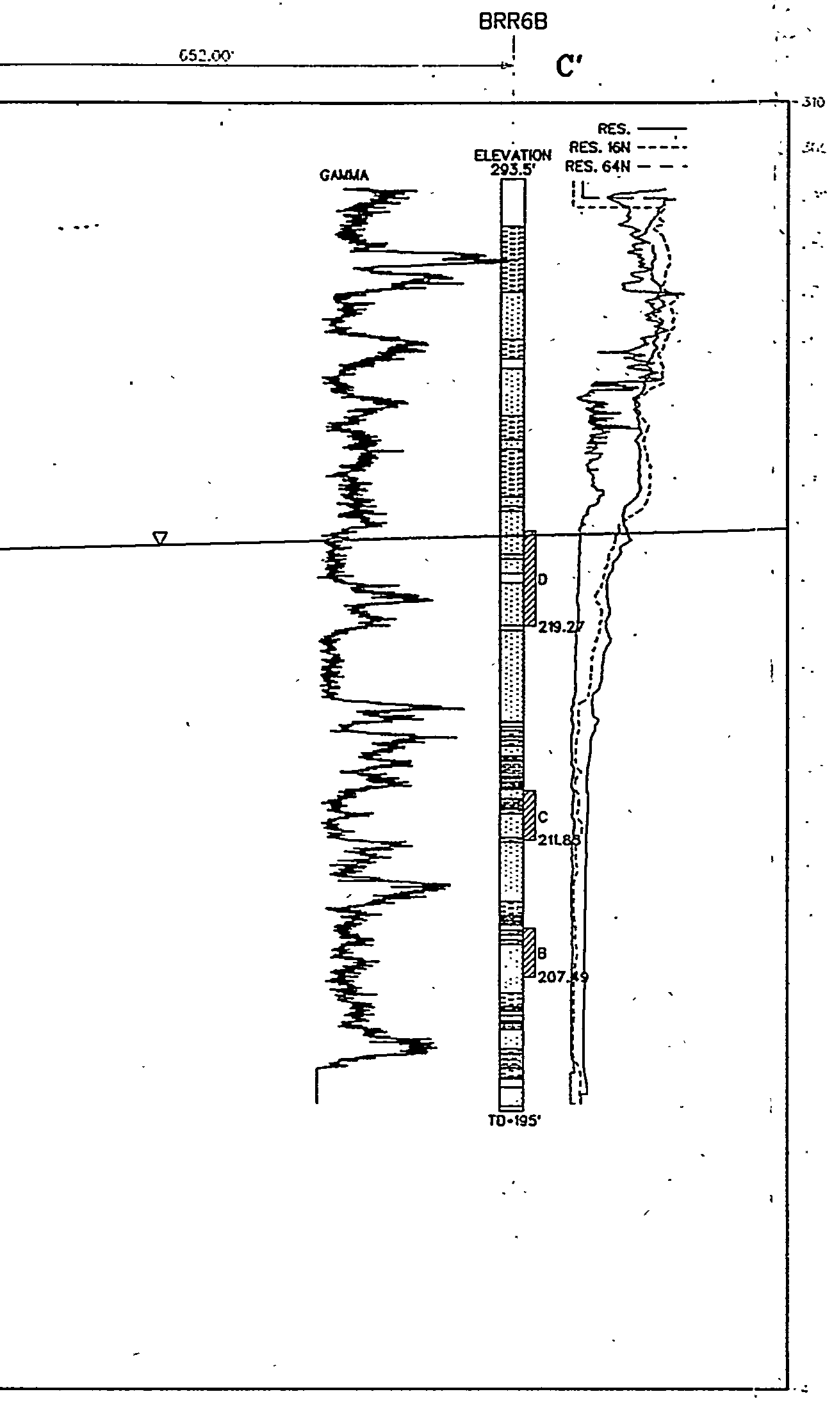
HYDROGEOLOGIC CROSS-SECTION FOR THE BURM







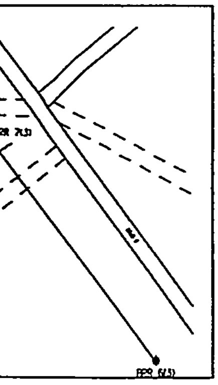
ROAD RUBBLE PIT

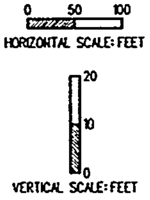


LEGEND:

- ▨ CALCAREOUS SAND
- ▨ CALCAREOUS MUD
- ▨ CLAYEY SAND
- ▨ SAND
- ▨ GRAVEL/PEBBLES
- ▨ SILT/CLAY
- ▨ SANDY LIMESTONE
- ▨ SANDY MUDDY LIMESTONE
- ▨ LIMESTONE
- ▨ MUDDY LIMESTONE
- ▨ SANDY CLAY
- ☐ NO RECOVERY
- SAND PACK INTERVAL
- SCREENED INTERVAL

TD - TOTAL DEPTH
GSA - GENERAL SEPARATIONS AREA
DUI - DEPTH USED FOR INTERPRETATION
——— - CONFINING ZONE, UNIT AND SYSTEM BOUNDARIES.
▽ - WATER TABLE





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SAFETY • RESPONSIBILITY • SECURITY SRS

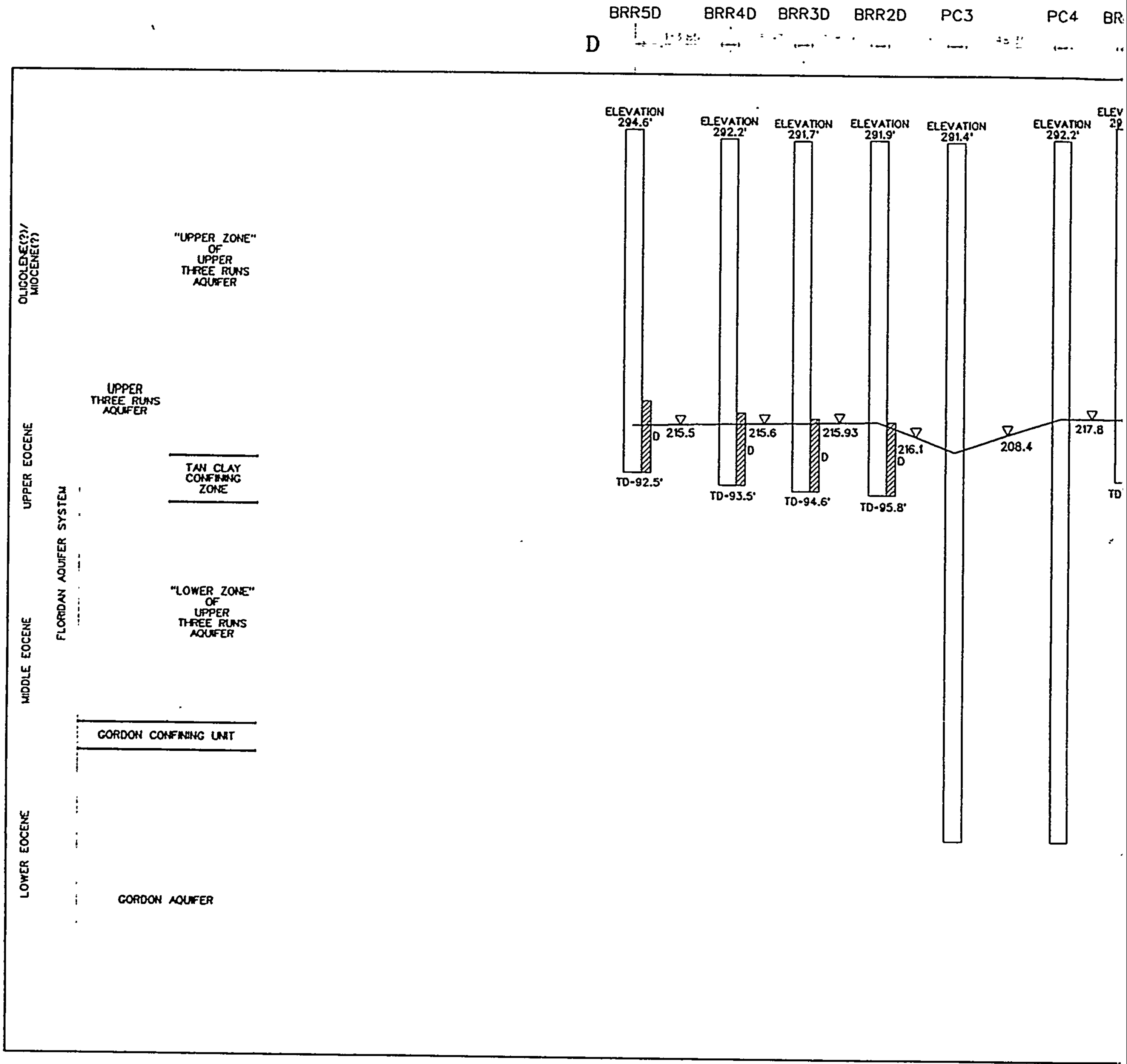
ENVIRONMENTAL RESTORATION
"Restoring the Environment Today for a Cleaner Tomorrow"

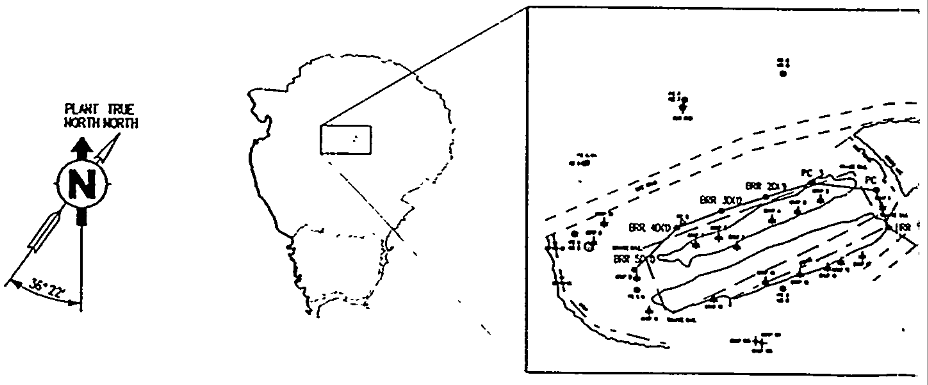
TITLE

FIGURE 4-17
HYDROGEOLOGIC
CROSS SECTION C-C'

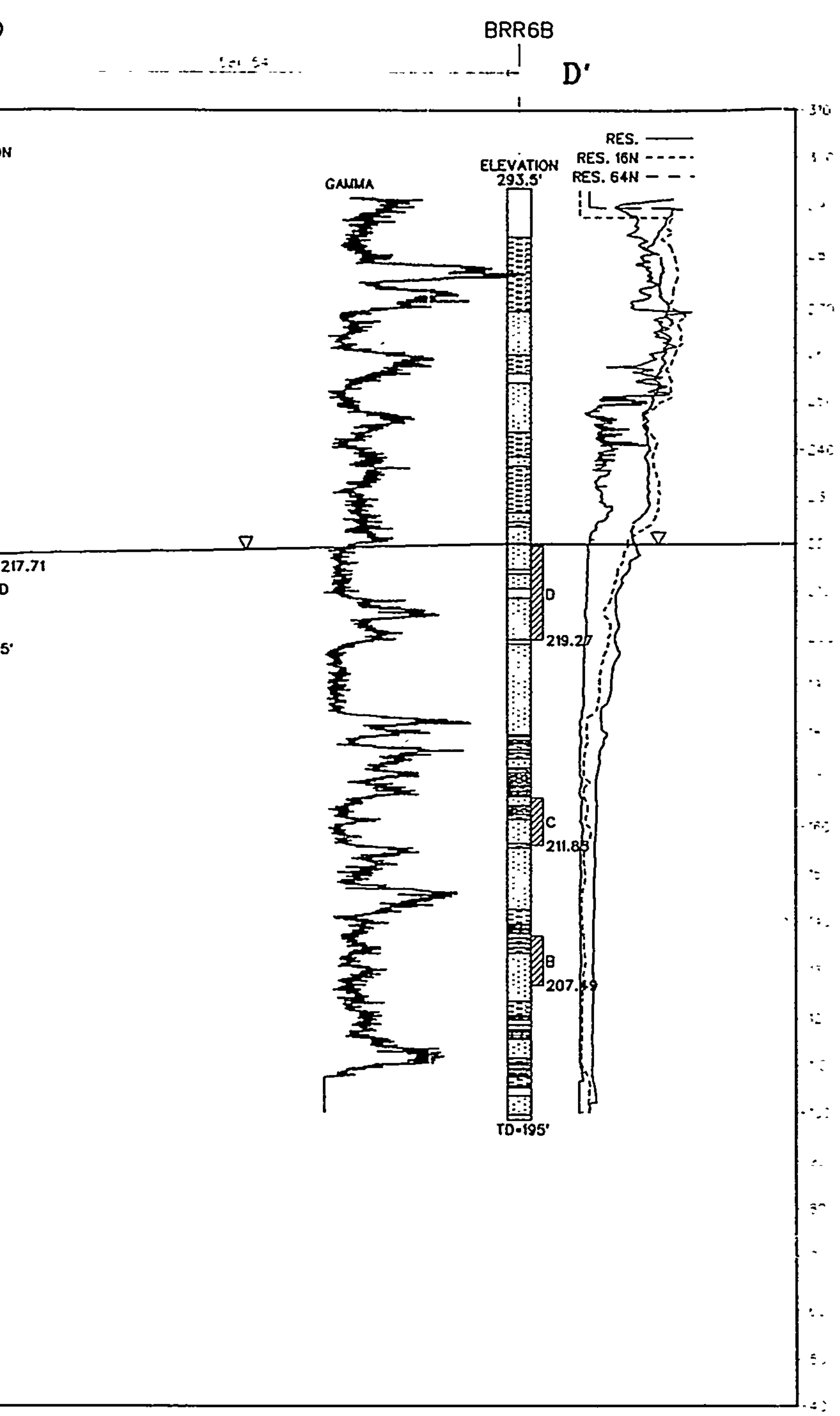
CREATED BY TRACY MICKLEY	DATE 6-20-95	APPROVED BY NA	DATE NA
PREPARED BY TOM MCADAMS	DATE 6-20-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE 4-49

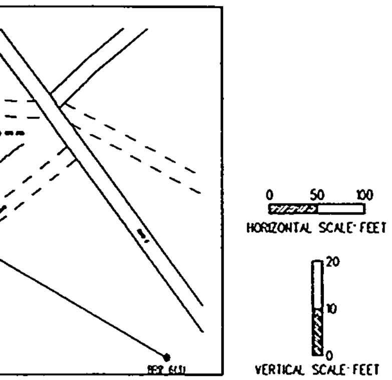
HYDROGEOLOGIC CROSS-SECTION FOR THE BURMA





ROAD RUBBLE PIT





LEGEND:

▨ CALCAREOUS SAND

▨ CALCAREOUS MUD

▨ CLAYEY SAND

▨ SAND

▨ GRAVEL/PEBBLES

▨ SILT/CLAY

▨ SANDY LIMESTONE

▨ LIMESTONE

▨ SANDY MUDDY LIMESTONE

▨ MUDDY LIMESTONE

▨ SANDY CLAY

☐ NO RECOVERY

—SAND PACK INTERVAL
—SCREENED INTERVAL

TD - TOTAL DEPTH
GSA - GENERAL SEPARATIONS AREA
DUI - DEPTH USED FOR INTERPRETATION
——— - CONFINING ZONE, UNIT AND SYSTEM BOUNDARIES.
∇ - WATER TABLE

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SRS — RESPONSIBILITY · SECURITY · SAFETY

ENVIRONMENTAL RESTORATION
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TITLE
FIGURE 4-18
HYDROGEOLOGIC
CROSS SECTION D-D'

	DATE	APPROVED BY	DATE
CREATED BY TRACY MICKLEY	6-20-95	NA	NA
PREPARED BY TOM MCADAMS	6-20-95	NA	NA
APPROVED BY NA	NA	NA	NA
APPROVED BY NA	NA	NA	4-53

Table 4-1 Burma Road Rubble Pit Estimated Groundwater Levels from Piezocone Investigation (November 1993)

Location	Groundwater Depth Below Surface (feet)
CPT-1	79.5
CPT-2	81.5
CPR-3	83.0
CPT-4	74.4
CPT-5	72.9
CPT-6	69.0*
CPT-7	63.5
CPT-8	61.5
CPT-9	82.0

* Because of the need for a drill rig auger at location CPT-6, data collected regarding the estimated groundwater level is suspect.

tributary to the Upper Three Runs Creek is located approximately 2,000 feet to the north. The BRRP Site ground surface elevation is approximately 290 feet MSL. Surface runoff is northwestward toward the tributary to the Upper Three Runs Creek.

Five monitoring wells were already in existence at the BRRP. Three three-well clusters were installed at the BRRP during this investigation. The wells, existing and new, are screened in different aquifers at the BRRP. The aquifers are the Water Table Aquifer which is located in the Upper Zone of the Upper Three Runs Aquifer and the upper and lower portions of the Lower Zone of the Upper Three Runs Aquifer. Table 4-2 shows the groundwater elevations for the different wells in the different aquifers.

The Upper Three Runs Aquifer is the shallow aquifer at the SRS. This aquifer is composed of sediments from the Tobacco Road, Dry Branch, and McBean Formation. The sediments of the Upper Three Runs Aquifer typically exhibit a wide variation in lithologic composition both vertically and laterally. The BRRP wells installed at the site during 1993 - 1994 are screened in the Upper Three Runs Creek Aquifer. The depth to water in the water table aquifer is approximately 61.0 feet to 83.0 feet below surface. **Figure 4-19** shows the potentiometric surface of this aquifer based on data collected from the Piezocone investigation and data from new and existing wells.

The prevalent groundwater flow direction for the water table aquifer is toward the west with deflections of flow toward the southwest and northwest. Water table groundwater flow direction was determined by using data from the piezocone, existing wells, and new well clusters BRR-6**D**, BRR-7**D**, and BRR-8**D**. These new monitoring wells were installed **above** the Tan Clay confining unit.

Water level data for the upper and lower portions of the Lower Zone of the Upper Three Runs Aquifer are **depicted on Figures 4-20 and 4-21. Figures 4-20 and 4-21 show the potentiometric surfaces of the upper and lower portions of the Lower Zone of the Upper Three Runs Aquifer based on the data collected from the recently installed wells (BRR 6, 7, and 8). These elevations generally demonstrate a similar flow direction (westerly) to the water table aquifer with a less steep gradient. These maps, Figure 4-20 and 4-21, have been constructed using only three points of control and as such depict the specific flow direction and magnitude only in the immediate area of the BRRP.**

Slug tests were performed in each of the nine monitoring wells to provide an estimate of hydraulic conductivity for the screened portions of the aquifer. Hydraulic conductivity test were performed on

Table 4-2 Burma Road Rubble Pit Groundwater Elevations

Aquifer[a]	Well Number[b]	Elevation (feet)[b]
D	BRR-1D	217.7
D	BRR-2D	216.27
D	BRR-3D	215.93
D	BRR-4D	215.6
D	BRR-5D	215.15
D	BRR-6D	219.27
D	BRR-7D	218.22
D	BRR-8DR	215.58
C	BRR-6C	211.85
C	BRR-7C	210.32
C	BRR-8C	209.05
B	BRR-6B	207.49
B	BRR-7BR	206.05
B	BRR-8B	204.68

a - "D" wells are screened in the Water Table Aquifer, Upper Zone of the Upper Three Runs Aquifer
"C" wells are screened in the upper portion of the Lower Zone of the Upper Three Runs Aquifer
"D" wells are screened in the lower portion of the Lower Zone of the Upper Three Runs Aquifer

b - The information was acquired during Second Quarter 1994 (04/17/94 & 04/18/94)

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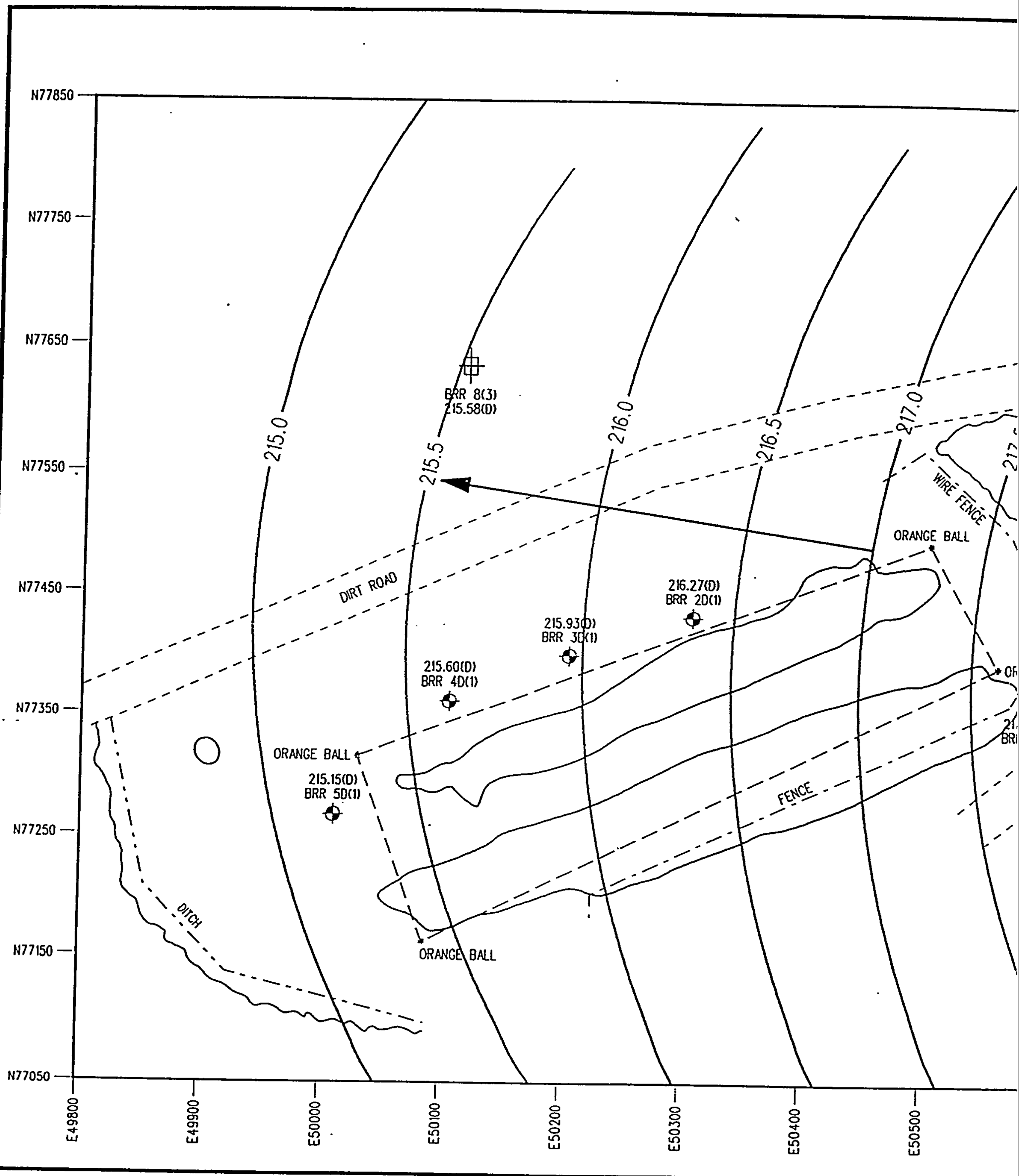
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N77150
N77050
E49800
E49900
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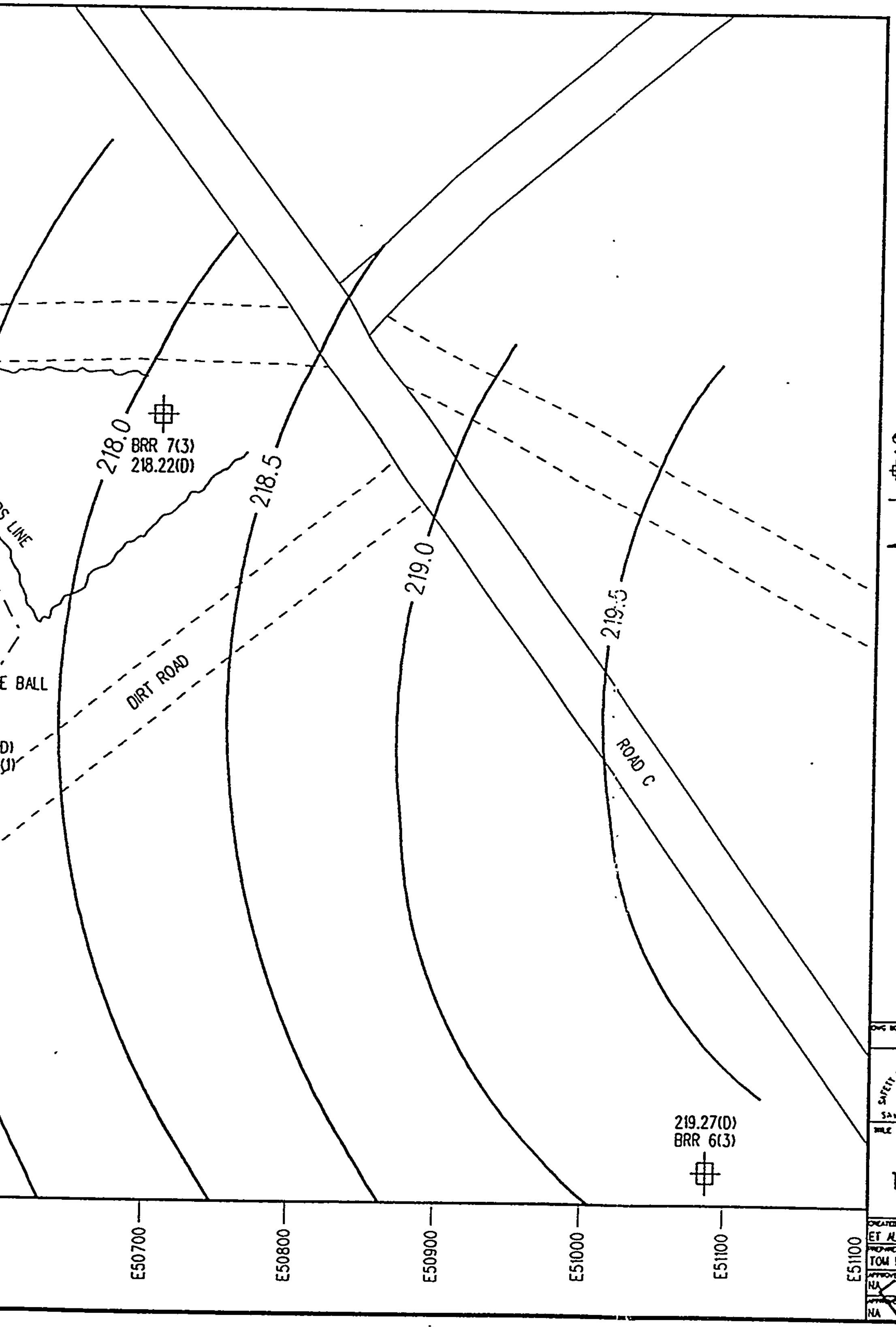
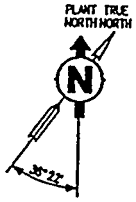
E50200
E50300
E50400
E50500
215.0
215.5
216.0
216.5
217.0
BRR 8(3)
215.58(D)
DIRT ROAD
WIRE FENCE
ORANGE BALL
216.27(D)
BRR 2D(1)
215.93(D)
BRR 3D(1)
215.60(D)
BRR 4D(1)
ORANGE BALL
215.15(D)
BRR 5D(1)
FENCE
DITCH
ORANGE BALL





NOTES

DATA ACQUIRED 2Q94 (4-17-94 AND 4-18-94)

LEGEND

- ⊗ EXISTING WELL LOCATION (APPROXIMATE)
- ⌖ NEW WELL LOCATION
- ——— APPROXIMATE LOCATION OF SUSPECTED PIT BOUNDARIES
- ◀—— GROUNDWATER FLOW DIRECTION

0 50 100

SCALE: FEET

DWG NO. GS1310	REV. NO. 0	REV. DATE 6-18-95	AREA GSA

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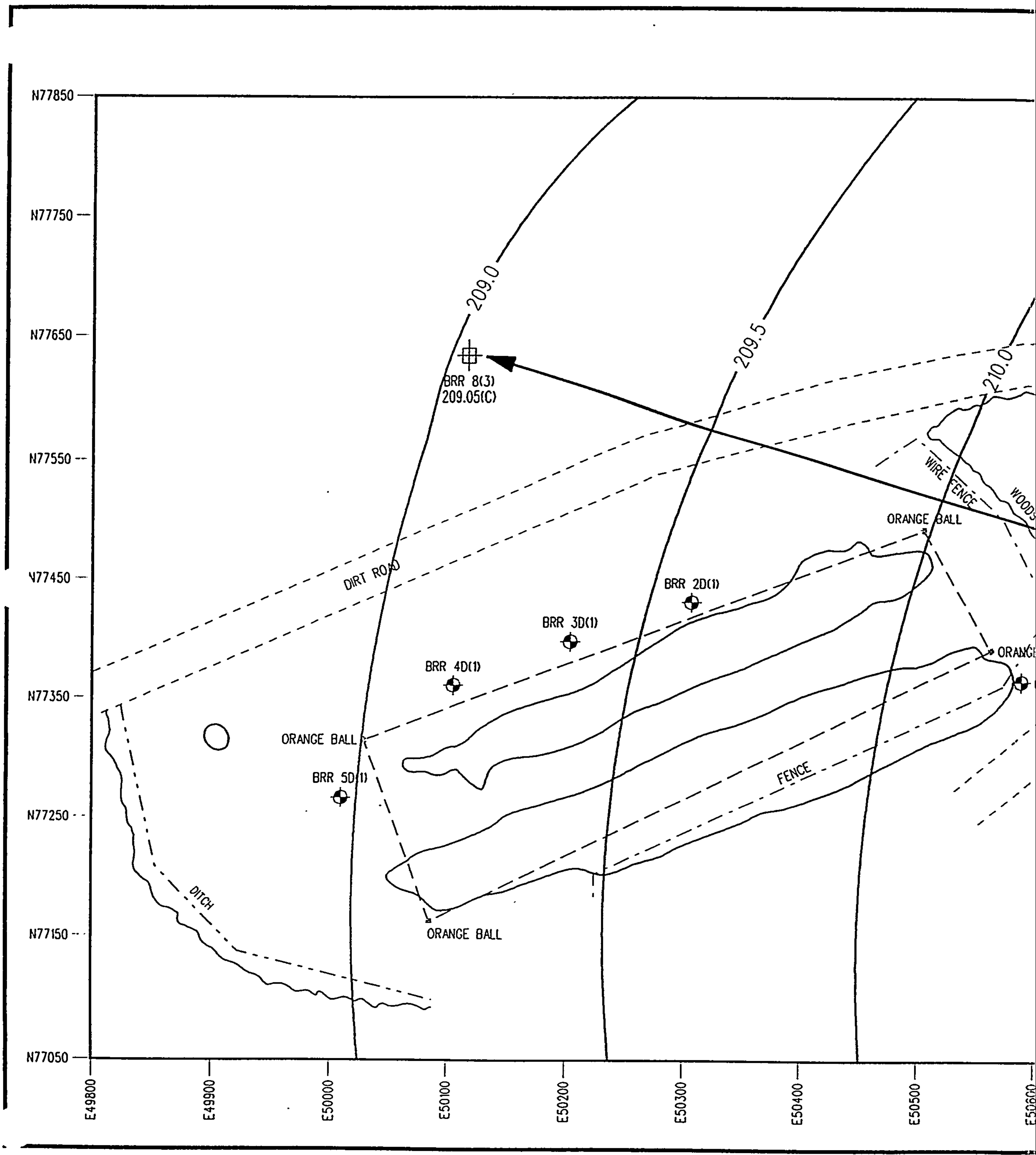
TITLE

POTENTIOMETRIC SURFACE UPPER ZONE OF THE UPPER THREE RUNS AQUIFER (WATER TABLE) BURMA ROAD RUBBLE PIT

CREATED BY ET ALEXANDER	DATE 6-18-95	APPROVED BY NA	DATE NA
PROVIDED BY TOM MCADAMS	DATE 6-18-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA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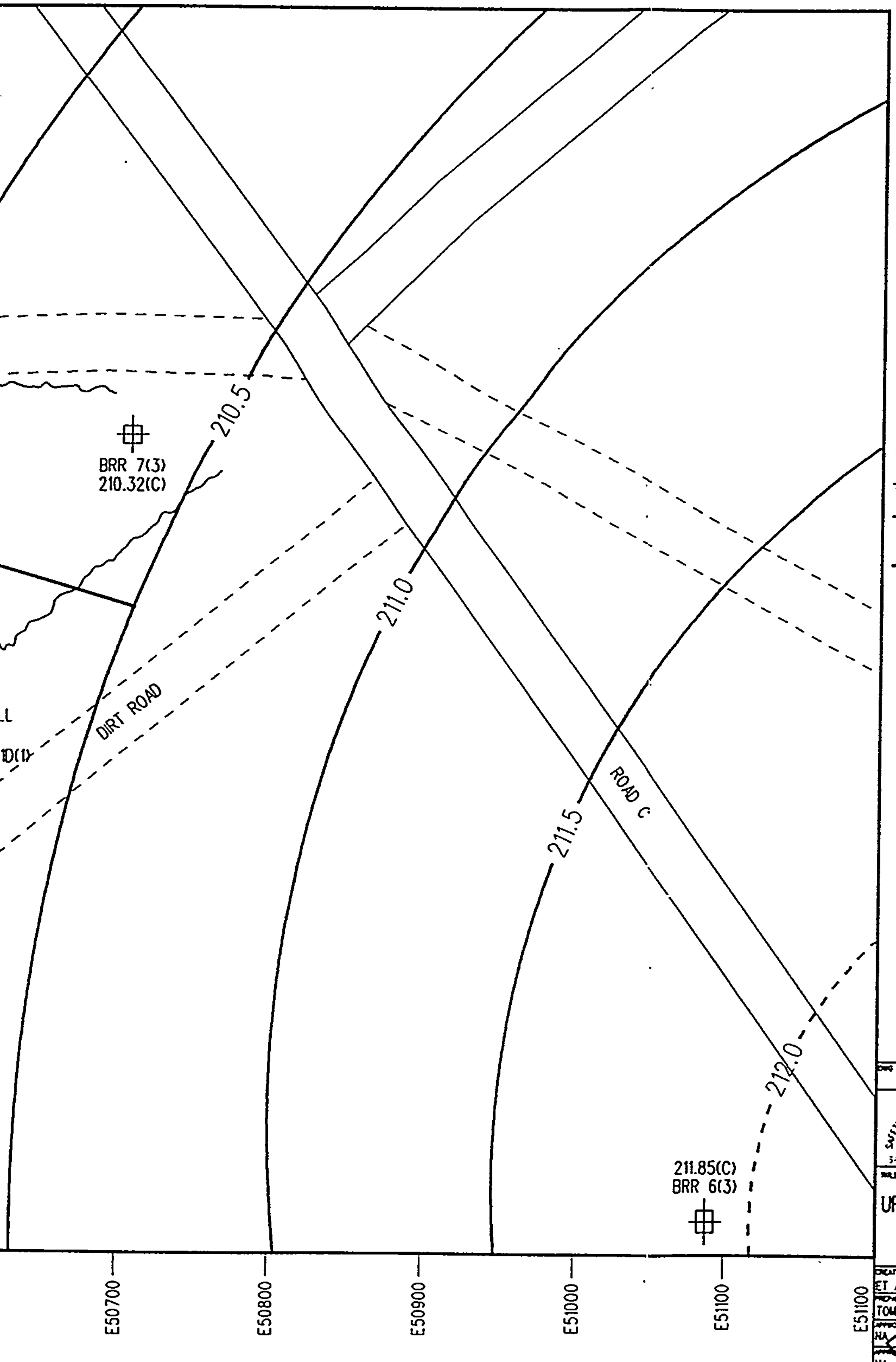
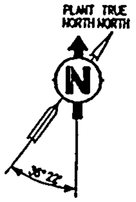
BRR 8(3)
209.05(C)
DIRT ROAD
WIRE FENCE
ORANGE BALL
BRR 2D(1)
BRR 3D(1)
BRR 4D(1)
ORANGE BALL
BRR 5D(1)
FENCE
DITCH
ORANGE BALL





NOTES

DATA ACQUIRED 2Q94 (4-17-94)

LEGEND

- ⊗ EXISTING WELL LOCATION (APPROXIMATE)
- ⌖ NEW WELL LOCATION
- —— APPROXIMATE LOCATION OF SUSPECTED PIT BOUNDARIES
- ←— GROUNDWATER FLOW DIRECTION

0 50 100

SCALE: FEET

DWG NO.	REV. NO.	REV. DATE	AREA
GS1811	0	6-18-95	GSA

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TITLE
POTENTIOMETRIC SURFACE
UPPER PORTION OF LOWER ZONE OF THE
UPPER THREE RUNS AQUIFER (IIB)
BURMA ROAD RUBBLE PIT

CREATED BY ET ALEXANDER	DATE 6-18-95	APPROVED BY NA	DATE NA
REVIEWED BY TOM MCADAMS	DATE 6-18-95	APPROVED BY NA	DATE NA
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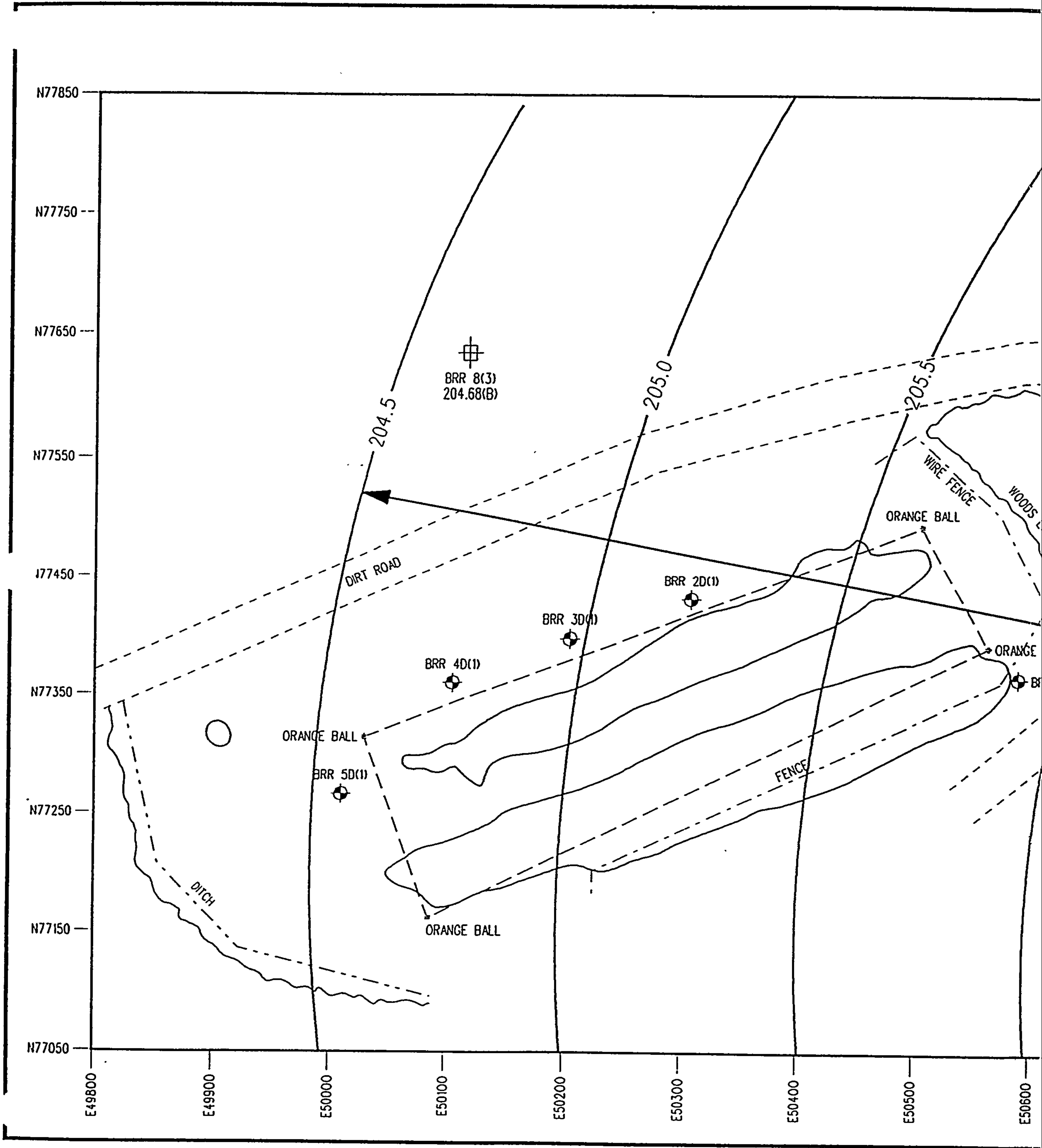
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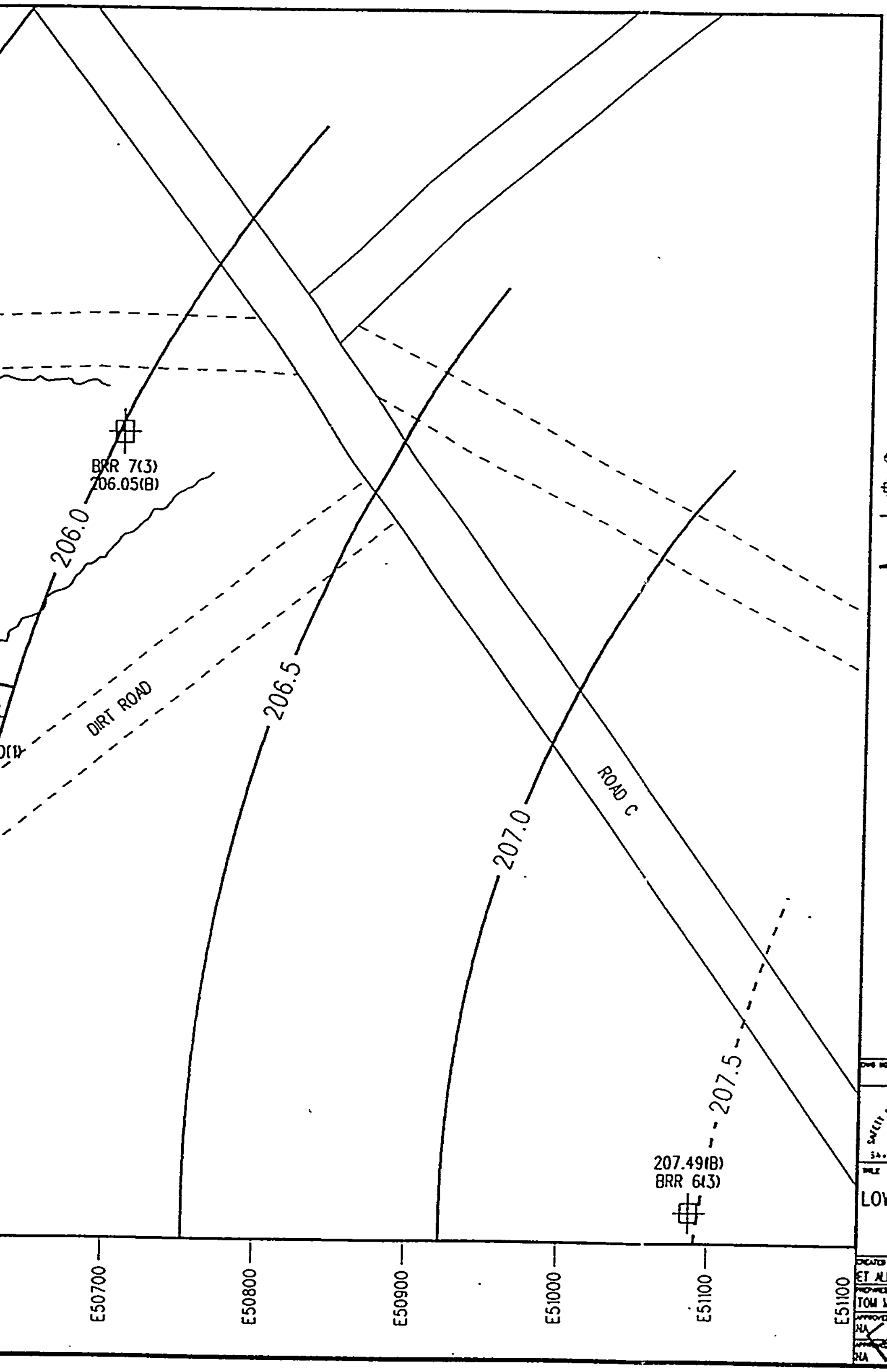
E50200
E50300
E50400
E50500
E50600
204.5
205.0
205.5
BRR 8(3)
204.68(B)
DIRT ROAD
WIRE FENCE
WOODS
ORANGE BALL
BRR 2D(1)
BRR 3D(1)
BRR 4D(1)
ORANGE BALL
BRR 5D(1)
ORANGE BALL
ORANGE
FENCE
DITCH



NOTES

DATA ACQUIRED 2094 (4-17-94)

LEGEND

- ⊗ EXISTING WELL LOCATION (APPROXIMATE)
- ⌖ NEW WELL LOCATION
- ——— APPROXIMATE LOCATION OF SUSPECTED PIT BOUNDARIES
- ←—— GROUNDWATER FLOW DIRECTION

0 50 100

SCALE: FEET

DWG NO.	REV. NO.	REV. DATE	AREA
GS1812	0	6-18-95	GSA

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TITLE
POTENTIOMETRIC SURFACE
LOWER PORTION OF LOWER ZONE OF THE
UPPER THREE RUNS AQUIFER (IIB)
BURMA ROAD RUBBLE PIT

CREATED BY ET ALEXANDER	DATE 6-18-95	APPROVED BY NA	DATE NA
REVIEWED BY TOM MCADAMS	DATE 6-18-95	APPROVED BY NA	DATE NA
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APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA

all nine monitoring wells. The hydraulic conductivity for the shallow "D" wells ranged from 7.2 x 10^{-3} ft/min (BRR-8D) to 1.94 x 10^{-5} ft/min (BRR-7D). The hydraulic conductivity for the intermediate "C" wells ranged from 7.40 x 10^{-5} ft/min (BRR-7C) to 1.54 x 10^{-4} ft/min (BRR-6C) and 2.53 x 10^{-4} ft/min (BRR-8C). The hydraulic conductivity for the deep "B" wells ranged from 1.24 x 10^{-4} ft/min (BRR-6B), 2.54 x 10^{-4} ft/min (BRR-7B) to 1.72 x 10^{-3} ft/min (BRR-8B). Freeze and Cherry (1979) indicate that the hydraulic conductivity ranges of the monitoring wells equal those of a silty sand or a silt/loess.

4.3.3 *Cone Penetrometer*

A piezocone and hydrocone investigation was conducted at the BRRP Site. The objectives of the cone penetrometer investigation were to characterize the subsurface lithology, to collect groundwater samples using a direct push technology, and to provide water table elevation data to aid in the location of a downgradient well cluster.

Nine piezocone soundings (PC-1 through PC-9) were performed to depths ranging from 61 feet to 97 feet below grade. The location of these soundings are shown in **Figure 4-22.**

A general discussion of the piezocone logs and the interpretation of these logs follows. The sounding of the logs and the soil classifications for each piezocone location are presented in Appendix G. Graphs are referenced from left to right with the graph to the extreme left being number one. The first two graphs labeled "Point" present the resistance to penetration of the point as the instrument is advanced into the soil. This value is used to determine both soil type (when compared with local friction) and soil strength. Note the first two graphs are the same with the exception of the plotting scale.

The third graph labeled "Sleeve" displays the sliding friction between the soil and the sleeve. This value is used in ratio with the point stress (location friction/point-stresses) to produce the fifth graph "Friction Ratio". This ratio is the major indicator of soil type. As the friction ratio rises, the soil changes from a coarse grained material and sand to fine grained silts and clays.

The fourth graph labeled "Pore Water" presents the measured pore pressures as the piezocone is advanced. There are two components of this measurement. The first is the total hydrostatic pressure which starts at the groundwater surface and rises as the instrument is advanced. The second is the pore pressure generated as the soil mass deforms due to the complex shearing processes produced

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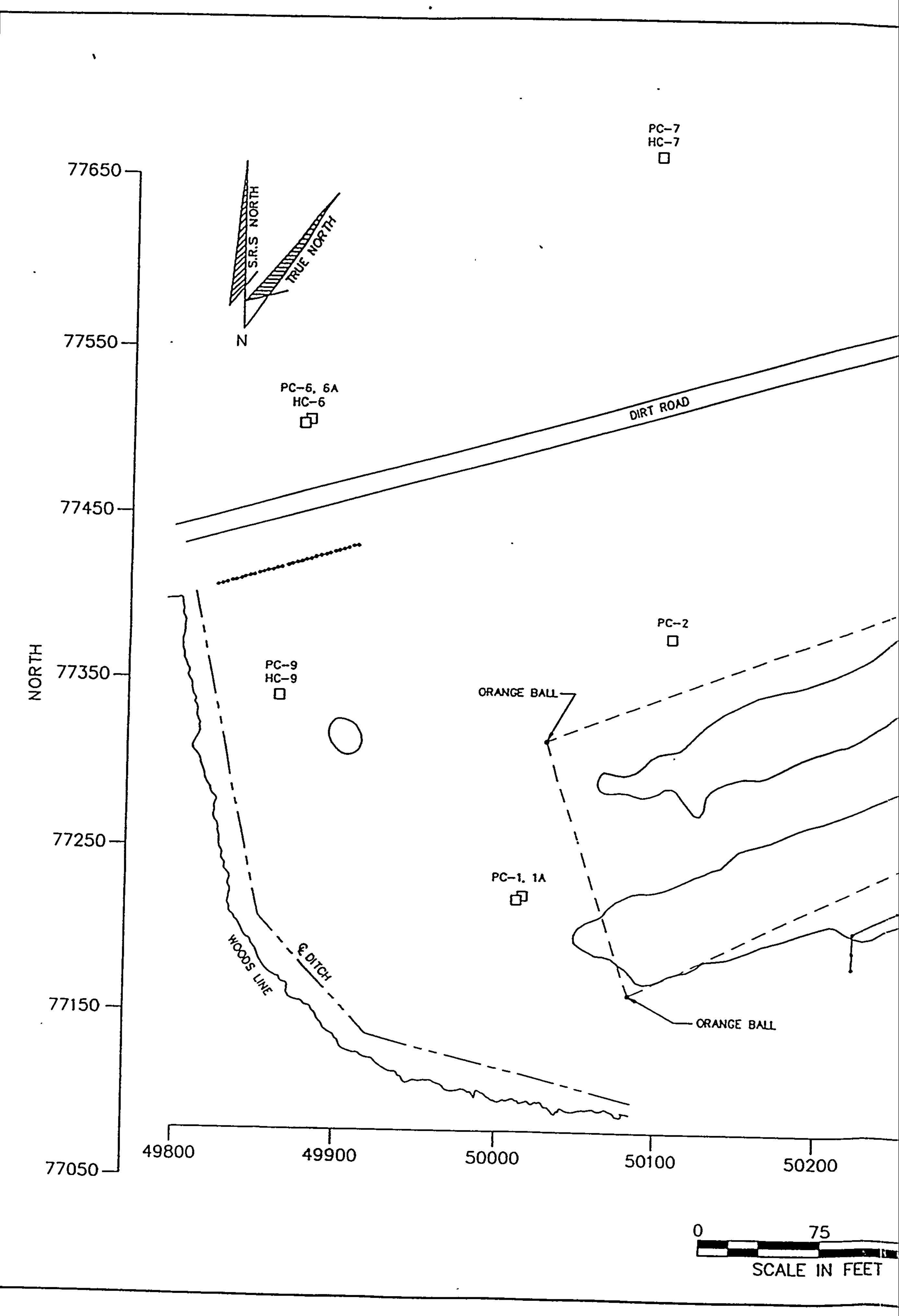

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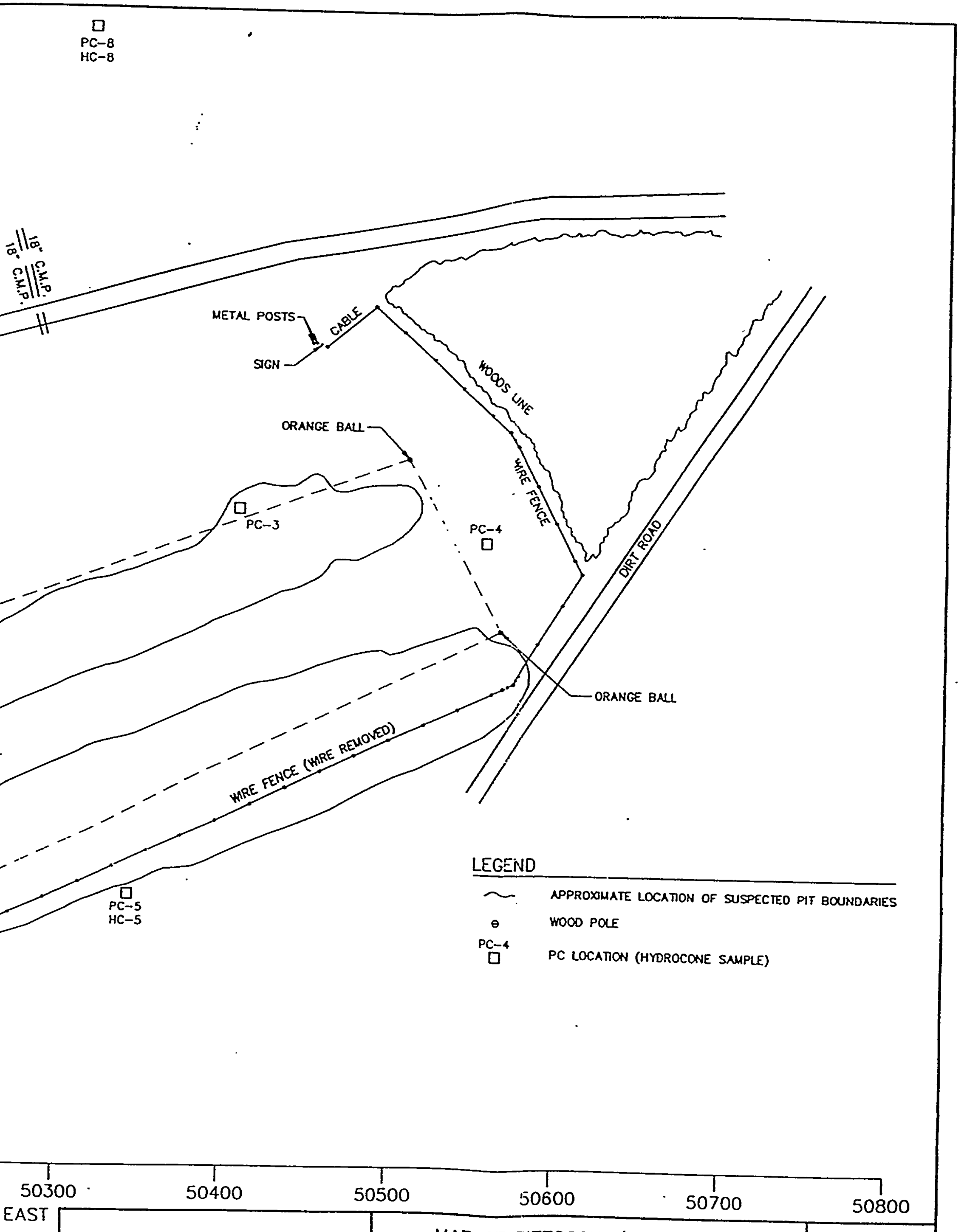

METCALF & EDDY

MAP OF PIEZOCONE/HYDROCONE LOCATIONS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
4-22

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during the dynamic testing. The total pore pressures are the sum of the components. When penetration is halted, the generated pore pressure will dissipate or "decay" back to static equilibrium. This pore pressure decay, when taken as a function of time, has been shown to be proportional to the coefficient of consolidation and thus soil permeability. Following full dissipation of excess pore pressures, a static value will be reached which represents the static piezometric pressure at that depth. Multi-color plots of the pore pressure decay as a function of time can also be generated and be used in estimating groundwater levels. The sixth graph labeled "A Factor" is the ratio of generated pore pressure (hydrostatic subtracted) to point stress (excess pore pressure/point stress). This ratio presents the amount of pore pressure generated relative to the total point stress generated. In general, increases in this parameter indicates soils that are finer grained and more poorly drained.

These soundings generally indicated that the soils surrounding the BRRP Site are mostly fine sand and silty fine sand with occasional lenses of clayey sands and cemented sands.

4.3.4 *Hydrocone Results*

Five hydrocone groundwater samples (HC-5 through HC-9) were collected from the top of the water table aquifer. These samples were collected at depths ranging from 67 feet to 87 feet. Due to the volume of groundwater required to fill the sample containers (4.5 liters), it was necessary to push the hydrocone to the prescribed sampling depth four times at each location. An estimated K-value was determined each time the Hydrocone sampler was filled. At location CPT-6, data for only the first trip down the hole could be collected and only one K-value plot could be generated; however, the K-value derived from this plot is suspect. Plots of the collected Hydrocone data are presented in Appendix H. Each Hydrocone plot consists of three graphs and an estimated hydraulic conductivity. A description of these graphs and what they represent as well as an explanation of how the hydraulic conductivity is calculated is presented below.

The upper left graph presents the volume of water in the GS-1 as a function of time on an arithmetic scale. This graph shows the filling sequence, the full sampler being retrieved to the surface, and the water sample being decanted from the sampler to the sample vials.

The lower graph shows the argon gas pressure, converted to feet of water, within the GS-1 as a function of time. The graph illustrates the initial application of high gas pressure needed to open the telescopic tip, the venting of the gas pressure to a level below that of natural hydrostatic pressure while the sample fills, the raising of the gas pressure to a level greater than hydrostatic to stop the in-flow of water and allow for the retrieval of the samples and the venting of the gas pressure to allow for decanting of the sample.

The upper right graph also presents the volume of water in the GS-1 as a function of time, but on a semi-log scale. This graph is used to determine the time parameters for estimating the soil's horizontal permeability. By observing this graph, the computer operator will choose the upper and lower time parameters based on the straight line portion of the rate of filling curve. The computer operator will then input these points. The computer will apply these data points to standard rate of rising slug test model (Bouwer and Rice, 1976) to determine the soil's horizontal permeability. The actual formula used reduces to:

$$K = [(3.14\ r^2h)A\_P] * \{1/((T_f - T_o)*60]*Log[ABS(Y_o/Y_f)]$$

Where:

A_P = a correction factor based on the ratio of effective radial distance over which the head difference Y is dissipated and the radial distance between the screen center and the undisturbed aquifer.

T_f = Time Final

T_o = Time Initial

Y = Head Difference

Y_f = Y at T_f (taking into account any argon back pressure)

Y_o = Y at T_o (taking into account any argon back pressure)

The following **Table 4-3** summarizes the estimated hydraulic conductivities determined at each hydrocone location.

4.3.4.1 Unusual and Nonspecification Activities

The piezocone soundings at two locations, PC-1 and PC-6, were not able to penetrate a layer of cemented sands encountered in the subsurface. In these two instances, an augering system was utilized to open a pilot hole through the cemented areas and then pushing with the piezocone was continued. This method was successful at location PC-1. However, at location PC-6, the augers were lost in the hole and could not be retrieved. **The coordinates of the borehole containing the augers were determined by land survey and the location was marked with a wooden stake.** A drill rig was used to open a pilot hole.

Table 4-3 Burma Road Rubble Pit Estimated K-Values from Hydrocone Investigation (November 1993)

Location	Depth (feet)	K-Value (cm/sec)	Average K (cm/sec)	Sample Number
CPT-5	84	7.469479E-04	6.31E-4	HC-5
	84	7.431055E-04		HC-5A
	84	4.021419E-04		HC-5B
	84	6.70625E-04		HC-5C
CPT-6*	70	3.017088E-03	3.02E-3	HC-6
CPT-7	67	1.638835E-03	3.27E-3	HC-7
	67	2.444732E-03		HC-7A
	67	3.430727E-03		HC-7B
	67	3.630977E-03		HC-7C
CPT-8	67	3.928688E-03	7.69E-3	HC-8
	67	8.654999E-03		HC-8A
	67	5.593407E-03		HC-8B
	67	1.074239E-02		HC-8C
CPT-9	87	5.750754E-03	6.76E-3	HC-9
	87	5.750754E-03		HC-9A
	87	7.759688E-03		HC-9B
	87	7.759688E-03		HC-9C

* Because of the need for a drill rig auger at location CPT-6, data collected regarding the estimated groundwater level is suspect.

CPT-5 was moved from location shown in RFI/RI Work Plan (with approval from SCDHEC) because the geophysical data showed original location to be within the pit boundaries.

The rate at which the Hydrocone filled at location CPT-6 was collected for the first trip down the hole, and therefore, only one K-value plot was generated; however, the K-value derived from this plot is suspect. An explanation of the sample collection procedures that occurred at CPT-6 is provided below.

The hollow stem augers use to pre-drill the hole were advanced to a depth of approximately 70 - 71 feet. The Hydrocone was advanced inside the augers to a depth of 68.5 feet. the Hydrocone was pushed into soils which had entered the augers. These soils compacted and made pushing difficult. On the first sampling attempt, water rushed into the Hydrocone and shorted the electronic circuits. The K-value obtained from this attempt is suspect because the Hydrocone was inside the augers and the soils around the Hydrocone were not characteristic of the conditions in the undisturbed aquifer. On subsequent attempts, the remaining water needed for analysis was collected using the Hydrocone with the argon pressure to open the tip and to seal it as the water sample was retrieved; however, the electronics were not operable and a K-value could not be obtained.

4.3.5 *Soil Sampling*

Soil sampling was completed in five stages. Surface and subsurface soil sampling began on December 15, 1993 and was completed on January 11, 1994. Surface and subsurface soil sampling was conducted in the areas of suspected contamination (i.e., the borings were located in areas where a soil gas anomaly was detected or adjacent to potential underground objects and/or areas of high metal concentrations as indicated by anomalies in the GPR, EM, or magnetometer surveys). Background soil samples were collected on January 17 and 18, 1994. The purpose of the background samples was to gather data for statistical and comparative analyses against samples collected in the areas suspected of containing hazardous waste. During December 13, 15, and 16, 1993, two boreholes were drilled adjacent to the rubble pits to obtain geotechnical data for engineering assessment and design. These data will be useful in remediation planning for the unit, if necessary. On February 22, 1994, two surface water samples and one sediment sample were collected from a pond in the borrow pit adjacent to the BRRP Site. These samples were collected to determine if the BRRP Site has impacted the quality of the water and sediment in the adjacent borrow pit. Surface runoff soil (sediment) samples were collected on December 28, 1993. The results will be used to determine if runoff from the unit has carried contamination to off site areas. The following illustrates the number of samples collected during each stage.

• Soil Sampling	BRRP 1 through BRRP 17
• Subsurface and Surface Background Samples	BRS-1 (BR-03-01), BRS-4 (BR-02-01), BRS-5 (BR-01-01), SBK-2 (BR-08-01), BR-07-01 (surface), SBK-1 (BR-04-01) (subsurface)
• Surface Runoff Sediment Samples	BRR-5 (BR-05-01), BRR-6 (BR-06-01)
• Geotechnical Borings	BRS-6, BRS-2

In-pit boring locations are illustrated in **Figure 4-23**; out-of-pit surface, subsurface, and background sampling locations are illustrated in **Figure 4-24**; surface water, sediment, and surface run-off sampling locations are illustrated in **Figure 4-25**; and geotechnical boring locations are illustrated in **Figure 4-26**.

The seventeen soil borings were located utilizing data obtained frome geotechnical investigative devices and the soil gas survey results. The contents of the pits and anomalous OVA readings were noted as drilling/augering proceeded through the pit and only inert material (i.e., wood, trash, wire, metal, bottles, concrete, gravel, etc.) was encountered. A detailed description of the characterization of the source material is located in Section 4.4.

4.3.5.1 Unusual and Nonspecification Activities

The headspace procedure used during this project contained a slight deviation from WSRC 3Q5. WSRC 3Q5 indicates that the sample should be placed in a plastic bag, not a glass jar. Field experience has demonstrated that an empty plastic bag can give a reading as high an 10 ppm on the OVA; thus, after consultation and agreement from the **Subcontract Technical Representative (STR)** a glass jar was utilized instead of a plastic bag. **The use of a glass jar, instead of a plastic bag, ensures that the values obtained in this investigation are valid screening data. The glass jar accomodates environmental factors (i.e., wind, rain, etc.) as well as eliminating inherent organic**

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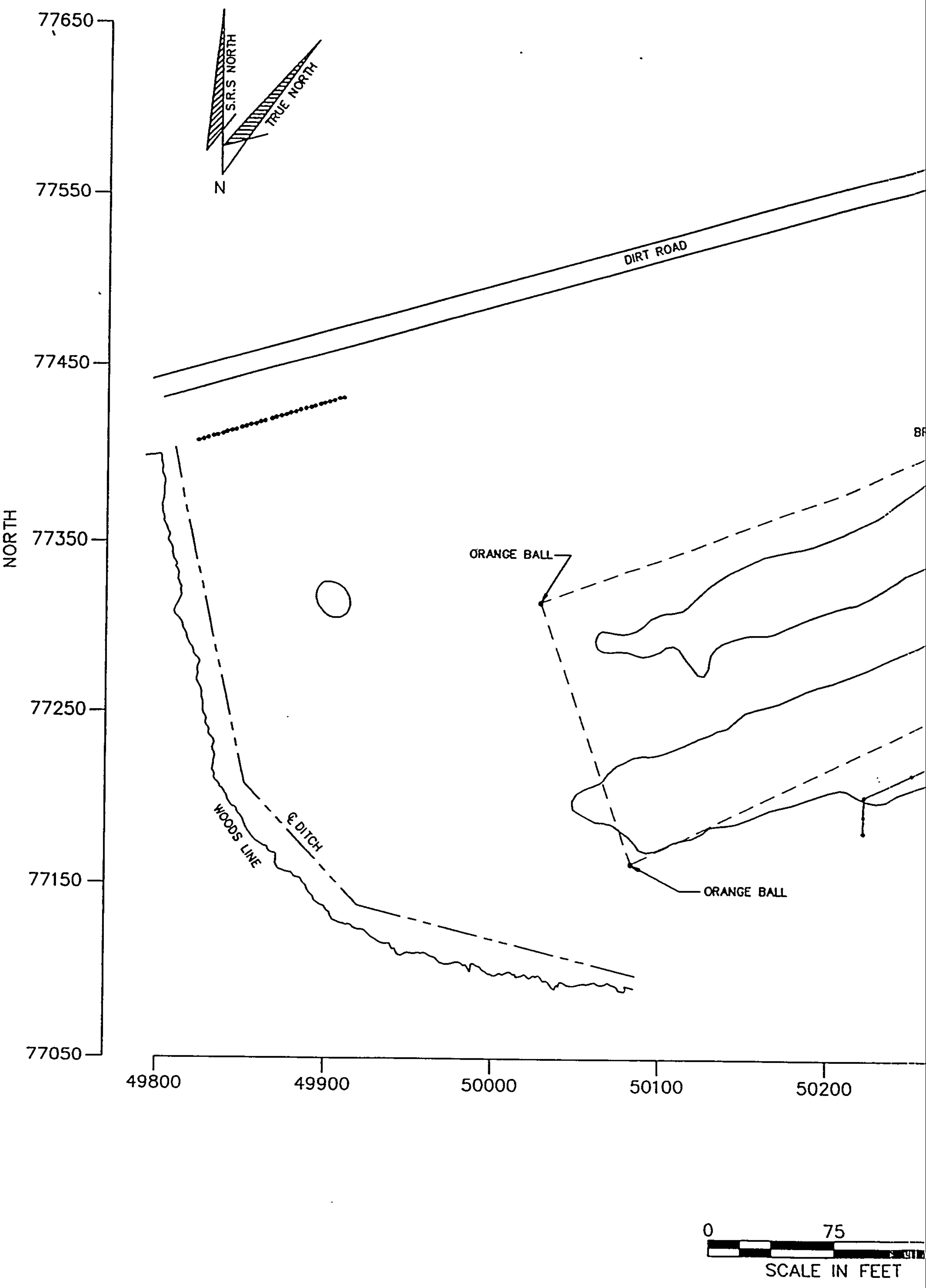

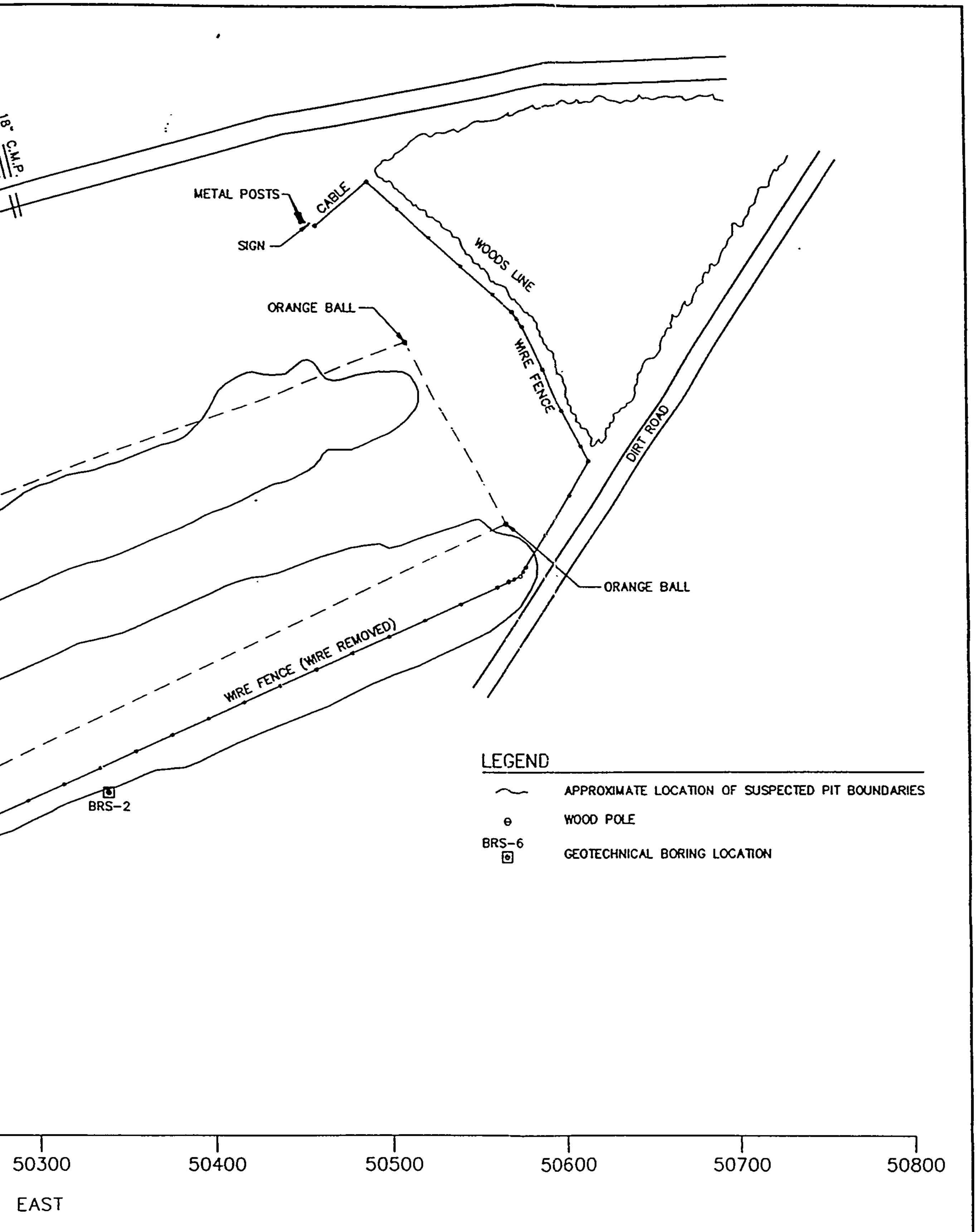

METCALF & EDDY

LOCATIONS OF GEOTECHNICAL BORINGS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE 4–23

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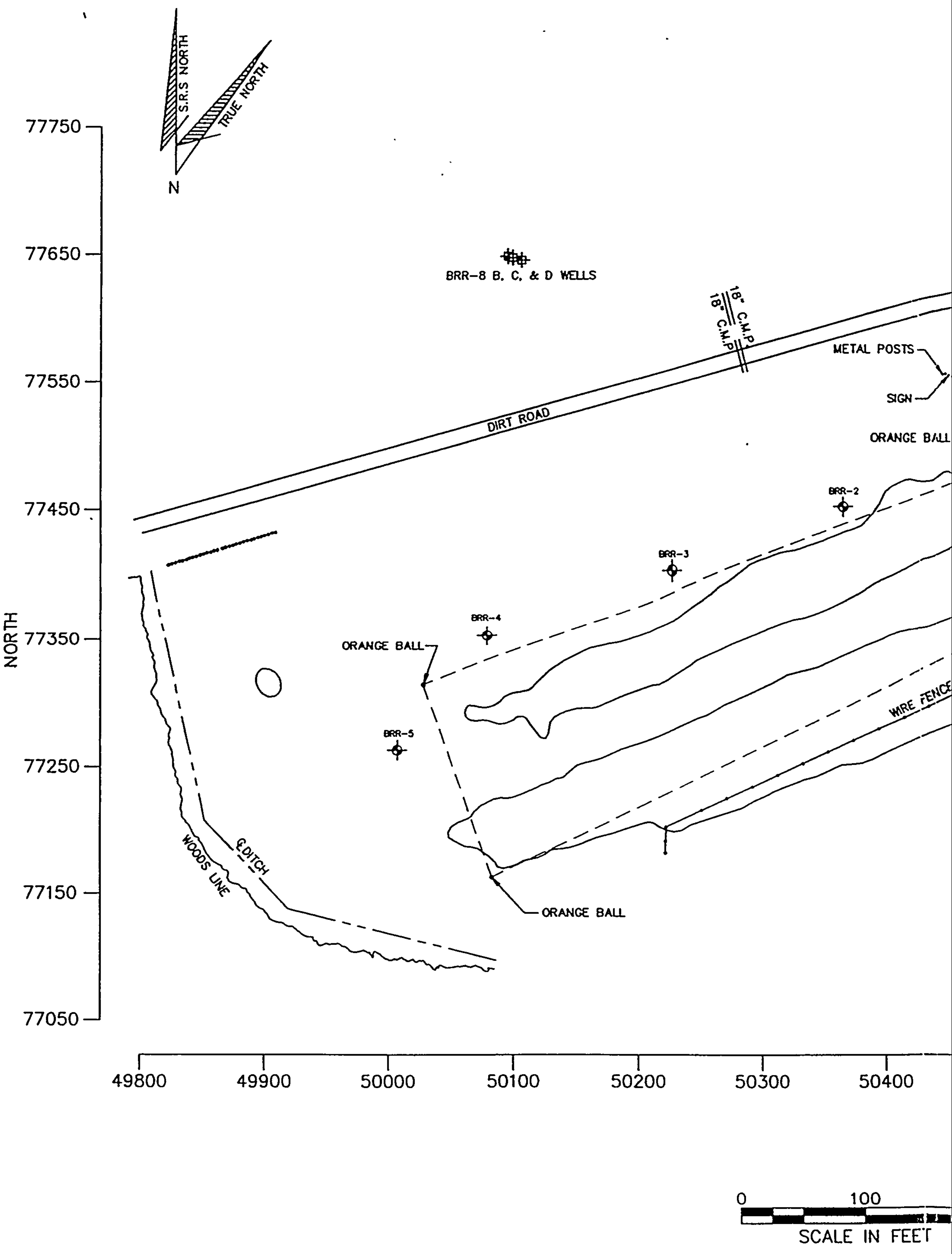
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TRUE NORTH
N
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77650
77550
77450
77350
77250
77150
77050
NORTH
BRR-8 B, C, & D WELLS
18" C.M.P.
18" C.M.P.
METAL POSTS
SIGN
ORANGE BALL
DIRT ROAD
BRR-2
BRR-3
BRR-4
BRR-5
ORANGE BALL
WIRE FENCE
ORANGE BALL
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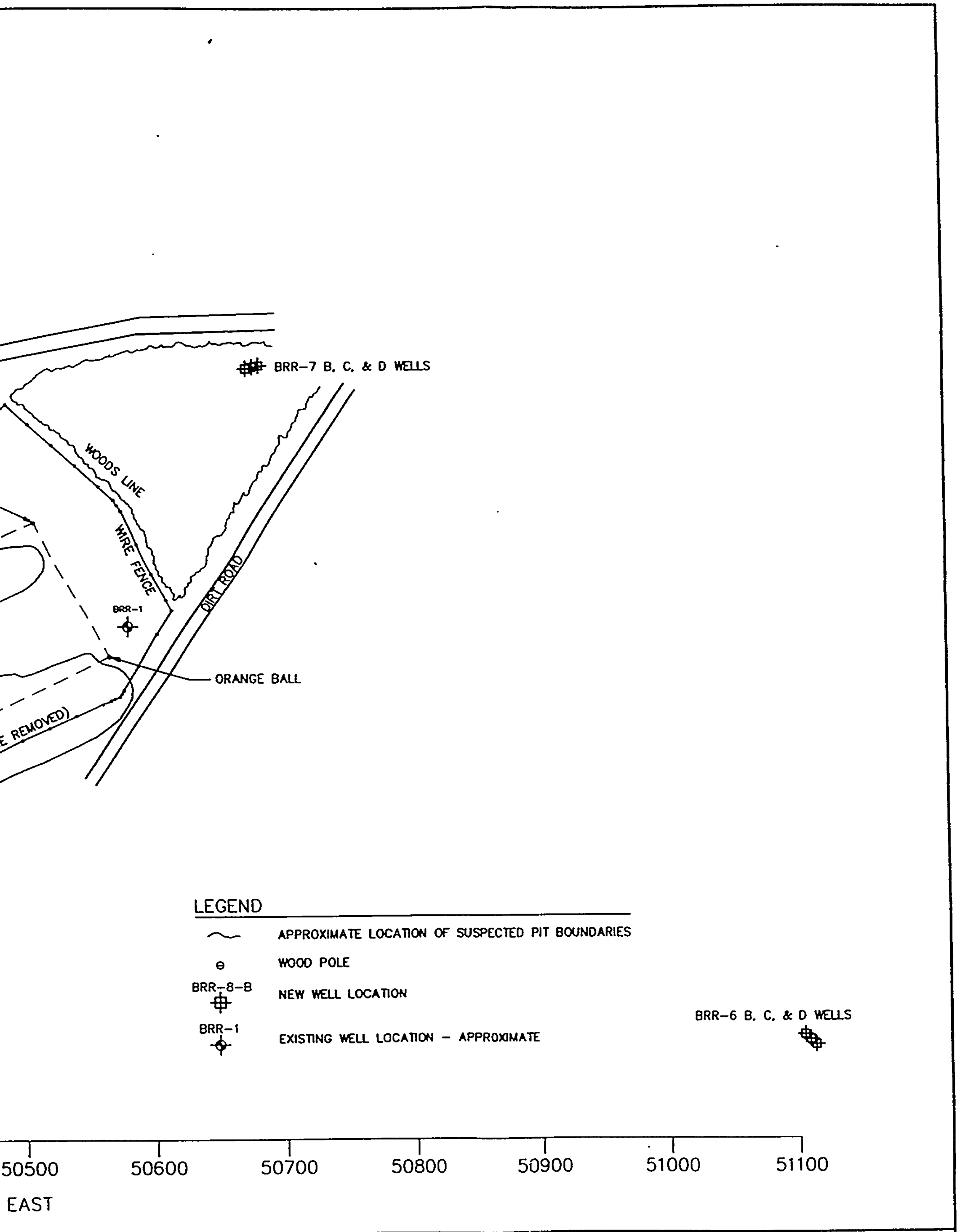

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LOCATION OF EXISTING WELLS
AND NEWLY INSTALLED WELL CLUSTERS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
4-24

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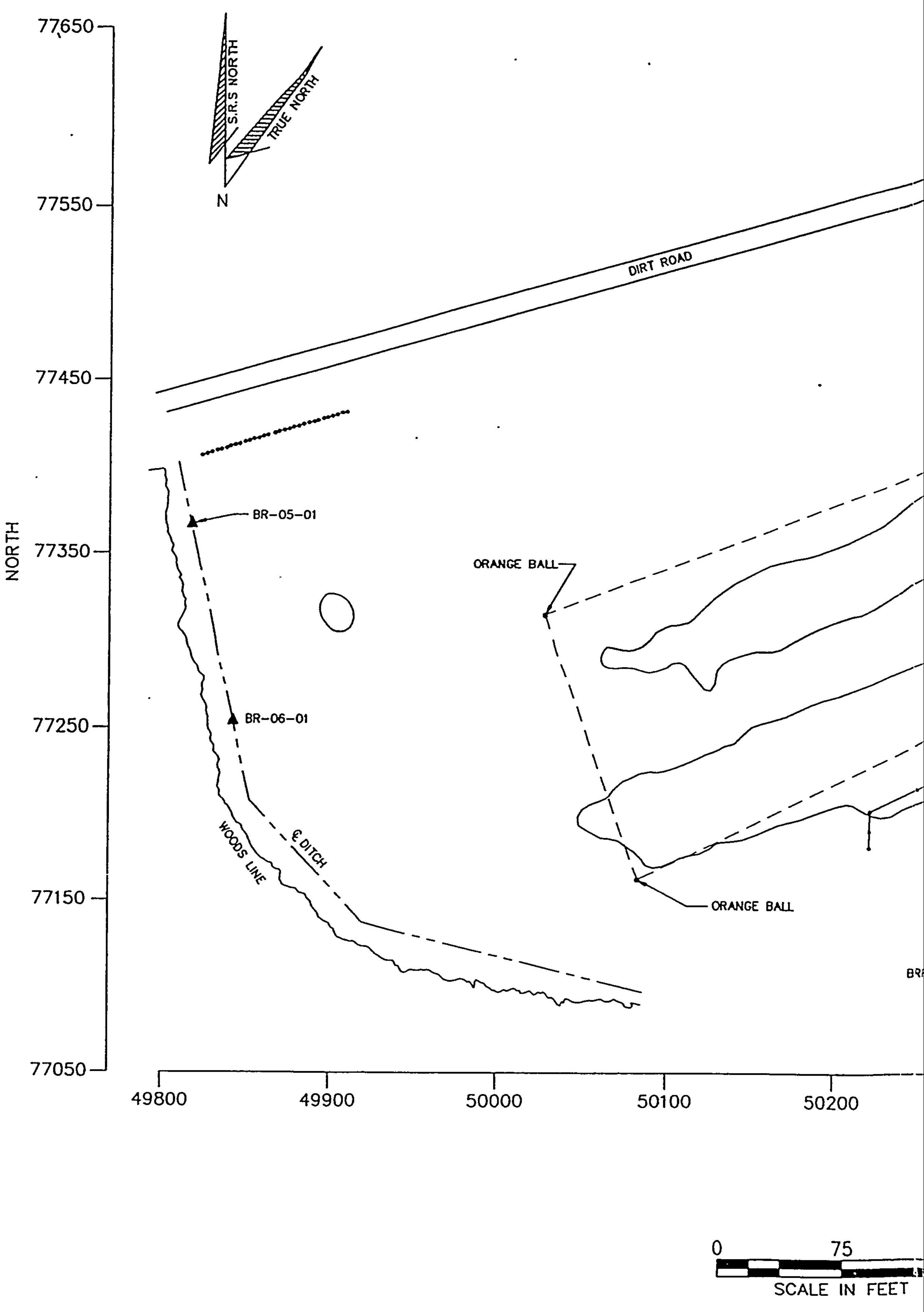

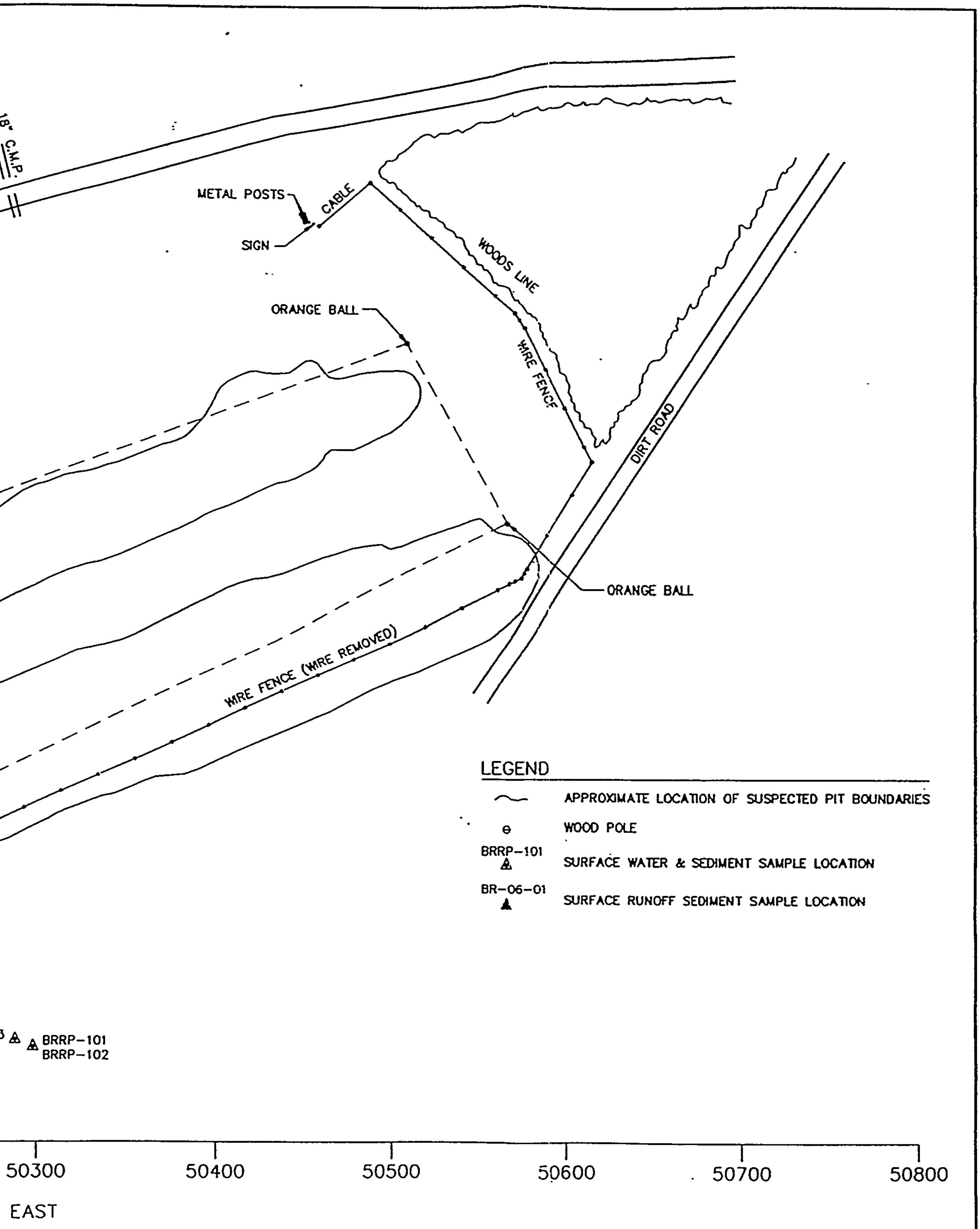

METCALF & EDDY

LOCATIONS OF SURFACE WATER AND
SEDIMENT SAMPLES

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
4-25

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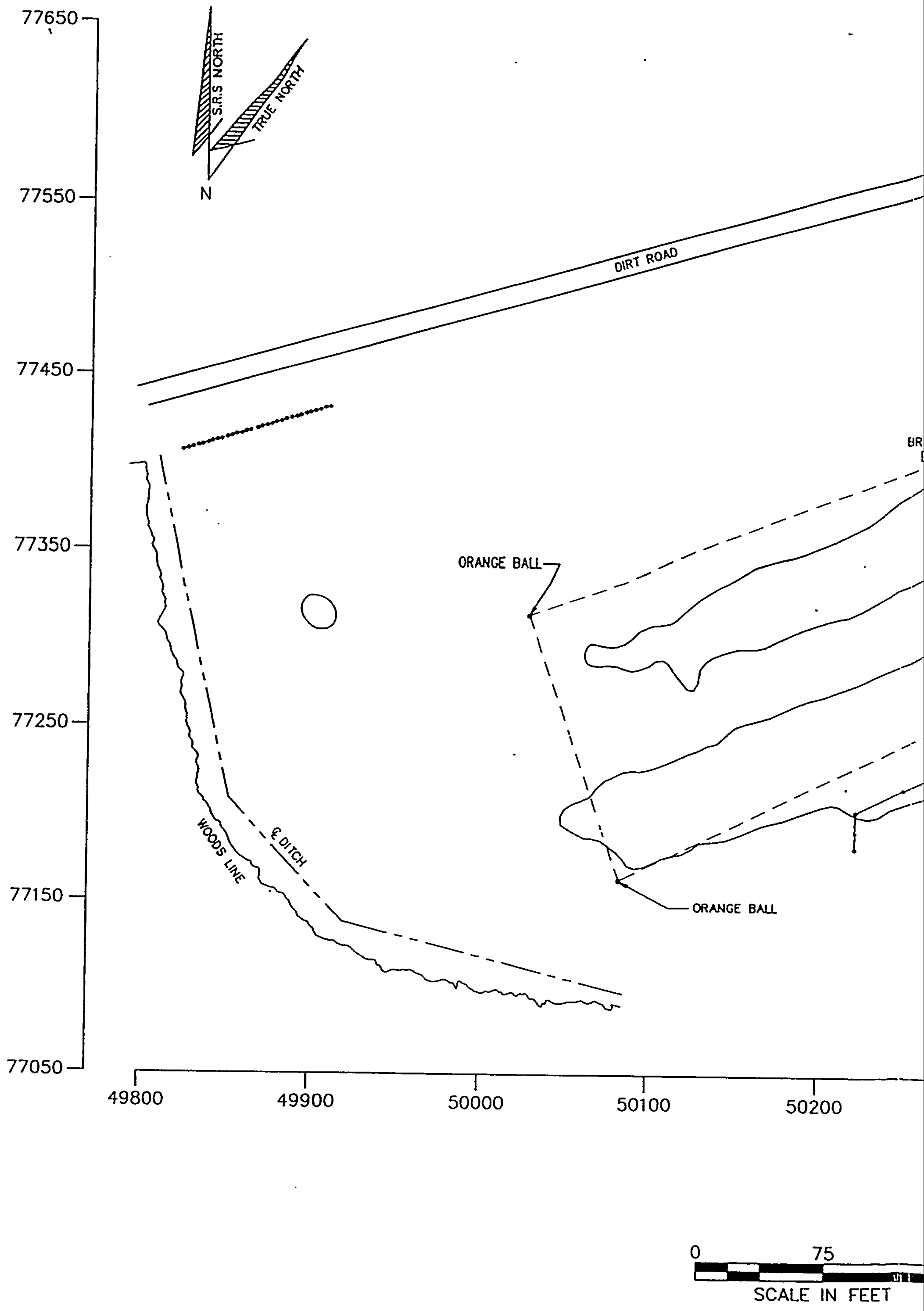

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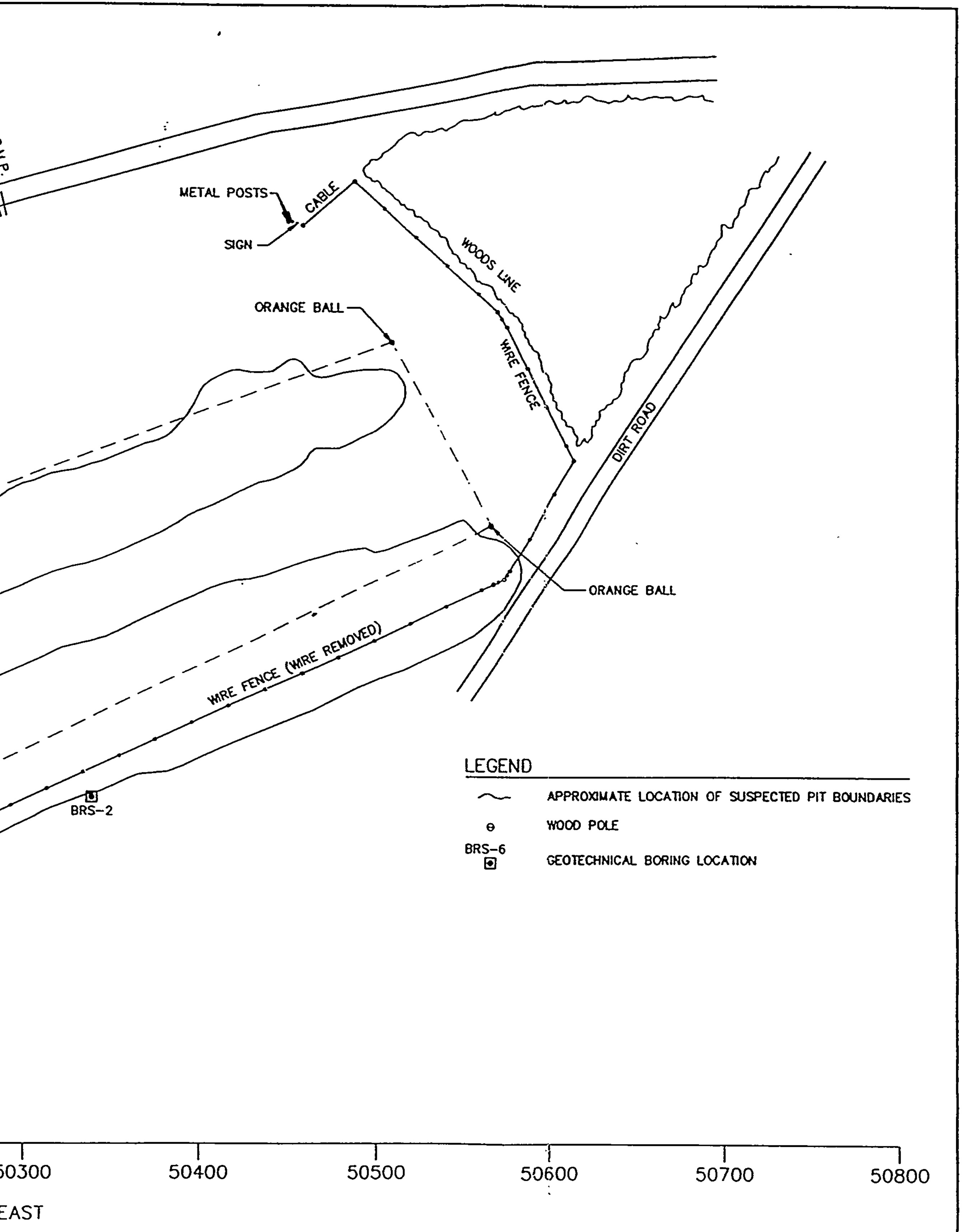

M&E METCALF & EDDY

LOCATIONS OF GEOTECHNICAL BORINGS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
4-26

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compounds contained in plastic bags that may provide a false positive reading by the screening tool.

During the in-pit boring investigation at location BRRP-3, metal and wood objects were encountered at 8 to 9 feet below the surface during the first attempt. This is consistent with the geophysical data, which showed a large amount of buried metal material at this location. The drill rig was then moved to a location three feet west of the original location and again met refusal at 9 to 10 feet below surface. The drill rig was moved five feet east of the original point and was able to reach the required depth at this location.

The OVA detected high concentrations of volatile organics (500 ppm) at the surface of the drill hole while auguring BRRP-4 at a depth of 14 to 16 feet. Aluminum strips, wiring, wood, plastic and bottles were found in the pit at this location. The next two sample intervals were screened and determined to be clean.

At location BRRP-11, removal of the head from the split spoon collected at 20 to 22 feet could not be achieved. The sample was collected with a spoon from the downhole end of the split spoon.

At location BRRP-12, the pit was encountered at approximately three feet. Pieces of wood were detected in the drill cuttings and a turpentine-like odor was detected. At the top of the drilling augers, the OVA detected as much as 600 ppm of volatile organic. These volatiles were allowed to dissipate for approximately 10 minutes before the area was resurveyed with an OVA and drilling was resumed.

At location BRRP-15 at a depth of 6 feet, the OVA detected volatile organics at around 250 ppm. Refusal was encountered 12 feet and the location was moved 2 feet to the southeast. At this location wires were encountered and a sample could not be taken. Relocation 15 feet north of the original location was required and again the augers met refusal. The boring was relocated about 10 feet southeast of the last site and a sample was collected.

During the geotechnical boring investigation, poor recovery was experienced for the 0-2 foot and 5-7 foot split spoons collected on December 13, 1993 at location BRS-6. On December 15, 1993 the rig was moved 10 feet south of BRS-6 and replacement samples were collected for the 0-2 foot and 5-7 foot depths. This new location was identified as BRS-6A. The 0-2 foot sample again had poor recovery so the initial sample was retained. The 5-7 foot sample collected at location BRS-6A and was retained for analysis.

The surface water and sediment samples collected on February 22, 1994 were not specified in the Work Plan (WSRC, 1993). The collection of these samples was requested by the WSRC STR in order to address concerns over data sufficiency for the BRA.

The sample identification numbers used for the survey and the identification numbers assigned to each sampling location on the chain-of-custody forms were different at many location. The sample identification numbers used in the field notes are the numbers identified on the chain-of-custody forms.

4.3.6 *Groundwater Well Installations*

Groundwater well installation began on November 4, 1993 and was completed on March 2, 1994. A total of nine wells were installed in three well clusters (See **Figure 4-27** for monitoring well locations). Well cluster BRR-7 was installed first, well cluster BRR-6 was installed second, and well cluster BRR-8 was installed last. The BRR-8 well cluster was installed last because its location was based upon the results of the piezocone investigation to ensure that this well cluster was installed downgradient of the rubble pits.

All nine monitoring wells were installed at varying depths. They are as follows:

• Water Table Wells - Installed just above the Tan Clay Confining Zone	6D, 7D, 8D
• Upper Portion of the "Lower" Aquifer Zone -The Upper Three Runs Aquifer	6C, 7C, 8C
• Lower Portion of the "Lower" Aquifer Zone - The Upper Three Runs Aquifer	6B, 7B, 8B

Well BRR-7B was replaced after the initial well collapsed (see **note in Appendix C**). In addition, monitoring well BRR-8D was replaced after the initial well collapsed due to a collapsed screen (see **the Abandonment Record located in Appendix C**). Although, there is no certain way of knowing, it is assumed that one of the following two things occurred to cause this collapse: 1) the improper placement of the filter pack allowed the above layer of grouting to seep **through** the filter pack and

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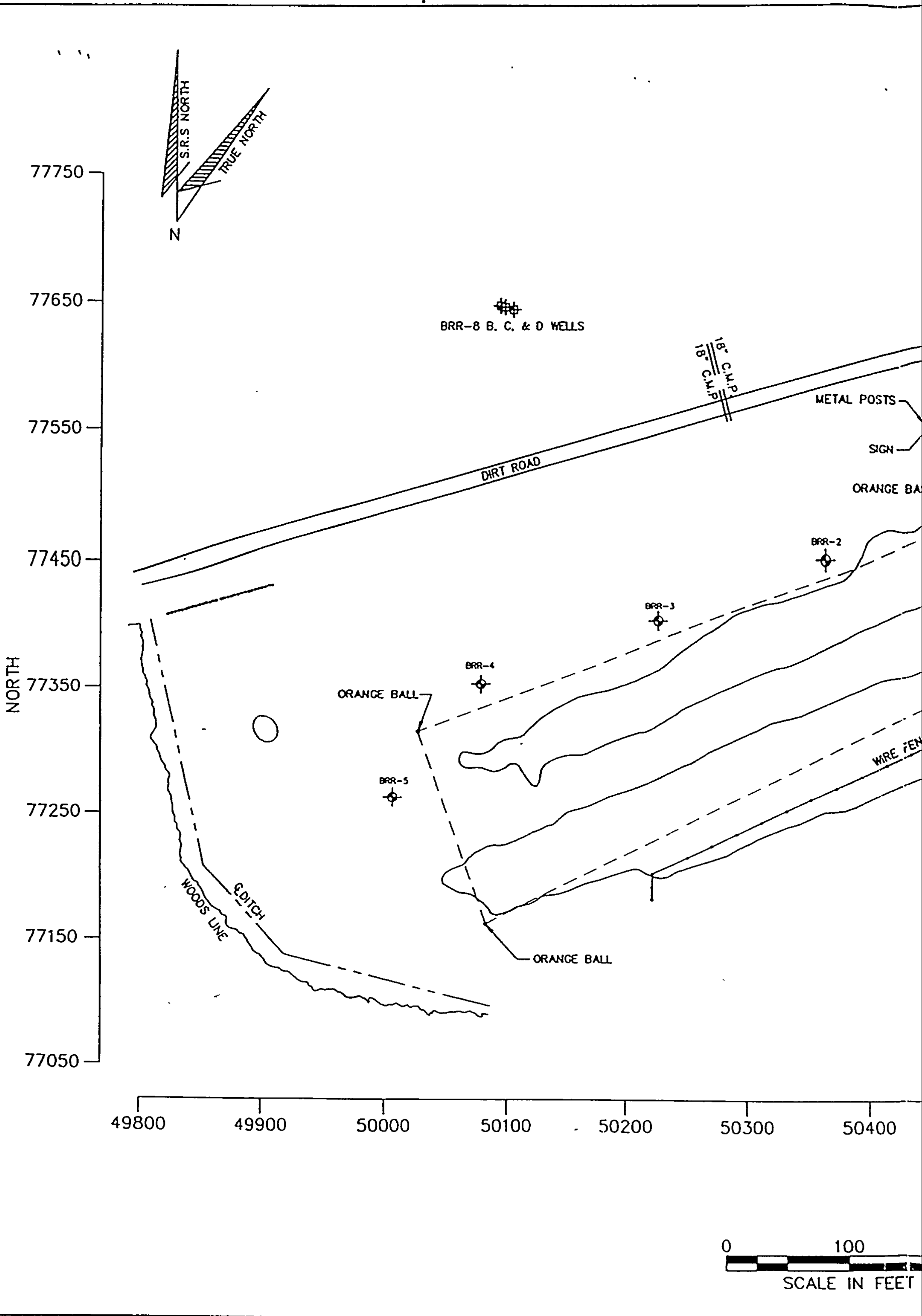

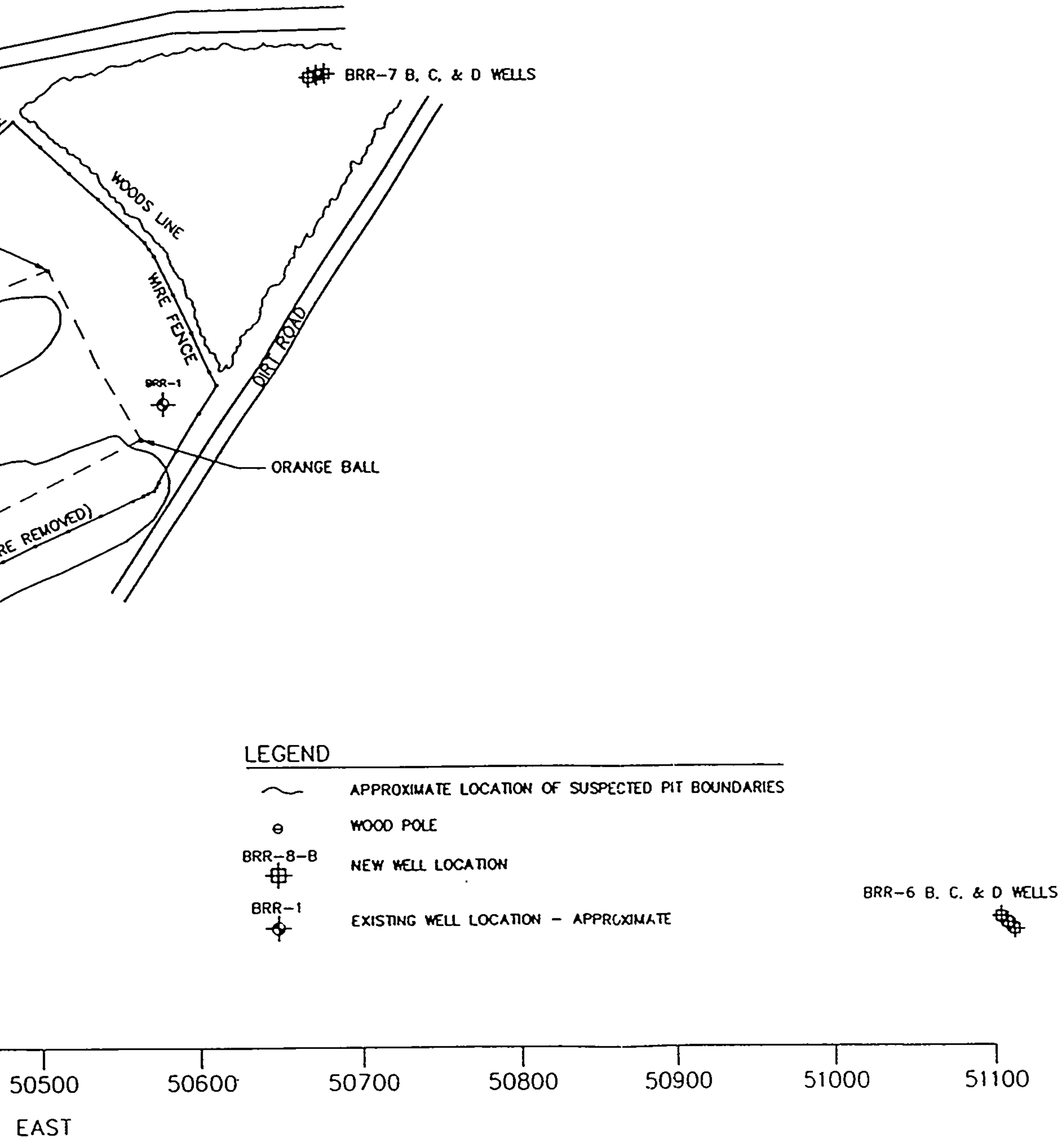

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METCALF & EDDY

LOCATION OF EXISTING WELLS
AND NEWLY INSTALLED WELL CLUSTERS

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE
4-27

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into the screen or 2) an imperfection in the casing allowed infiltration of grout into the well. Although there is no foolproof way of avoiding these problems, common practice is to more frequently inspect the filter pack during installation of the replacement wells. This practice was followed at the BRRP during installation of the replacement wells for BRR-8D and BRR-7B.

The deepest boring in each well cluster was continuously cored and geophysically logged. Upon completion of the geophysical logging (Caliper, natural gamma, spontaneous potential, single point resistance, and long and short normal resistivity), lithologic and geophysical information were used to select optimum well screen intervals for individual wells in each cluster.

The following sections discuss the specifics of each well type. **Tables 4-4 and 4-5** provide information on the wells installed during this field investigation. **The wells were installed in accordance with WSRC 3Q5 which states that the bentonite seal shall have a minimum thickness of 4 feet. The thickness of the bentonite seal, filter pack, and fine sand seal is often varied in order to ensure a good seal with a local confining unit to minimize the potential for cross contamination between the aquifers.**

Groundwater flow direction was determined during the field investigation from piezocone data and from water level measurements taken in the existing wells. The new groundwater elevation data obtained from well BRR-8D altered the apparent groundwater flow direction as illustrated in **Figure 4-19.**

4.3.7 *Slug Testing*

WSRC performed rising head and falling head borehole permeability tests (slug test) in all nine monitoring wells. These tests provide estimates of the hydraulic conductivity of the aquifer around the screened zone of the well. The tests are also useful in determining if the wells have been properly developed.

The Bouwer and Rice Method (Bouwer, 1976) was used to analyze field data collected from performing slug tests in unconfined aquifers (water table) and confined aquifers. Theoretically, the slug test applies to aquifers where the upper boundary is unconfined; however, the method should also be applicable to situations where the upper boundary of the aquifer is an impermeable or semi-permeable upper confining layer (Bouwer, 1989). Bouwer indicates that the slug test should provide reasonable values for K-values in a confined, semi-confined, or stratified aquifer. Bouwer further

Table 4-4 Burma Road Rubble Pit Monitoring Well Construction Details

Well Identification Number	Date Installed	SRS Coordinates	Pad Elevation Mean Sea Level (MSL)	Total Boring Depth (BGS) (feet)	Screened Interval (feet)	Top of Filter Pack (feet)	Top of Fine Sand (feet)	Top of Bentonite Seal (feet)	Hydrostratigraphic Units
BRR-6B	12/02/93	North: 77054.62 East: 51099.97	293.55 GRND	195	157 - 167	153.8	152	142.5	Lower portion of the "Lower" Aquifer Zone of the Upper Three Runs Aquifer
BRR-6C	12/06/93	North: 77062.91 East: 51094.67	294.0	144	128 - 138	125.9	124.3	117.5	Upper portion of the "Lower" Aquifer Zone of the Upper Three Runs Aquifer
BRR-6D	12/09/93	North: 77070.94 East: 51088.62	294.3	108.0	75 - 95	70.3	64.9	56.4	Upper Aquifer Zone of the Upper Three Runs Aquifer
BRR-7B	02/10/94	North: 77575.38 East: 50707.54	288.8 GRND	153	138 - 148	134	No fine sand seal	128.2	Lower portion of the "Lower" Aquifer Zone of the Upper Three Runs Aquifer
BRR-7C	11/19/93	North: 77572.90 East: 50698.14	288.9	116.2	103 - 113	96.4	93.8	89.6	Upper portion of the "Lower" Aquifer Zone of the Upper Three Runs Aquifer
BRR-7D	11/22/93	North: 77570.69 East: 50688.27	289.2	88	67.3 - 87.3	64.2	62.4	58.7	Upper Aquifer Zone of the Upper Three Runs Aquifer
BRR-8B	01/26/94	North: 77634.65 East: 50116.48	276.7	165	128 - 138	124.9	122.2	116	Lower portion of the "Lower" Aquifer Zone of the Upper Three Runs Aquifer
BRR-8C	01/31/94	North: 77631.97 East: 50125.64	277:7	1101	85 - 95	83	78.4	72	Upper portion of the "Lower" Aquifer Zone of the Upper Three Runs Aquifer
BRR-8D	02/28/94	North: 77627.31 East: 50142.28	NO DATA	74	58 - 73	52.1	48.9	43.4	Upper Aquifer Zone of the Upper Three Runs Aquifer

Table 4-5 Monitoring Well Seals for B, C, and D Wells

Well Number	Feet of Filter Pack Above Top of Screen	Feet of Fine Sand Seal	Feet of Bentonite Seal
BRR-6D	4.7	5.4	8.5
BRR-7D	3.1	1.8	3.7
BRR-8DR	6.26	3.2	5.5
BRR-6B	3.2	1.8	9.5
BRR-7BR	4	0	5.8
BRR-8B	3.1	2.7	6.2
BRR-6C	2.1	1.6	6.8
BRR-7C	6.6	2.6	4.2
BRR-8C	2	4.6	6.4

indicates that "Theoretically, the larger the distance between the top of the screened or open section of the well and the upper confining layer, the more accurate the resulting values of K will be. In actuality, however, source boundaries of groundwater flowing into the well in response to lowering the water level are hard to define because of elastic deformation of aquifer material and confining layers." (Bouwer, 1989).

The slug test is based on the addition or removal of a slug. The former is known as a falling head test; the latter is a rising head test. If the equilibrium water level in the well is below the top of the screen - as is the case in each of the D wells - the data collected from a falling head test tends to overestimate the hydraulic conductivity of the aquifer. This overestimation is caused by water flowing into the aquifer through the unsaturated vadose zone above the water table. For this reason, the data collected from the falling head tests for the D well may be suspect and our discussion will focus on the rising head tests. However, the data collected from wells BRR-8B and BRR-6D are from falling head tests. Field experience had demonstrated this data to be identical to the rising head data. The results from BRR-8D are suspect due to the lack of water in the well.

The data collected from the slug test are shown in Appendix I. Most of these curves exhibit a straight line section followed by a section which curves away from the straight line. The curved portion of the plot at late times should be ignored as it reflects drawdown effects of the water table surrounding the well. Slug test hydraulic conductivity values are presented in **Table 4-6.**

4.4 Source Characterization

Three geophysical techniques were used at the BRRP to determine the subsurface characteristics of the area: (1) electromagnetic (EM) survey, (2) magnetic survey, and (3) ground penetrating radar (GPR). The objectives of each of these techniques are notes in Section 3. In addition to these, four separate soil gas surveys were completed at the BRRP. In all the soil gas surveys, the light hydrocarbons (C1-C4), gasoline range aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylene (BTEX)), selected chlorinated organics, and mercury were monitored. Seventeen soil borings were performed in the BRRP. The boring locations were chosen after reviewing results from the various geotechnical investigative devices and soil gas survey results. In general, the borings were located in areas adjacent to potential underground objects/areas of high metal concentration indicated by anomalies in the GPR, EM, or magnetometer surveys, and/or areas where a soil gas anomaly was detected. In each of the borings, the first of the split spoon samples was collected from the 0.0 to 2.0 feet interval. The top of the pit and the base of the

Table 4-6 Summary of Hydraulic Conductivity Values Obtained from Slug Tests

Well Number/Slug Test Type	Hydraulic Conductivity (ft/min)
BRR-6B	1.24E-4
BRR-6C	1.54E-4
BRR-6D	3.25E-4
BRR-7B	2.38E-4
BRR-7C	7.40E-5
BRR-7D	1.94E-5
BRR-8B	1.72E-3
BRR-8C	2.53E-4
BRR-8D	7.24E-3

pit were detected from disturbed soil or encountering anomalous material. OVA readings were taken continuously while drilling/augering. The second sample for laboratory analysis was collected from the base of the pit to two feet below the base of the pit. The contents of the pit were noted and OVA readings were taken in the breathing zone. The information obtained was noted in the field notes and the lithology of the samples and pit contents noted on the soil boring log. These data (field notes and soil boring logs) are located in Appendix K. Anomalous OVA readings, the depth where the readings were taken and contents of the pit, where encountered, at each soil boring location are noted in Table 4-7.

Two cross sections (Figures 4-28 and 4-29) depicting the contents of the pit were constructed. These cross sections extend from west to east across each of the pits. Data from all the soil borings were included in these cross sections. Cross section A-A' (Figure 4-28) traverses the northerly of the two pits. The OVA readings and descriptions of the material encountered are noted on the cross section. Only inert material was encountered in the drilling of the soil borings noted in this cross section. Cross section B-B' (Figure 4-29) traverses the more southerly of the two pits. As with the other cross section, the OVA readings and descriptions of the material encountered are noted on the cross section. Only inert material was encountered in the drilling of the soil borings.

At soil boring BRRP-12, the smell of turpentine was noted and an OVA reading of ~600 ppm in the hole at approximately 3 feet below land surface, near the top of pit, was noted. Turpentine is a naturally occurring degradation product of pine wood. No liquid, sludge, or containers (i.e., drums, etc.) were noted; and, the OVA registered a 10 ppm reading from a piece of wood taken from the auger at the same depth. The contents noted on the other borings include wood, trash, lead wire, copper wire, metal, bottles, plastic, aluminum, rubble, foam, 1/2 inch cable, concrete, gravel, and disturbed soil.

Two borings encountered impenetrable material/drilling refusal and had to be moved to achieve appropriate sample depth intervals. BRRP-3 was relocated three feet to the west from its original location because of drilling refusal at 8 to 9 feet below land surface. This boring also encountered drilling refusal at approximately 9 feet below land surface. The boring was moved to a location 5 feet east of the original hole and was able to auger to the desired depth of investigation. BRRP-15 also encountered drilling/augering problems of a similar nature. At the original location, a sample was attempted at the 10 to 12 feet depth, but was unable to obtain a sample. The location was moved two feet in a westerly direction and encountered the same problem at approximately 10 feet below land surface. Lead wire was caught in the augers. The hole was moved 15 feet

Table 4-7 Burma Road Rubble Pit Contents and OVA Readings from Soil Borings

Soil Boring	Depth (feet)	OVA Reading (ppm)	Pit Contents
BRRP-1	0 - 2 10 - 12	0 0	Does not appear to have disturbed soil
BRRP-2	0 - 2 @ 7 8 - 10	3.0 30 at the top of the hole 5.0; consistent, high of 18	Wire, metal, wood, concrete, gravel
BRRP-3	0 - 2 @ 8 15 - 17	0 80 4	Rubble, metal, foam, copper, wood, plastic, 1/2-inch cable
BRRP-4	0 - 2 @15 16 - 18	0 peak at ~500 at surface of hole, safe at breathing zone 32	Wood, bottles, aluminum, plastic, wiring
BRRP-5	0 - 2 15 - 17	6.4 5	Small pieces of wiring at 8 feet; apparent disturbed soil to 15 feet
BRRP-6	0 - 2 16 - 18	0 0.8	Only disturbed soil encountered
BRRP-7	0 - 2 @18	0 0	No trash; did not reach bottom of pit; could not tell if in pit
BRRP-8	0 - 2 10 - 12	0 0	Disturbed soil to 10 feet
BRRP-9	0 - 2 10 - 12	0 0	Disturbed soil to 10 feet
BRRP-10	0 - 2 10 - 12	0 0	Fill and in-situ soil to 10 feet
BRRP-11	0 - 2 10 - 12	0 0	Disturbed soil to 10 feet
BRRP-12	@3 6 - 8	600 in hole; 0 in breathing zone; 10 from piece of wood 1.0	Wood, trash, smell of turpentine (at 3 feet)
BRRP-13	13 - 15 6 - 13	0.6 (Headspace) No OVA hits while drilling	Wire. wood, metal
BRRP-14	0 - 2 10 -12	0 0	No trash; only disturbed soil
BRRP-15	0 - 2 @6 10 - 12	0 250 0	Lead wire, copper wire, wood, metal
BRRP-16	0 - 2 10 - 12	0 0	No trash; only disturbed soil
BRRP-17	0- 2 10 - 12	0 0	Possible fill and in-situ soil; no trash

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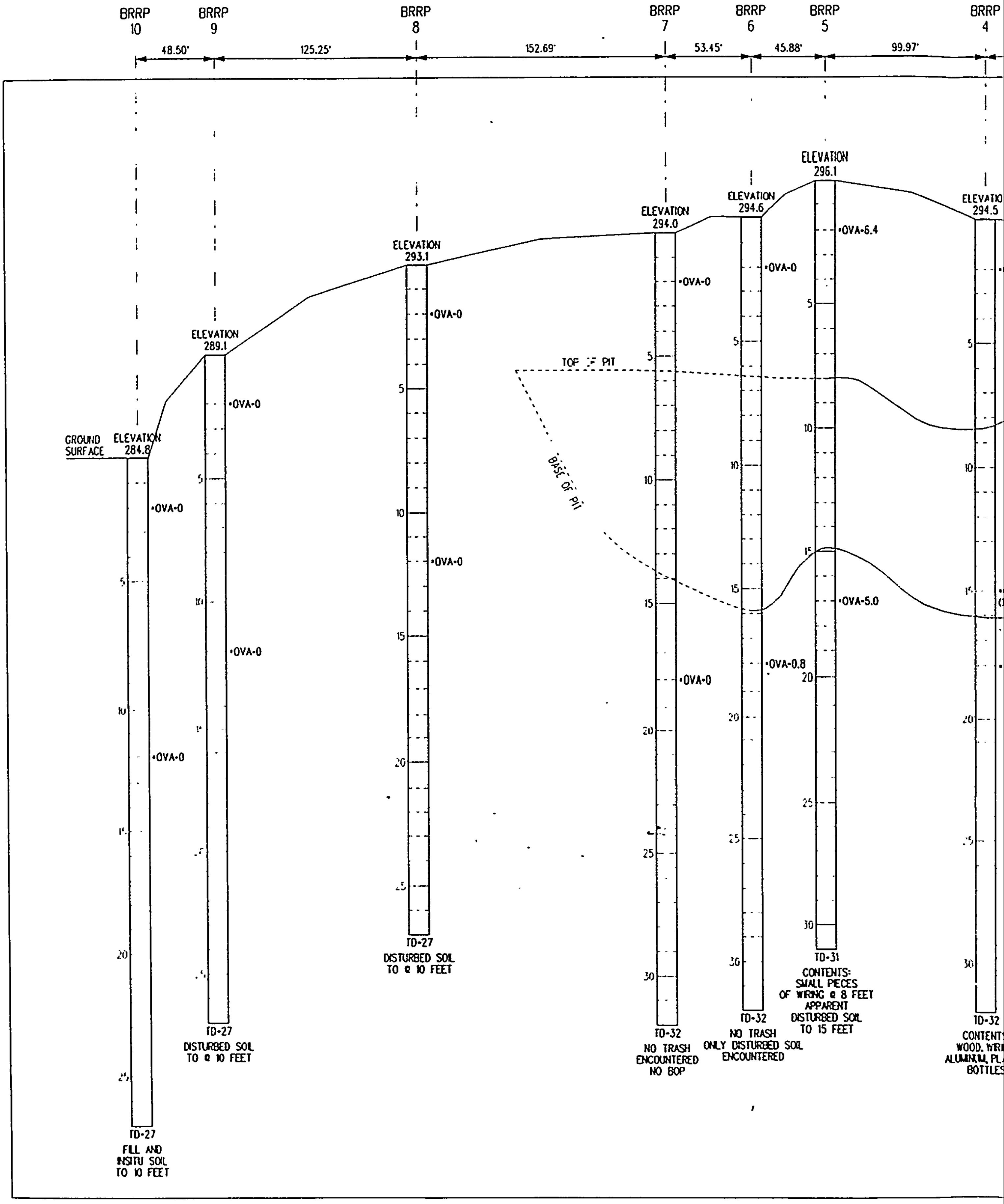
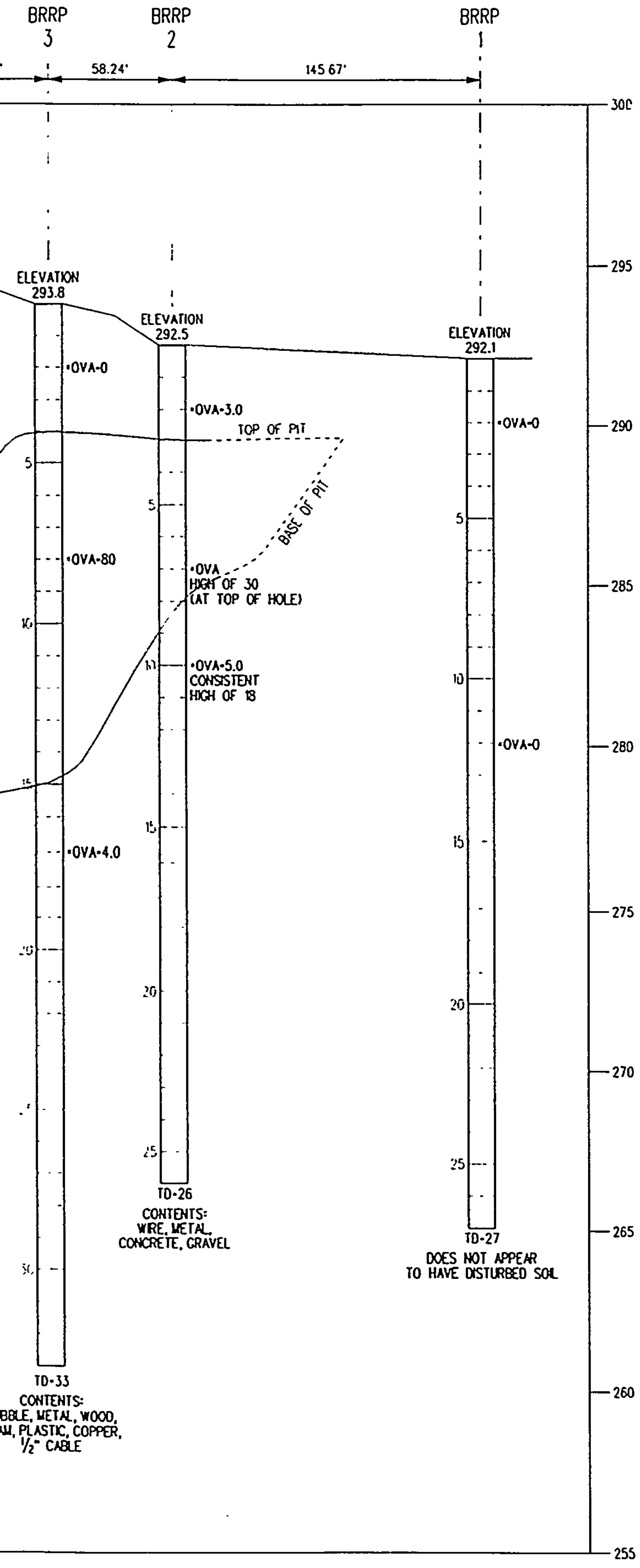
CROSS-SECTION A-A'
BURMA ROAD RUBBLE PIT

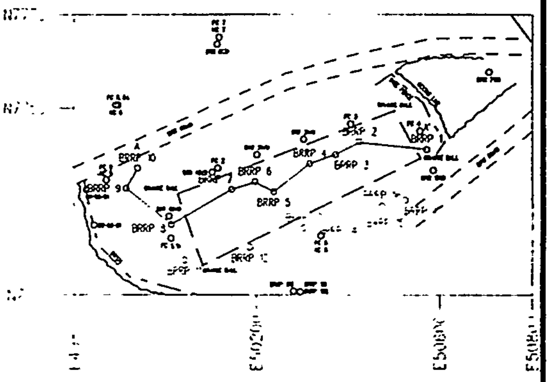


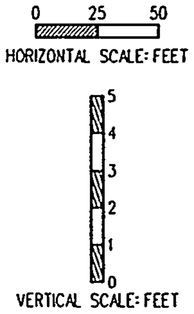


NOTES:

OVA VALUES NOTED ARE IN PPM

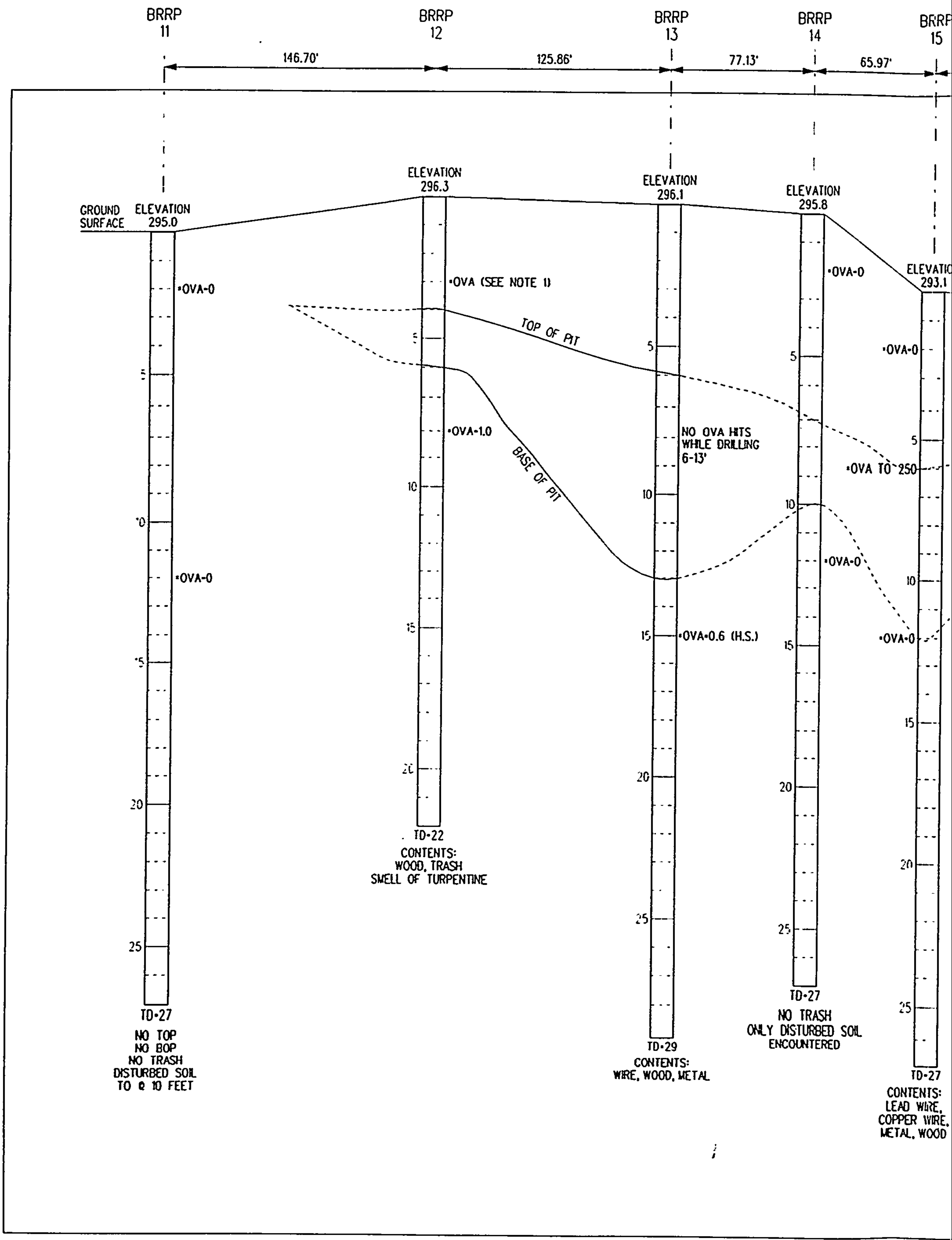
1. OVA PEAK AT ~500 SURFACE OF HOLE
   SAFE AT BREATHING ZONE

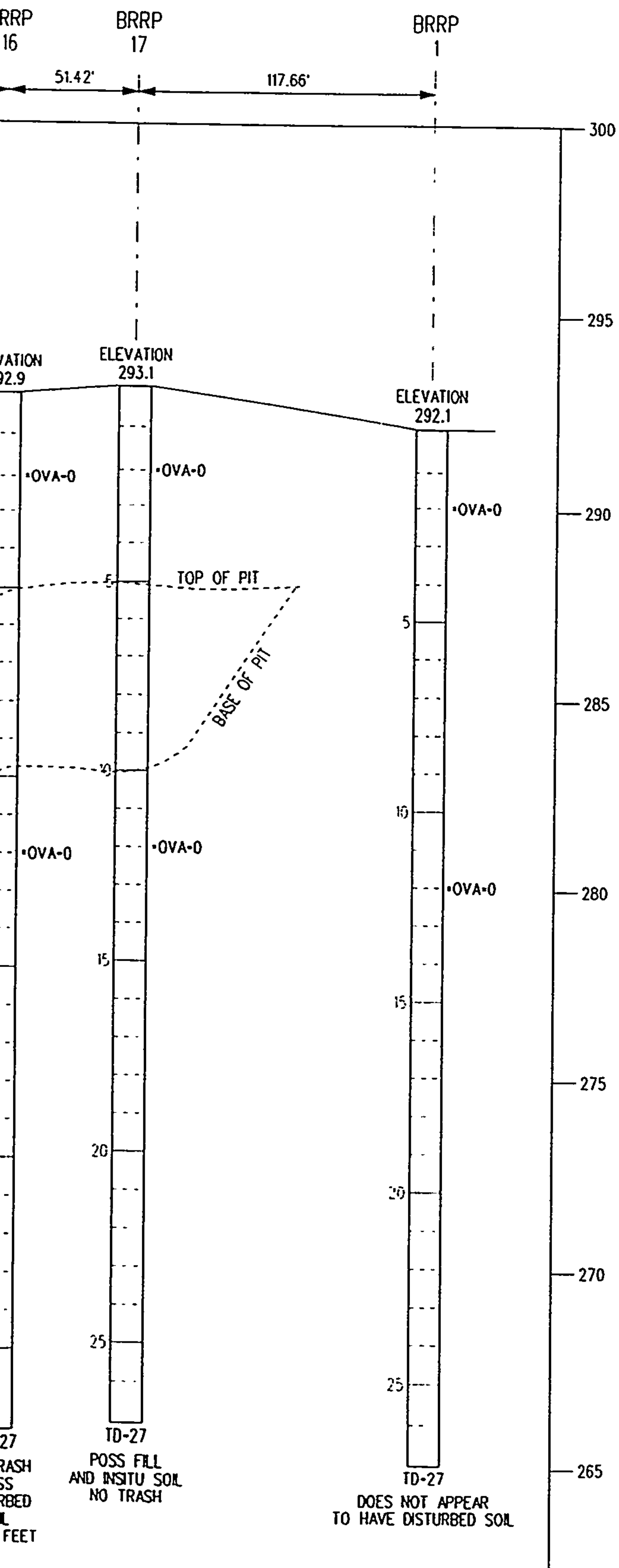




SS1722	0	5-22-95	GSA
SRS	ENVIRONMENTAL RESTORATION		
BURMA ROAD RUBBLE PIT CROSS-SECTION A-A'			
ETA/TLM	5-22-95	NA	NA
TOM McADAMS	5-22-95	NA	NA
	NA	NA	NA

CROSS-SECTION B-B'
BURMA ROAD RUBBLE PIT

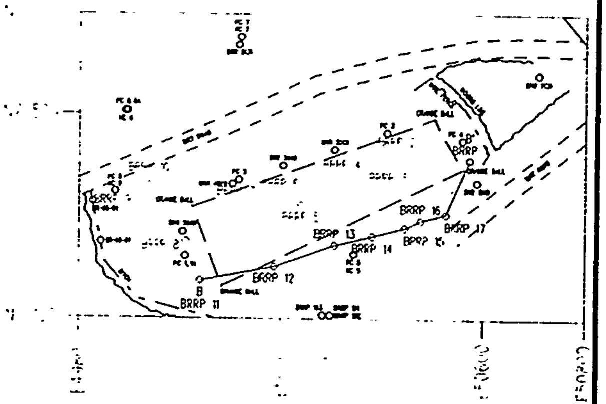


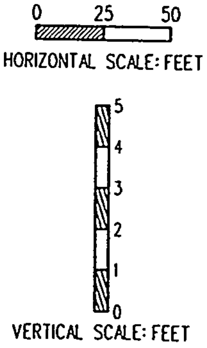


NOTES:

OVA VALUES NOTED ARE IN PPM

1. OVA-0 IN BREATHING ZONE
   HOLE MEASURED @ 600 PPM
   @ 10 PPM FROM PIECE OF WOOD





DWG NO.	REV. NO.	REV. DATE	AREA
SS1723	0	5-22-95	GSA

SRS

ENVIRONMENTAL RESTORATION

TITLE

BURMA ROAD RUBBLE PIT
CROSS-SECTION B-B'

CREATED BY	DATE	APPROVED BY	DATE
ETA/TLM	5-22-95	NA	NA
TOM McADAMS	5-22-95	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA

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north of the original location and the augers could not auger past 10.5 feet. The location was moved 10 feet in a southerly direction and was able to auger to the required depths and obtain the desired samples. All final locations were surveyed and these points are noted in Figure 4-23.

Actual contents of the pits were not sent for laboratory analysis. All the contents encountered were inert. Laboratory analysis of the inert material encountered in the pits would provide questionable, biased, or limited valuable data with respect to contaminant release to the environment. Soils both above and below the pits were sampled and analysis was performed. The Baseline Risk Assessment utilized these data in its analysis of risk.

Historical practices and pictures of the BRRP support the contention that inert construction material was placed in the pits. The results from a total of two hundred twenty-six (226) soil gas survey points and three geophysical techniques were utilized in biasing the position of the seventeen soil borings in areas where anomalies occurred. This was to target areas of highest potential for contamination. Continuous OVA readings were taken during drilling operations. The contents of the pit were noted, when encountered. Only inert material was found. At no time while drilling/augering was rod drop or any other indication of drilling into a drum, sludge, liquid, or other contaminated material experienced. Cross sections depicting the contents of the pit have been constructed and are included.

5.0 NATURE AND EXTENT OF CONTAMINATION

5.1 Introduction

This chapter discusses the results of the RFI/RI investigation to characterize the nature and extent of contamination at the BRRP. The following sections are organized by media (soil, sediment and surface water, and groundwater) and by contaminant type (metals, volatile organic compounds, semi-volatile organic compounds, radionuclides, Toxicity Characteristic Leaching Procedure (TCLP) contaminants, and pesticides, PCBs and dioxin/furans). Background concentrations and regulatory guidance levels for the media are provided in Section 5.2.

5.2 Regulatory Guidance and Background Concentrations

5.2.1 *Soils*

The soils sampled at the BRRP are considered Udorthents. Udorthents are so extensively graded, exposed, transported, mixed, and compacted during earth moving and construction, that they cannot be assigned to a particular soil series with a high level of confidence. The soils typically lack the horizons and soil structures that characterize mature soils. They are generally more friable, but may be firmer due to compaction than in situ soils. Organic matter and other plant nutrients are usually low in these soils due to stripping and mixing, and extreme variations may occur laterally within very small distances. The soil pH may be low, and permeability is low to moderate. Udorthents still bear strong similarities to their parent soils with regard to the following parameters: general chemistry, relative elemental abundance, grain size, and texture.

The locations of background soil samples are indicated in Figure 5-1. Four background **subsurface** samples (BR-01-01, BR-02-01, BR-03-01, and BR-04-01) were taken from a depth of 10 - 12 feet. Two background surface samples (BR-07-01 and BR-08-01) were taken **from a depth of 0 - 2 feet.** Background concentrations and regulatory guidance levels are given only for those contaminants detected at the BRRP. Appendix J contains laboratory analytical results for the soil samples.

The background samples were located in areas that were away from GPR Zones 1, 2, and 3 and were outside of the soil gas anomalies. The background subsurface samples (BR-01-01, BR-02-01, BR-03-01, and BR-04-01) were drilled to a depth that corresponded stratigraphically to the base of the BRRP waste unit (i.e., 10 to 12 feet below the ground surface). The background

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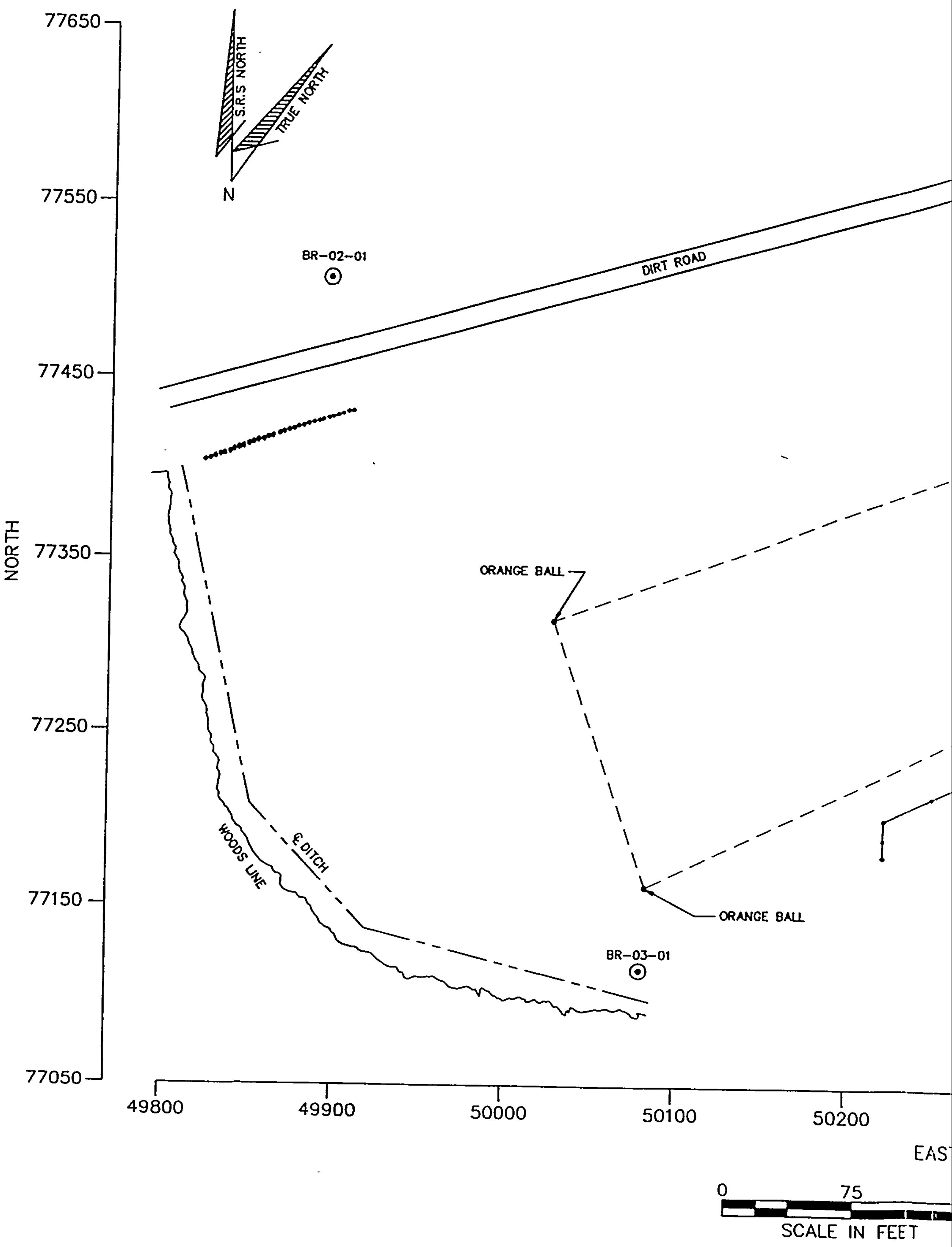

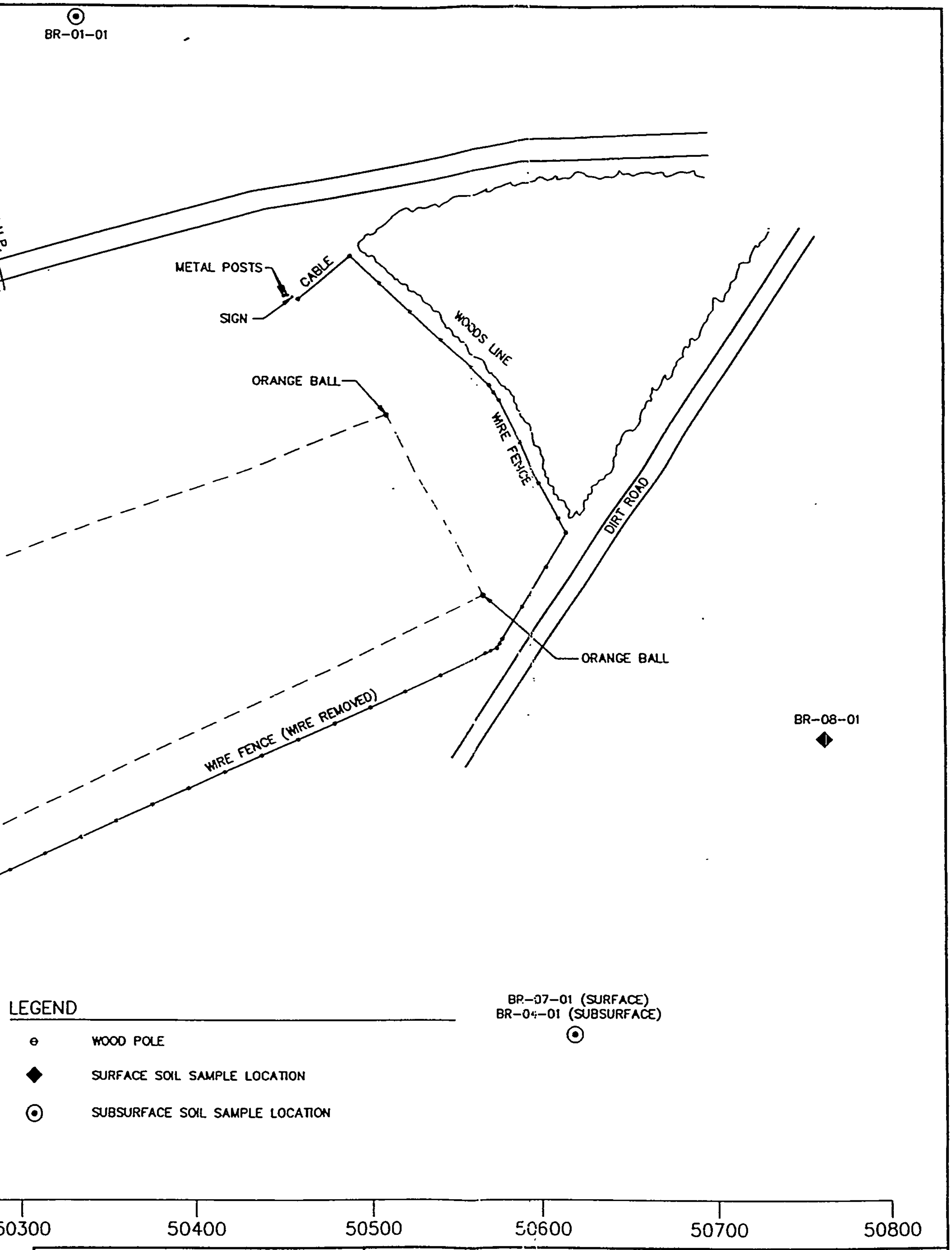

METCALF & EDDY

LOCATION OF SUBSURFACE AND SURFACE
BACKGROUND SOIL SAMPLES

SAVANNAH RIVER PLANT

FIGURE
5-1

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surface samples (BR-07-01 and BR-08-01) were located upgradient and at a great distance from the BRRP waste unit. The background levels were established based upon the analysis of the background samples.

Enforceable regulatory standards have not been promulgated for soil contamination. Analyte concentrations detected in soil samples collected on site were first compared to two times unit-specific background concentrations (i.e., criterion background concentration (CBC)) to evaluate site contamination. If the soil sample analyte concentration was less than or equal to the CBC, then the analyte was screened out as a site contaminant. If the contaminant was not detected in the background samples or was above the CBC, then analyte concentrations were compared to U.S. EPA Region III residential risk-based concentration (RBC) levels (Smith, 1995) for site contamination evaluation. Volatile organic compounds were only compared to RBC levels; they were not compared to unit-specific background concentrations. The RBC levels correspond with "fixed levels of risk" for various sampling matrices. Region III toxicologists have used the RBCs as screening and validation tools during risk assessment studies and reviews (Smith, 1995). The SCDHEC typically compares soil concentrations to background or site-specific risk cleanup goals which consider human health for site remediation.

5.2.1.1 Metals

Table 5-1 summarizes surface (0-2 feet) site-specific background concentrations for metals detected at the BRRP (BR-07-01, and BR-08-01). Table 5-2 summarizes subsurface (10 - 12 feet) site-specific background concentrations for metals detected at the BRRP (BR-01-01, BR-02-01, BR-03-01, and BR-04-01). Table 5-3 displays the residential RBC levels for metals detected at the BRRP waste unit.

5.2.1.2 Semi-Volatile Organic Compounds

Table 5-4 summarizes surface (0-2 feet) site-specific background concentrations for semi-volatile organic compounds detected at the BRRP. Table 5-5 summarizes subsurface (10-12 feet) site-specific background cconcentrations for semi-volatile organic compounds. Table 5-6 displays the residential RBC levels for semi-volatile contaminants detected on site.

Table 5-1 Surface (0-2 feet) Background Analyte Concentrations - Target Analyte List (TAL) Constituents

TAL Constituents	Frequency of Detection	Surface Site-Specific Background Conc.(mg/kg)		Avg. Background Conc. (mg/kg)	Criterion Background Conc. (mg/kg)
		Minimum	Maximum		
Aluminum	2/2	3410	11900	7600	15310
Antimony	0/2	1.91 UJ	2.13 U	ND	ND
Arsenic	0/2	1.53 U	1.70 U	ND	ND
Barium	2/2	42.4	97.5	69.95	139.9
Beryllium	2/2	0.17 J	0.385 J	0.278	0.555
Cadmium	0/2	0.201 U	0.223 U	ND	ND
Calcium	2/2	137	730	433.5	867
Chromium	2/2	3.65	10.6	7.13	14.25
Cobalt	2/2	0.558 J	1.88 J	1.22	2.44
Copper	2/2	1.16 J	4.11	2.64	5.27
Cyanide	2/2	0.116 J	0.256 J	0.186	0.372
Iron	2/2	2180	7020	4600	9200
Lead	2/2	4.21 J	14.1	9.16	18.31
Magnesium	2/2	61.4	295	178.2	356.4
Manganese	2/2	132 J	437 J	284.5	569
Mercury	2/2	0.0306 J	0.0862 J	0.0584	0.1168
Nickel	2/2	0.786 J	3.07	1.93	3.86
Potassium	2/2	41.3 J	184 J	112.7	225.3
Selenium	0/2	3.17 U	3.51 U	ND	ND
Silver	0/2	0.283 U	0.314 U	ND	ND
Sodium	1/2	8.76 U	12.2 J	8.29	16.58
Vanadium	2/2	6.1	19.9	13	26
Zinc	2/2	2.29 J	10.6 J	6.45	12.89

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

Table 5-2 Subsurface (10-12 feet) Background Analyte Concentrations - TAL Constituents

TAL Constituents	Frequency of Detection	Subsurface Site-Specific Background Conc.(mg/kg)		Avg. Background Conc. (mg/kg)	Criterion Background Conc. (mg/kg)
		Minimum	Maximum		
Aluminum	4/4	2980	5100	3882.5	7765
Antimony	0/4	1.90 U	2.06 UJ	ND	ND
Arsenic	4/4	2.42 J	4.06 J	3.34	6.68
Barium	4/4	1.90 J	7.22 J	3.30	6.60
Beryllium	4/4	0.0583 J	0.0842 J	0.0649	0.1298
Cadmium	0/4	0.200 U	0.216 U	ND	ND
Calcium	4/4	9.02 J	44.7	25.3	50.6
Chromium	4/4	6.96	13.4	9.86	19.72
Cobalt	4/4	0.244 J	0.663 J	0.417	0.834
Copper	4/4	2.43 J	5.38	4.21	8.42
Cyanide	4/4	0.0575 J	0.0977 J	0.0763	0.1526
Iron	4/4	4320	10800	7875	15750
Lead	4/4	2.82 J	6.64	4.69	9.38
Magnesium	4/4	13.8	42.8	28.1	56.2
Manganese	4/4	5.44 J	13.1 J	9.72	19.44
Mercury	1/4	0.0183 U	0.0207 U	0.012	0.024
Nickel	4/4	0.539 J	1.66 J	0.896	1.79
Potassium	1/4	31.0 U	35.4 J	20.7	41.4
Selenium	0/4	3.14 U	3.40 U	ND	ND
Silver	0/4	0.280 U	0.304 U	ND	ND
Sodium	0/4	8.68 U	9.42 U	ND	ND
Vanadium	4/4	23.7	40.9	31.1	62.1
Zinc	4/4	1.34 J	3.98	2.45	4.90

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-3 Residential Risk-Based Concentration (RBC) Levels - TAL Constituents

TAL Constituents	RBC Level (mg/kg)
Aluminum	78000n
Antimony	31n
Arsenic	23n/0.37c
Barium	5500n
Beryllium	0.15c
Cadmium	39n
Calcium	NR
Chromium	390n (VI)
Cobalt	4700n
Copper	2900n
Cyanide	1600n
Iron	NR
Lead	NR
Magnesium	NR
Manganese	390n
Mercury	23n (inorganic)
Nickel	1600n
Potassium	NR
Selenium	390n
Silver	390n
Sodium	NR
Vanadium	550n
Zinc	23000n

n - Noncarcinogenic value that will be achieve a hazard of 1.0

c - Carcinogenic effect or a value that will achieve a 1.0E-06 risk

NR - No regulatory level has been set

Table 5-4 Surface (0-2 feet) Background Analyte Concentrations - Semi-Volatile Organics

Semi-Volatile Constituents	Frequency of Detection	Surface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
1,3-Dichlorobenzene	0/2	1.03 U	1.13 U	ND	ND
1,4-Dichlorobenzene	0/2	5.59 U	6.16 U	ND	ND
2-Chlorophenol	0/2	2.67 UJ	6.81 U	ND	ND
2-Methylnapthalene	0/2	1.54 U	1.69 U	ND	ND
Acenaphthene	0/2	1.62 U	1.78 U	ND	ND
Anthracene	0/2	0.432 U	0.476 U	ND	ND
Benzo(a)anthracene	0/2	1.30 U	1.43 U	ND	ND
Benzo(a)pyrene	0/2	1.09 U	1.20 U	ND	ND
Benzo(b)fluoranthene	1/2	1.03 U	7.21	3.86	7.73
Benzo(g,h,i)perylene	0/2	0.432 U	0.476 U	ND	ND
Benzo(k)fluoranthene	0/2	1.09 U	1.20 U	ND	ND
Benzoic Acid	1/2	4.65 U	538	270.2	540.3
Bis(2-ethylhexyl)phthalate	0/2	14.5 U	26.4 U	ND	ND
Butylbenzyl phthalate	0/2	1.32 UJ	1.45 UJ	ND	ND
Chrysene	0/2	0.788 U	0.869 U	ND	ND
Di-n-Butyl phthalate	0/2	15.6 U	20.0 U	ND	ND
Di-n-Octyl phthalate	0/2	2.28 U	2.52 U	ND	ND
Dibenzofuran	0/2	1.45 U	1.60 U	ND	ND
Fluoranthene	1/2	0.611 U	5.61 J	2.96	5.92
Fluorene	0/2	1.39 U	1.53 U	ND	ND

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-4 Surface (0-2 feet) Background Analyte Concentrations - Semi-Volatile Organics (continued)

Semi-Volatile Constituents	Frequency of Detection	Surface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
Indeno(1,2,3-cd)pyrene	0/2	0.898 U	0.990 U	ND	ND
Napthalene	0/2	1.54 U	1.69 U	ND	ND
Pentachlorophenol	1/2	12.7 J	13.7 U	9.78	19.55
Phenanthrene	1/2	0.611 U	4.41 J	2.36	4.72
Pyrene	2/2	5.81 J	8.01 J	6.91	13.82

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-5 Subsurface (10-12 feet) Background Analyte Concentrations - Semi-Volatile Organics

Semi-Volatile Constituents	Frequency of Detection	Subsurface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
1,3-Dichlorobenzene	0/4	1.04U	1.12 U	ND	ND
1,4-Dichlorobenzene	2/4	5.80 UJ	44.5	15.46	30.92
2-Chlorophenol	0/4	2.70 U	2.90 U	ND	ND
2-Methylnapthalene	0/4	1.55 U	1.67 U	ND	ND
Acenaphthene	0/4	1.63 U	1.75 U	ND	ND
Anthracene	0/4	0.436 U	0.488 U	ND	ND
Benzo(a)anthracene	0/4	1.31 U	1.41 U	ND	ND
Benzo(a)pyrene	0/4	1.10 U	1.18 U	ND	ND
Benzo(b)fluoranthene	0/4	1.04 U	1.12 U	ND	ND
Benzo(g,h,i)perylene	0/4	0.436 U	0.469 U	ND	ND
Benzo(k)fluoranthene	0/4	1.10 U	1.18 U	ND	ND
Benzoic Acid	0/4	4.69 U	5.05 U	ND	ND
Bis(2-ethylhexyl)phthalate	0/4	4.46 U	4.80 U	ND	ND
Butylbenzyl phthalate	0/4	1.33 U	1.43 U	ND	ND
Chrysene	0/4	0.796 U	0.856 U	ND	ND
Di-n-Butyl phthalate	4/4	10.2 J	18.1 J	13.05	26.1
Di-n-Octyl phthalate	0/4	2.31 U	2.48 U	ND	ND
Dibenzofuran	0/4	1.47 U	1.58 U	ND	ND
Fluoranthene	0/4	0.616 U	0.663 U	ND	ND
Fluorene	0/4	1.40 U	1.51 U	ND	ND

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-5 Subsurface (10-12 feet) Background Analyte Concentrations - Semi-Volatile Organics (continued)

Semi-Volatile Constituents	Frequency of Detection	Subsurface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
Indeno(1,2,3-cd)pyrene	0/4	0.907 U	0.976 U	ND	ND
Napthalene	0/4	1.55 U	1.67 U	ND	ND
Pentachlorophenol	0/4	12.5 U	13.5 U	ND	ND
Phenanthrene	0/4	0.616 U	0.663 U	ND	ND
Pyrene	3/4	0.666 U	22.1 J	11.19	22.37

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-6 Residential Risk-Based Concentration (RBC) Levels - Semi-Volatile Constituents

Semi-Volatile Constituents	RBC Level (mg/kg)
1,3-Dichlorobenzene	7000n
1,4-Dichlorobenzene	27c
2-Chlorophenol	390n
2-Methylnaphthene	NR
Acenaphthene	4700n
Anthracene	23000n
Benzo(a)anthracene	0.88c
Benzo(a)pyrene	0.088c
Benzo(b)fluoranthene	0.88c
Benzo(g,h,i)perylene	NR
Benzo(k)fluoranthene	8.8c
Benzoic Acid	310000n
Bis(2-ethylhexyl)phthalate	46c
Butylbenzyl phthalate	16000n
Chrysene	88c
Di-n-butyl phthalate	NR
Di-n-octyl phthalate	1600n
Dibenzofuran	310n
Fluoranthene	3100n
Fluorene	3100n
Indeno(1,2,3-cd)pyrene	0.88c
Napthalene	3100n
Pentachlorophenol	5.3c
Pyrene	2300n

n - Noncarcinogenic value that will be achieve a hazard of 1.0

c - Carcinogenic effect or a value that will achieve a 1.0E-06 risk

NR - No regulatory level has been set

5.2.1.3 Volatile Organic Compounds

Table 5-7 displays the surface (0-2 feet) background concentration information. Table 5-8 displays the subsurface (10-12 feet) background data. Table 5-9 displays the residential RBC levels for volatile organic compounds detected on site. However, per regulatory guidance, the volatile organic compounds were screened using the RBC levels only.

5.2.1.4 Radionuclides and Radionuclide Indicators

Table 5-10 summarizes surface site-specific background levels for radionuclides and radionuclide indicators detected on site. Table 5-11 summarizes subsurface background levels for radionuclides and radionuclide indicators. No RBC levels have been promulgated for radionuclides. Risk based preliminary remediation goals (PRGs) for radionuclides (Nix, 1994) were used to evaluate radionuclide concentrations in soil samples. Table 5-12 displays PRGs for radionuclides and radionuclide indicators detected at the BRRP.

5.2.1.5 Pesticides, PCBs, and Dioxins/Furans

Table 5-13 summarizes surface site specific background levels of contaminants detected in soil samples. Table 5-14 displays the subsurface background levels of contaminants detected in soil samples. Table 5-15 displays RBC levels.

5.2.1.6 TCLP

The TCLP is a laboratory procedure used to determine if a solid waste exhibits the characteristics of toxicity and thus, would be regulated as a hazardous waste. Table 5-16 displays the regulatory thresholds for toxicity.

5.2.2 *Surface Water and Groundwater*

The Safe Drinking Water Act-Maximum Contaminant Levels (SDWA-MCLs) are often used by regulatory agencies to evaluate contamination of water (Table 5-17). Background surface water samples were not collected because there is no upgradient body of surface water within the immediate vicinity of the waste unit from which to obtain a unit-specific background sample. One group of wells (BRR-6) is upgradient of the BRRP and has been designated as a site specific

Table 5-7 Surface (0-2 feet) Background Analyte Concentrations - Volatile Organics

Volatile Organic Constituents	Frequency of Detection	Surface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
1,1-Dichloroethane	0/2	0.0187 U	0.04150	ND	ND
1,2-Dichloroethane	0/2	0.0165 U	0.0366 U	ND	ND
Acetone	1/2	7.73 U	10.6	7.23	14.47
Benzene	0/2	0.0187 U	0.0415 U	ND	ND
Carbon disulfide	1/2	0.142 U	0.634 J	0.353	0.705
Chloroform	0/2	0.0187 U	0.0415 U	ND	ND
Chloromethane	0/2	0.0264 U	0.0585 U	ND	ND
Dichloromethane (Methylene Chloride)	0/2	0.626 U	1.15 U	ND	ND
Ethylbenzene	0/2	0.0165 U	0.0366 U	ND	ND
Methyl ethyl ketone	0/2	0.352 U	0.829 U	ND	ND
Tetrachloroethylene	0/2	0.0286 U	0.0634 U	ND	ND
Toluene	0/2	0.756 U	1.74 U	ND	ND
Trichloroethylene	0/2	0.0187 U	0.0415 U	ND	ND
Trichlorofluoromethane*	----	-----	------	-----	-----
Xylenes	1/2	0.146 U	0.242	0.158	0.315

* Trichlorofluoromethane was not analyzed for in the surface background soil samples. Therefore, this information cannot be provided.

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-8 Subsurface (10-12 feet) Background Analyte Concentrations - Volatile Organics

Volatile Organic Constituents	Frequency of Detection	Subsurface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
1,1-Dichloroethane	0/4	0.0189 UJ	0.0205 UJ	ND	ND
1,2-Dichloroethane	0/4	0.0167 UJ	0.0181 UJ	ND	ND
Acetone	0/4	3.52 UJ	3.82 UJ	ND	ND
Benzene	0/4	0.0556 U	0.0690 U	ND	ND
Carbon disulfide	0/4	0.143 UJ	0.155 UJ	ND	ND
Chloroform	0/4	0.0189 UJ	0.0205 UJ	ND	ND
Chloromethane	2/4	0.0289 UJ	0.0556 J	0.0467	0.0934
Dichloromethane (Methylene Chloride)	4/4	0.494 J	0.552 J	0.521	1.04
Ethylbenzene	0/4	0.0167 UJ	0.0181 UJ	ND	ND
Methyl ethyl ketone	0/4	0.807 U	0.966 U	ND	ND
Tetrachloroethylene	0/4	0.0289 UJ	0.0313 UJ	ND	ND
Toluene	0/4	0.108 U	0.167 U	ND	ND
Trichloroethylene	0/4	0.0189 UJ	0.0205 UJ	ND	ND
Trichlorofluoromethane*	----	-----	------	-----	-----
Xylenes	0/4	0.0667 UJ	0.0723 UJ	ND	ND

* Trichlorofluoromethane was not analyzed for in the surface background soil samples. Therefore, this information cannot be provided.

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-9 Residential Risk-Based Concentration (RBC) Levels - Volatile Organic Constituents

Volatile Organic Constituents	RBC Level (mg/kg)
1,1-Dichloroethane	7800n
1,2-Dichloroethane	7c
Acetone	7800n
Benzene	22c
Carbon disulfide	7800n
Chloroform	100c
Chloromethane	49c
Dichloromethane (Methylene Chloride)	85c
Ethylbenzene	7800n
Methyl ethyl ketone	47000n
Tetrachloroethylene	12c
Toluene	16000n
Trichloroethylene	58c
Trichlorofluoromethane	23000n
Xylenes	160000n

n - Noncarcinogenic value that will achieve a hazard of 1.0.

c - Carcinogenic effect or a value that will achieve a 1.0E-06 risk.

NR - No regulatory level has been set.

Table 5-10 Surface (0-2 feet) Background Analyte Concentrations - Radionuclides & Radionuclide Indicators

Radionuclides & Radionuclide Indicators	Frequency of Detection	Surface Site-Specific Background Conc. (pCi/g)		Avg. Background Conc. (pCi/g)	Criterion Background Conc. (pCi/g)
		Minimum	Maximum		
Actinium-228	2/2	0.759 J	1.29 J	1.02	2.05
Antimony-124	0/2	-0.00001 UJ	-0.0 UJ	ND	ND
Antimony-125	0/2	0.00099 UJ	0.0027 UJ	ND	ND
Barium-133	0/2	-0.03410 UJ	0.00131 UJ	ND	ND
Cerium-144	0/2	-0.00201 UJ	0.00077 UJ	ND	ND
Cesium-134	0/2	-0.00129 UJ	-0.0133 UJ	ND	ND
Cesium-137	2/2	0.00753 J	0.822 J	0.415	0.830
Cobalt-58	0/2	0.00002 UJ	0.00007 UJ	ND	ND
Cobalt-60	0/2	0.00058 UJ	0.002 UJ	ND	ND
Europium-154	1/2	-0.00088 UJ	0.00537 J	0.002	0.005
Europium-155	2/2	0.226 J	0.401 J	0.314	0.627
Gross Alpha	2/2	4.70 J	9.40 J	7.05	14.1
Lead-212	2/2	0.606 J	1.01 J	0.81	1.62
Manganese-54	2/2	0.0082 J	0.01 J	0.009	0.018
Neptunium-239	2/2	0.0363 J	0.0832 J	0.06	0.12
Nonvolatile Beta	2/2	3.40 J	6.10 J	4.75	9.50
Potassium-40	2/2	0.764 J	2.48 J	1.62	3.24
Promethium-144	0/2	-0.00032 UJ	0.00029 UJ	ND	ND
Promethium-146	2/2	0.00499 J	0.0143 J	0.01	0.019
Ruthenium-106	0/2	-0.0008 UJ	0.00376 UJ	ND	ND

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-10 Surface (0-2 feet) Background Analyte Concentrations - Radionuclides & Radionuclide Indicators - (continued)

Radionuclides & Radionuclide Indicators	Frequency of Detection	Surface Site-Specific Background Conc. (pCi/g)		Avg. Background Conc. (pCi/g)	Criterion Background Conc. (pCi/g)
		Minimum	Maximum		
Sodium-22	0/2	0.00103 UJ	0.00145 UJ	ND	ND
Thorium-234	2/2	0.84 J	1.44 J	1.14	2.28
Tin-113	0/2	0.00006 UJ	0.00018 UJ	ND	ND
Tritium	0/2	3.89 U	4.71 U	ND	ND
Yttrium-88	0/2	0.00008 UJ	0.00022 UJ	ND	ND
Zinc-65	0/2	-0.00029 UJ	0.00086 UJ	ND	ND
Zirconium-95	2/2	0.00024 J	0.00049 J	0.0004	0.0007

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-11 Subsurface (10-12 feet) Background Analyte Concentrations - Radionuclides & Radionuclide Indicators

Radionuclides & Radionuclide Indicators	Frequency of Detection	Subsurface Site-Specific Background Conc. (pCi/g)		Avg. Background Conc. (pCi/g)	Criterion Background Conc. (pCi/g)
		Minimum	Maximum		
Actinium-228	4/4	1.20	1.58	1.41	2.82
Antimony-124	0/4	-0.00653 U	0.00425 U	ND	ND
Antimony-125	0/4	-0.00125 U	0.00683 U	ND	ND
Barium-133	0/4	-0.0298 U	0.00202 U	ND	ND
Cerium-144	0/4	-0.0241 U	0.00305 U	ND	ND
Cesium-134	1/4	-0.00920 U	0.00438 J	0.0013	0.0026
Cesium-137	2/4	-0.00183 U	0.0215	0.009	0.018
Cobalt-58	1/4	-0.00598 U	0.0131 J	0.003	0.006
Cobalt-60	0/4	0.0001 U	0.00412 U	ND	ND
Europium-154	0/4	-0.00831 U	0.00163 U	ND	ND
Europium-155	4/4	0.330	0.367	0.351	0.704
Gross Alpha	4/4	3.90 J	9.10	6.78	13.55
Lead-212	4/4	1.25	1.54	1.44	2.88
Manganese-54	4/4	0.0168	0.0276	0.022	0.043
Neptunium-239	4/4	0.798	0.886	0.842	1.69
Nonvolatile Beta	0/4	3.20 U	7.80 U	ND	ND
Potassium-40	4/4	1.26	1.82	1.49	2.98
Promethium-144	0/4	-0.00344 U	0.0255 U	ND	ND
Promethium-146	2/4	0.0191 J	0.00311 U	0.009	0.017
Ruthenium-106	1/4	-0.00547 U	0.04510 J	0.014	0.029

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-11 Subsurface (10-12 feet) Background Analyte Concentrations - Radionuclides & Radionuclide Indicators - (continued)

Radionuclides & Radionuclide Indicators	Frequency of Detection	Subsurface Site-Specific Background Conc. (pCi/g)		Avg. Background Conc. (pCi/g)	Criterion Background Conc. (pCi/g)
		Minimum	Maximum		
Sodium-22	0/4	-0.00053 U	0.00192 U	ND	ND
Thorium-234	4/4	0.652 J	0.727 J	0.686	1.372
Tin-113	1/4	-0.00185	0.00822	0.002	0.004
Tritium	0/4	0.0805 U	7.05 U	ND	ND
Yttrium-88	1/4	0.0227 U	0.0514 J	0.022	0.044
Zinc-65	1/4	-0.00175 U	0.0122 J	0.003	0.007
Zirconium-95	1/4	-0.0194 U	0.015 J	0.002	0.004

Criterion background concentration equals two times the average background concentration.

J - Estimate quantity

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-12 Residential Preliminary Remediation Goals (PRGs) - Radionuclides & Radionuclide Indicators

Radionuclides & Radionuclide Indicators	PRG Level* (pCi/g)
Actinium-228	0.0144
Antimony-124	0.00641
Antimony-125	0.0347
Barium-133	0.438
Cerium-144	1.64
Cesium-134	2.08
Cesium-137	0.0208
Cobalt-58	838
Coablt-60	0.00484
Europium-154	0.0102
Europium-155	0.706
Gross Alpha	NA
Lead-212	0.149
Manganese-54	0.0144
Neptunium-239	0.181
Nonvolatile Beta	NA
Potassium-40	0.0771
Promethium-144	NA
Promethium-146	NA
Ruthenium-106	81.0
Sodium-22	0.00579
Thorium-234	11.2
Tin-113	12.4
Tritium	14200
Yttrium-88	NA
Zinc-65	0.0208
Zirconium-95	0.0167

* This is the concentration that will achieve a 1.0E-06 risk. NA - Not available

Table 5-13 Surface (0-2 feet) Background Analyte Concentrations - Pesticides, PCBs, Dioxins/Furans

Pesticides/PCBs/Dioxins/ Furans	Frequency of Detection	Surface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
Aldrin	0/2	2.28 U	2.54 UJ	ND	ND

Table 5-14 Subsurface (10-12 feet) Background Analyte Concentrations - Pesticides/PCBs/Dioxins/Furans

Pesticides/PCBs/Dioxins/ Furans	Frequency of Detection	Subsurface Site-Specific Background Conc. (ug/kg)		Avg. Background Conc. (ug/kg)	Criterion Background Conc. (ug/kg)
		Minimum	Maximum		
Aldrin	0/4	0.457 U	0.501 U	ND	ND

Table 5-15 Residential Risk-Based Concentration (RBC) Levels - Pesticides/PCBs/Dioxins/Furans

Pesticides/PCBs/Dioxin/ Furans	RBC (mg/kg)
Aldrin	0.038 c

Criterion background concentration equals two times the average background concentration.

c - Carcinogenic effect or a value that will achieve a 1.0E-06 risk

ND - Not Determined (analyte concentrations were below sample quantification limit)

U - Analyte not detected; sample result below quantification limit

Table 5-16 Toxicity Characteristic Leaching Procedure Regulatory Levels

Constituent	Regulatory Level (mg/l)
1,1-Dichloroethylene	0.7
1,2-Dichloroethane	0.5
1,4-Dichlorobenzene	7.5
2,4,5-TP (Silvex)	1.0
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4-D	10.0
2,4-Dinitrotoluene	0.13
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
Cresol	200.0
Endrin	0.02
Heptachlor (and its hydroxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
m-Cresol	200.0

Table 5-16 Toxicity Characteristic Leaching Procedure Regulatory Levels (continued)

Constituent	Regulatory Level (mg/l)
Nitrobenzene	2.0
o-Cresol	200.0
Pentachlorophenol	100.0
Pyridine	5.0
p-Cresol	200.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
Vinyl Chloride (Chloroethene)	0.2

Table 5-17 Safe Drinking Water Act Maximum Contaminant Levels (SDWA MCLs)

Target Analyte List Constituents	MCL (mg/l)
Aluminum	NR
Antimony	0.0006
Arsenic	0.05
Barium (ionic)	2
Beryllium	0.004
Cadmium	0.005
Calcium	NR
Chromium (total)	0.1
Cobalt	NR
Copper	1.0*
Cyanide (as free cyanide)	0.2
Iron	NR
Lead	0.05**
Magnesium	NR
Manganese	NR
Mercury (inorganic)	0.002
Nickel	0.1
Potassium	NR
Selenium	0.05
Silver	NR
Sodium	NR
Vanadium	NR
Zinc	NR

* The SDWA standard for copper is a secondary MCL.

** - The SDWA standard for lead is an "at the tap" action level.

Volatile Organics	MCL (mg/l)
1,1-Dichloroethane	NR
1,2-Dichloroethane	0.005
Acetone	NR
Benzene	0.005
Carbon disulfide	NR
Carbon tetrachlotide	0.005
Chlorobenzene	0.1
Chloroethene (Vinyl Chloride)	0.002
Chloroform	0.1
Chloromethane	NR
Dichloromethane	0.005
Ethylbenzene	0.7
Methyl ethyl ketone	NR
Tetrachloroethylene	0.005
Toluene	1
Trichloroethylene	0.005
Xylenes	10

Pesticides/PCBs/ Dioxins/Furans	MCL (mg/l)
Aldrin	NR

MCL refers to primary MCL.

NR indicates no regulatory level has been set.

Table 5-17 Safe Drinking Water Act Maximum Contaminant Levels (SDWA MCLs) - (continued)

Semi-Volatile Organics	MCL (mg/l)
1,3-Dichlorobenzene	NR
1,4-Dichlorobenzene	0.075
2-Chlorophenol	NR
2-Methylnaphthene	NR
Acenaphthene	NR
Anthracene	NR
Benzo(a)anthracene	0.0001
Benzo(a)pyrene	0.0002
Benzo(b)fluoranthene	0.0002
Benzo(g,h,i)perylene	NR
Benzo(k)fluoranthene	0.0002
Benzoic Acid	NR
Bis(2-ethylhexyl)phthalate	NR
Butylbenzyl phthalate	0.1
Chrysene	0.0002
Di-n-butyl phthalate	NR
Di-n-octyl phthalate	NR
Dibenzofuran	NR
Fluoranthene	NR
Fluorene	NR
Indeno(1,2,3-cd)pyrene	0.0004
Napthalene	NR
Pentachlorophenol	0.001
Phenanthrene	NR
Pyrene	NR

Radionuclides & Radionuclide Indicators	MCL (pCi/l)
Actinium-228	NR
Antimony-124	NR
Antimony-125	NR
Barium-133	NR
Cerium-144	NR
Cesium-134	NR
Cesium-137	NR
Cobalt-58	NR
Cobalt-60	NR
Europium-154	NR
Europium-155	NR
Gross Alpha	15
Lead 212	NR
Manganese-54	NR
Neptunium-239	NR
Nonvolatile Beta	4 (mrem/yr)
Potassium-40	NR
Promethium-144	NR
Promethium-146	NR
Ruthenium-106	NR
Sodium-22	NR
Thorium-234	NR
Tin-113	NR
Tritium	**20000**
Yttrium-88	NR
Zinc-65	NR
Zirconium-95	NR

MCL refers to primary MCL.

NR indicates no regulatory level has been set.

background well. It should be noted that this well is sidegradient of the F-Area Separations Facility (a potentially contaminated area).

Surface water and sediment samples were taken from a small pond near the site, to which runoff from the site could potentially flow. No comparable water (or sediment) background locations were available in the vicinity. Therefore, sediment samples are compared to background surface soil samples **and discussed in the context of the RBC or PRG thresholds for soils;** and surface water is discussed in the context of SDWA MCLs.

5.3 Soils

The purpose of this investigation was to detemine the nature and horizontal and vertical extent of soil contamination at the BRRP. Samples from seventeen locations (BRRP 1 - 17, Figure 5-2) within the boundaries of suspected contamination in the BRRP area were analyzed. In general, the borings were located in areas where a soil gas anomaly was detected or adjacent to a potential underground source. **At a minimum,** for each sampling location, one surface sample and five samples from lower depths were analyzed. The complete results of soil analysis are presented in Appendix J.

As discussed in Section 5.2, background samples (Figure 5-1) were gathered to generate data for comparative analyses with soil samples taken from areas of suspected contamination. Subsurface soil samples were gathered from four locations (BR-01, BR-02, BR-03, and BR-04) at depths of 10 - 12 feet **(approximating the bottom of the pit).** Background surface samples were taken from two locations (BR-07 and BR-08) at depths of 0 - 2 feet.

5.3.1 *Metals*

Tables 5-18 and 5-19 summarize the results of analysis of metals in **surface and subsurface soils samples, respectively.** Soil sample metal concentrations are discussed in the context of **unit-specific background** and regulatory guideline levels.

Each individual sampling location and depth was compared to background samples: BR 0101, BR 0201, BR 0301, BR 0401, BR 0701,and BR 0801. This method was selected since there were multiple data points for the background grouping against which individual samples could be tested. This approach was selected over the other methods due to the limited number of non-background data

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DATE	09/27/94
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DATE	
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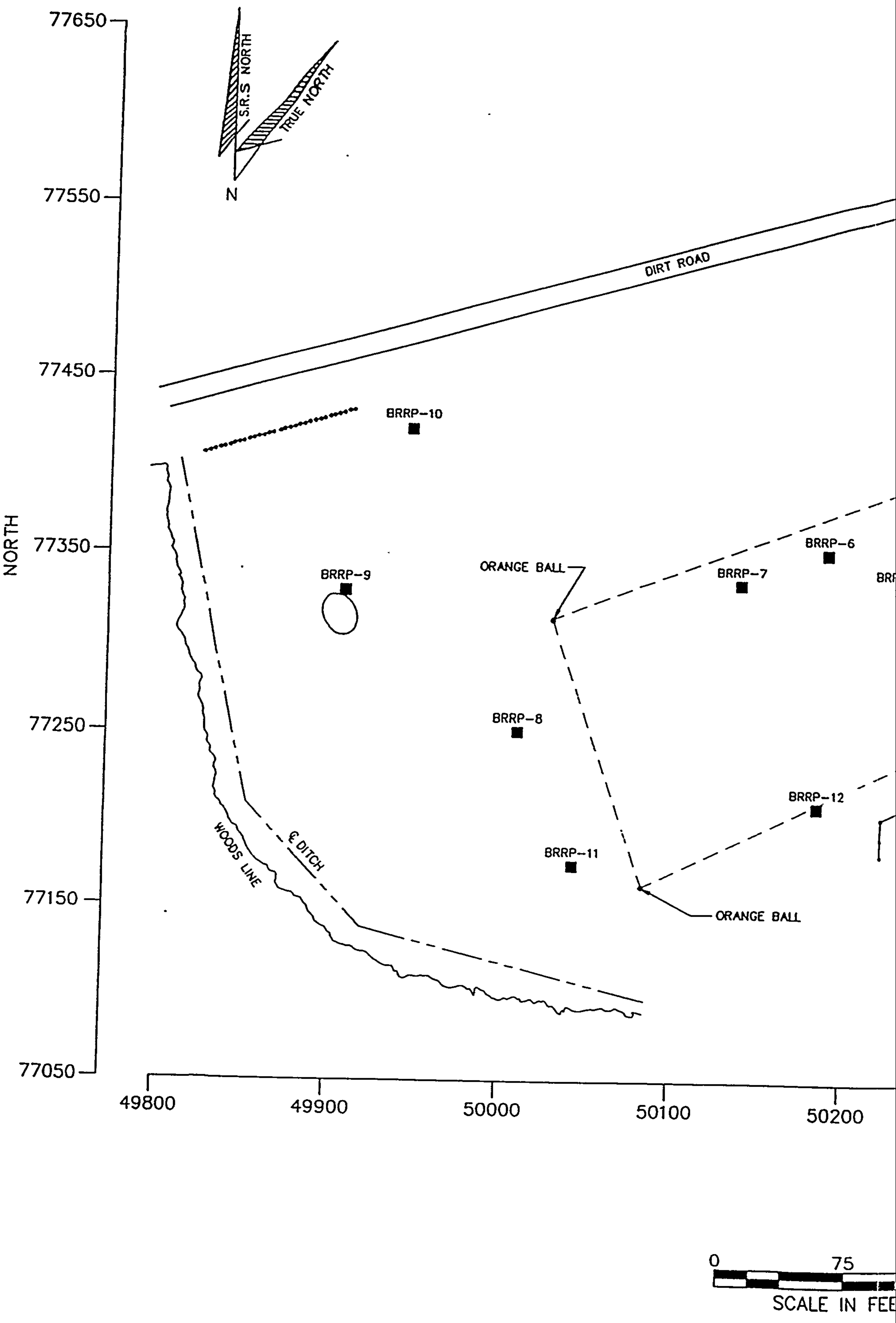

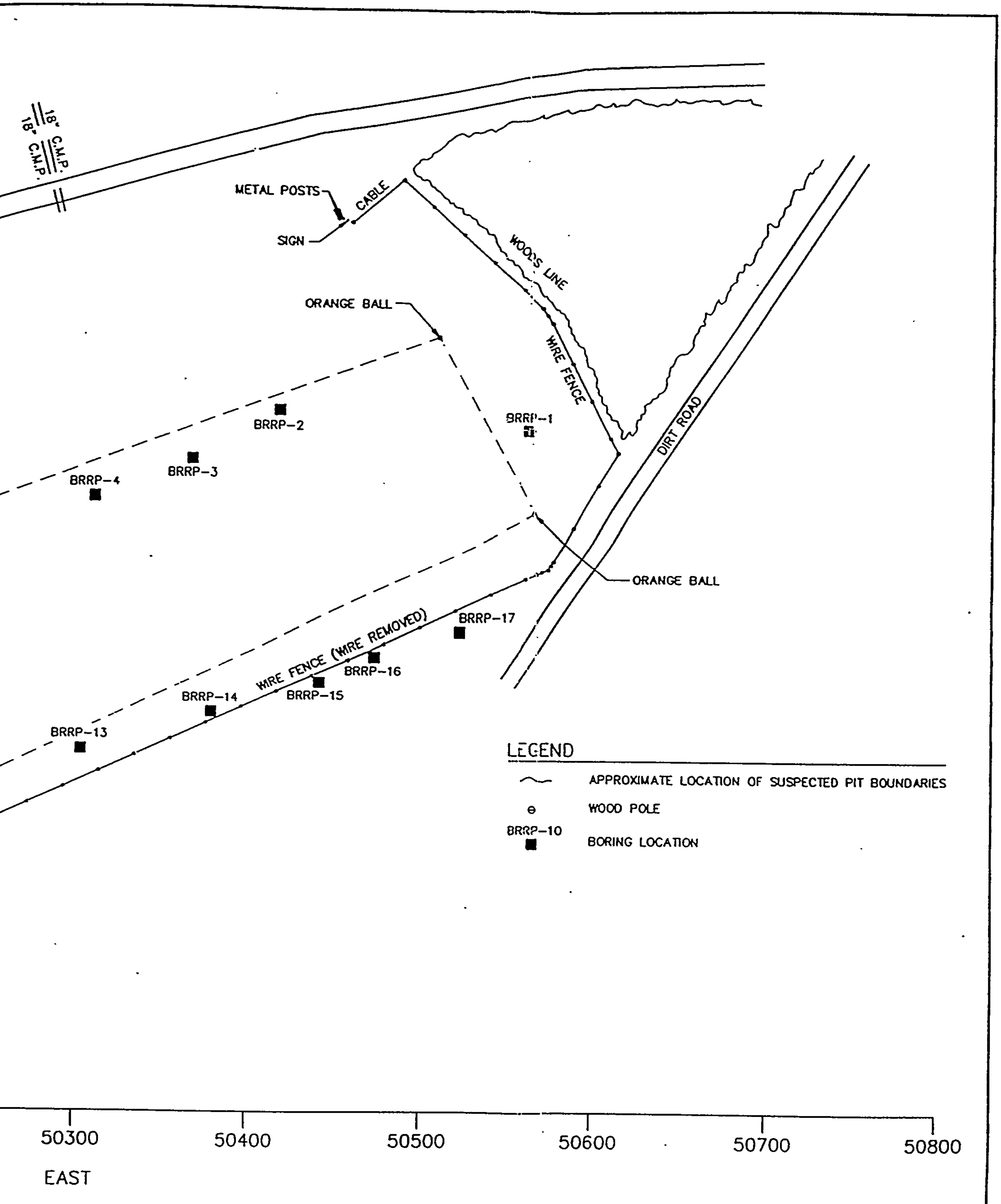

METCALF & EDDY

LOCATION OF BORINGS DRILLED IN AREAS OF SUSPECTED CONTAMINATION

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA

FIGURE 5-2

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Table 5-18 Summary of Surface Sampling Results - Target Analyte List

Target Analytes	Frequency of Detection	Surface Soil Sample Concentration (mg/kg)	Number > CBC	Soil Boring Number	Depth (feet)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected						
Aluminum	17/17	19000	1/17	BRRP 08	0-2	0/17	NA	NA
Antimony	2/17	6.07	NC	NA	NA	0/17	NA	NA
Arsenic	2/17	4.33	NC	NA	NA	2/17	BRRP 06, 15	0 - 2
Barium	17/17	30.2	0/17	NA	NA	0/17	NA	NA
Beryllium	17/17	0.221	0/17	NA	NA	9/17	BRRP 02-05, 07, 08, 14-16	0-2
Cadmium	0/17	ND	NC	NA	NA	0/17	NA	NA
Calcium	17/17	360	0/17	NA	NA	NR	NA	NA
Chromium	17/17	33.5	4/17	BRRP 03, 06, 08, 11	0-2	0/17	NA	NA
Cobalt	17/17	1.20	0/17	NA	NA	0/17	NA	NA
Copper	17/17	5.95	2/17	BRRP 03, 08	0-2	0/17	NA	NA
Cyanide	8/17	0.493	2/17	BRRP 03, 10	0-2	0/17	NA	NA
Iron	17/17	28200	11/17	BRRP 03, 05, 06, 07, 08, 09, 11, 12, 14, 15, 16	0-2 0-2	NR	NA	NA
Lead	17/17	6.54	0/17	NA	NA	NR	NA	NA
Magnesium	17/17	224	0/17	NA	NA	NR	NA	NA
Manganese	17/17	139	0/17	NA	NA	0/17	NA	NA
Mercury	15/17	0.395	1/17	BRRP 09	0-2	0/17	NA	NA
Nickel	16/17	17.6	1/17	BRRP 10	0-2	0/17	NA	NA
Potassium	16/17	136	0/17	NA	NA	NR	NA	NA
Selenium	0/17	ND	NC	NA	NA	NA	NA	NA
Silver	0/17	ND	NC	NA	NA	NA	NA	NA
Sodium	7/17	22.5	1/17	BRRP 08	0-2	NR	NA	NA
Thallium	0/17	ND	NA	NA	NA	NA	NA	NA
Vanadium	17/17	65.1	9/17	BRRP 03, 05, 06, 07, 08, 11, 12, 15, 16	0-2 0-2	0/17	NA	NA
Zinc	17/17	11.1	0/17	NA	NA	0/17	NA	NA

NA = Not applicable
NC = No criterion background concentration
ND = Not detected (sample was below the quantification limit)
NR = No regulatory level (RBC)

Table 5-19 Summary of Subsurface Sampling Results - Target Analyte List

Target Analytes	Frequency of Detection	Subsurface Soil Sample Concentration (mg/kg)	Number > CBC	Soil Boring Number	Depth (feet)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected						
Aluminum	51/51	18600	3/51	BRRP 02	8 - 10	0/51	NA	NA
				BRRP 02	10 - 12			
				BRRP 07	16 - 18			
Antimony	3/51	3.49	NC	NA	NA	0/51	NA	NA
Arsenic	6/85	4.77	0/85	NA	NA	6/85	BRRP 12	6 - 8
							BRRP 02, 12	8 - 10
							BRRP 02, 10, 15	10 - 12
Barium	85/85	18.3	3/85	BRRP 02	8 - 10	0/85	NA	NA
				BRRP 02	10 - 12			
				BRRP 07	16 - 18			
Beryllium	51/51	0.198	3/51	BRRP 02	8 - 10	3/51	BRRP 02	8 - 10
				BRRP 10	10 - 12		BRRP 10	10 - 12
				BRRP 07	16 - 18		BRRP 07	16 - 18
Cadmium	3/85	0.344	NC	NA	NA	0/85	NA	NA
Calcium	50/51	408	12/51	BRRP 02	8 - 10	NR	NA	NA
				BRRP 14, 14A, 15, 15A	10 - 12			
				BRRP 13, 13A	13-15			
				BRRP 03, 05, 13	15 - 17			
				BRRP 07	16 - 18			
				BRRP 13	17 - 19			
Chromium	85/85	29.9	6/85	BRRP 02	8 - 10	0/85	NA	NA
				BRRP 11, 12, 14A, 17	10 - 12			
				BRRP 07	16 - 18			
Cobalt	32/85	1.08	1/85	BRRP 07	16 - 18	0/85	NA	NA
Copper	51/51	34.6	2/51	BRRP 05, 05A	19 - 21	0/51	NA	NA
Cyanide	29/51	0.353	15/51	BRRP 12	6 - 8	0/51	NA	NA
				BRRP 02	8 - 10			
				BRRP 01, 08, 10, 15, 15A, 16	10 - 12			
				BRRP 02, 14, 15	12 - 14			
				BRRP 01, 10, 11	14 - 16			
				BRRP 07	20 - 22			
Iron	51/51	26700	4/51	BRRP 12	6 - 8	NR	NA	NA
				BRRP 02	8 - 10			
				BRRP 17	10 - 12			
				BRRP 07	16 - 18			
Lead	72/85	9.04	0/85	NA	NA	NR	NA	NA
Magnesium	51/51	332	6/51	BRRP 02	8 - 10	NR	NA	NA
				BRRP 02	10 - 12			
				BRRP 02	12 - 14			
				BRRP 03, 05	15 - 17			
				BRRP 07	16 - 18			
Manganese	51/51	52.1	3/51	BRRP 03, 05	15 - 17	0/51	NA	NA
				BRRP 07	16 - 18			
Mercury	32/85	0.204	20/85	BRRP 02, 12	8 - 10	0/85	NA	NA
				BRRP 02, 10, 14, 14A	10 - 12			
				BRRP 02, 11	12 - 14			
				BRRP 08, 09, 10	14 - 16			
				BRRP 04, 06, 07	16 - 18			
				BRRP 03	17 - 19			
				BRRP 12, 14, 14A, 17	20 - 22			
				BRRP 13	27 - 29			
Nickel	20/51	73.8	7/51	BRRP 02	8 - 10	0/51	NA	NA
				BRRP 14A	10 - 12			
				BRRP 13A	13 - 15			
				BRRP 14	14 - 16			
				BRRP 03, 05	15 - 17			
				BRRP 07	16 - 18			
Potassium	16/51	158	7/51	BRRP 02	8 - 10	NR	NA	NA
				BRRP 13, 13A	13 - 15			
				BRRP 03, 05	15 - 17			
				BRRP 07	16 - 18			
				BRRP 04	18 - 20			
Selenium	1/85	4	NC	NA	NA	0/85	NA	NA
Silver	1/85	0.313	NC	NA	NA	0/85	NA	NA
Sodium	21/51	55.2	NC	NA	NA	NR	NA	NA
Thallium	0/51	ND	NA	NA	NA	NA	NA	NA
Vanadium	51/51	63.2	1/51	BRRP 02	8 - 10	0/51	NA	NA
Zinc	51/51	16.6	4/51	BRRP 02	8 - 10	0/51	NA	NA
				BRRP 03, 05	15 - 17			
				BRRP 07	16 - 18			

A = Duplicate sample
ND = Not detected (sample was below the quantification limit)
NA = Not applicable
NC = No criterion background concentration
NR = No regulatory level (RBC)

observations. Individual location/depth observations were compared to the **CBC** of the background grouping.

Thallium was not detected in any soil samples. Otherwise, all metals analyzed for in the samples were detected in at least some of the samples.

Aluminum

Aluminum was detected in all of the surface and subsurface soil samples. **The maximum concentration detected was 19000 mg/kg in the surface soil and 18600 in the subsurface soil. These values are above the CBC of 15310 mg/kg for surface soil and 7735 mg/kg for the subsurface soil concentrations. However, the maximum surface and subsurface soil samples are below the residential RBC level (noncarcinogenic) of 78000 mg/kg. Therefore, aluminum was not considered a contaminant of potential concern for the BRRP waste unit.**

Antimony

Antimony was detected in 2 of 17 surface soil samples with a maximum concentration of 6.07 mg/kg. Antimony was also detected in 3 of 51 subsurface soil samples with a maximum concentration of 3.49 mg/kg. No CBC exists for this compound as the background data were below quantification limits. These values are both below the RBC level (noncarcinogenic) of 31 mg/kg. Therefore, antimony was not considered as a contaminant for the BRRP.

Arsenic

Arsenic was detected in 2 of 17 surface soils with a maximum concentration of 4.33 mg/kg. Arsenic was also detected in 6 of 85 subsurface soils with a maximum concentration of 4.77 mg/kg. Table 5-20 shows the samples and depths of arsenic concentrations. No CBC exists for arsenic in the surface soil; however, these values are below the CBC of 6.88 mg/kg for subsurface soils and the RBC level (noncarcinogenic) of 23 mg/kg. Both of the surface and subsurface soils maximum concentration values are above the RBC level (carcinogenic) of 0.37 mg/kg. All the values for the soil borings are plotted on cross sections (see Figures 5-3 and 5-4).

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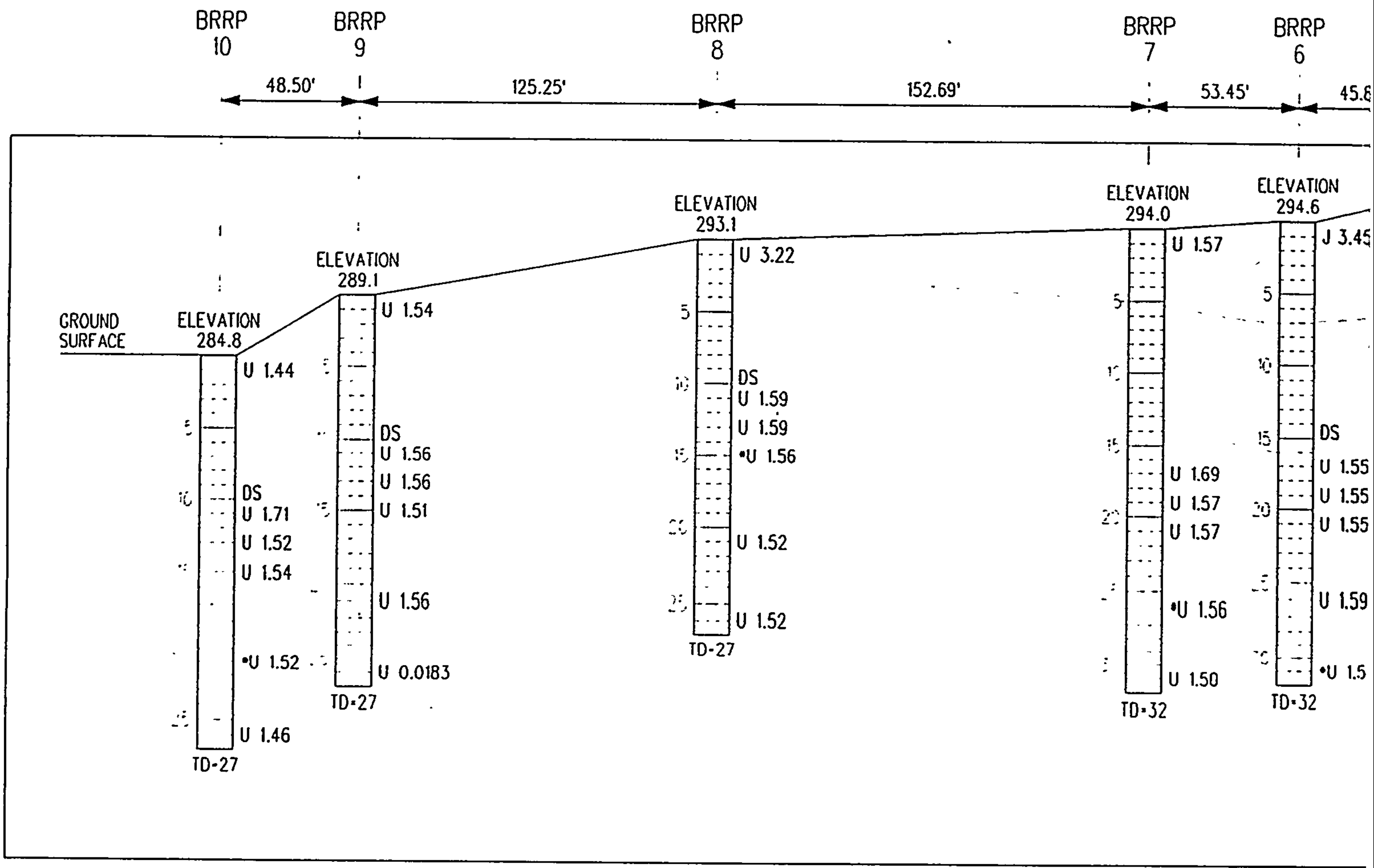
CROSS-SECTI
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN PPM

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

• - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

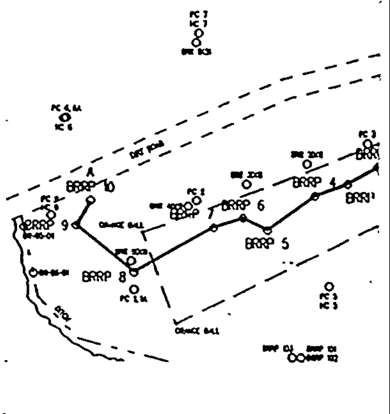
PIT CONTOUR SHOWN DASHED WHERE INFERRED

SURFACE CBC - N/A

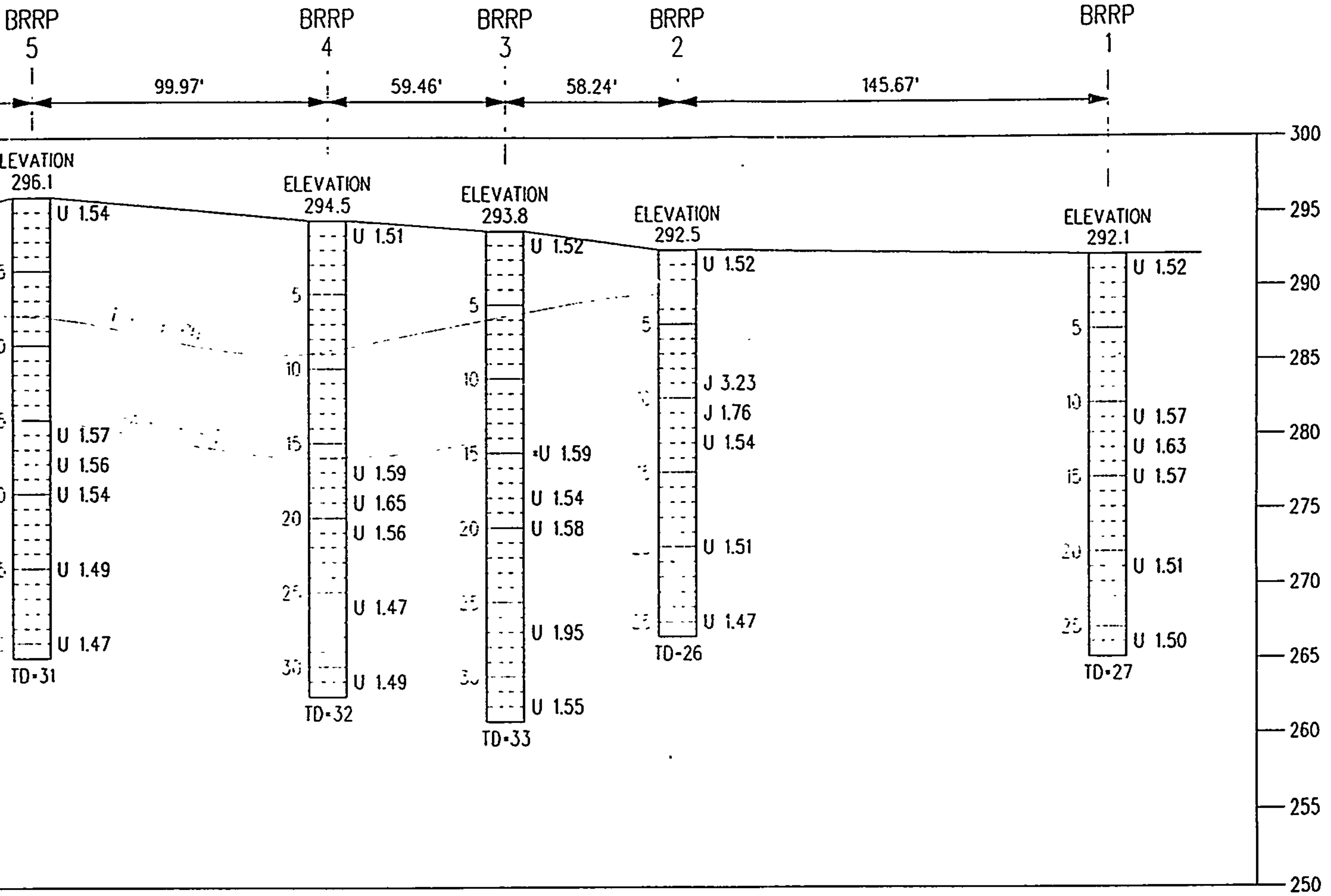
SUBSURFACE CBC - 6.68 mg/kg

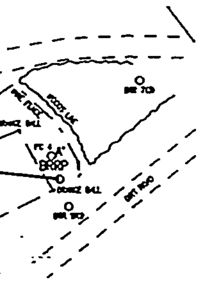
RBC LEVEL - 23 mg/kg (NONCARCINOGENIC)
0.37 mg/kg (CARCINOGENIC)

NO VALUE EXCEEDS CBC



N A-A'
JBBLE PIT





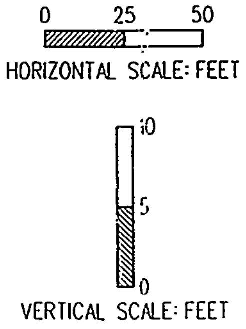


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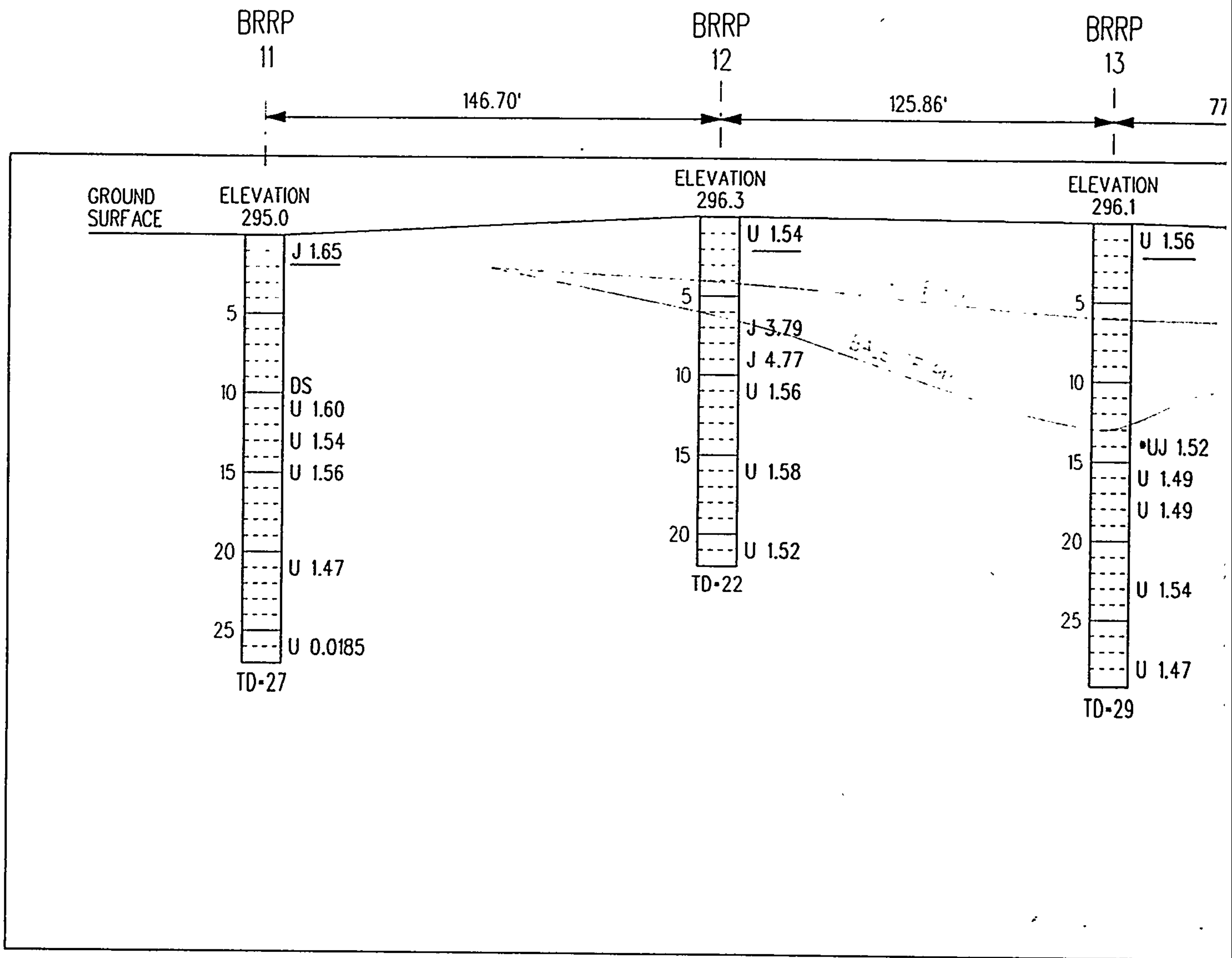
FIGURE 5-3
ARSENIC CONCENTRATION MG/KG (PPM)
BURMA ROAD RUBBLE PIT
CROSS SECTION A-A'

CREATED BY ET ALEXANDER	DATE 6-8-95	APPROVED BY NA	DATE NA
PREPARED BY TOM McADAMS	DATE 6-8-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE 5-35

CROSS-SECTI
BURMA ROAD R



NOTES:

CONTAMINANT VALUES NOTED ARE IN PPM

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS = DISTURBED SOIL

NA = NOT ANALYZED FOR THIS CONTAMINANT

• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

* - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17) (IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

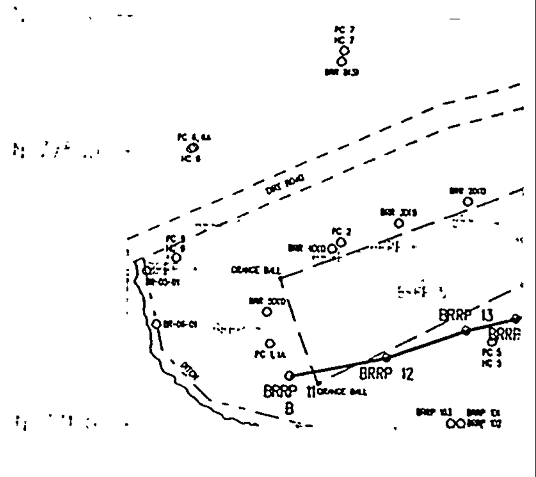
PIT CONTOUR SHOWN DASHED WHERE INFERRED

SURFACE CBC = NA

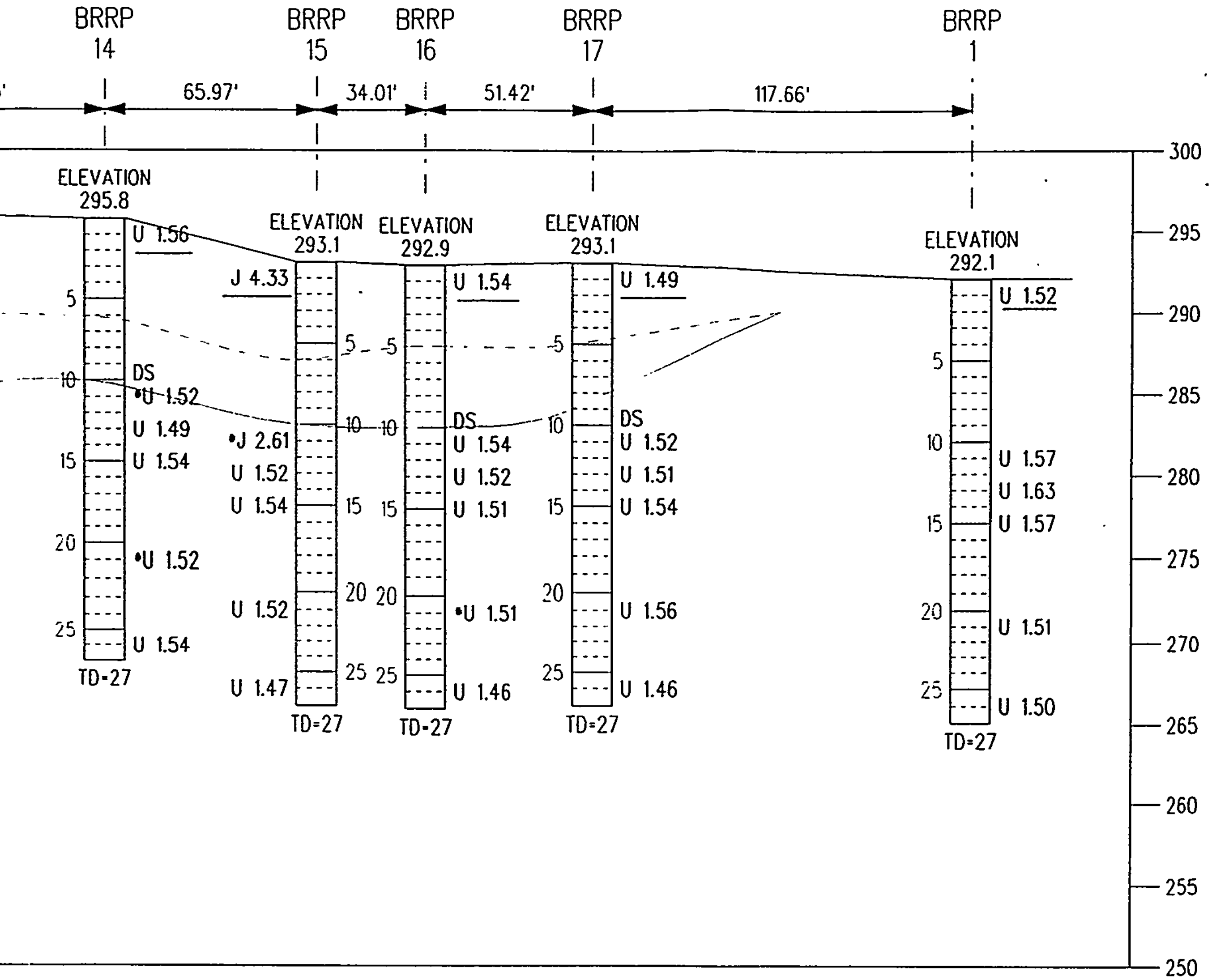
SUBSURFACE CBC - 6.68 mg/kg

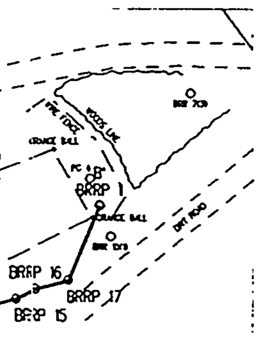
RBC LEVEL - 23mg/kg (NONCARCINOGENIC)
0.37 mg/kg (CARCINOGENIC) - VALUES ABOVE UNDERLINED

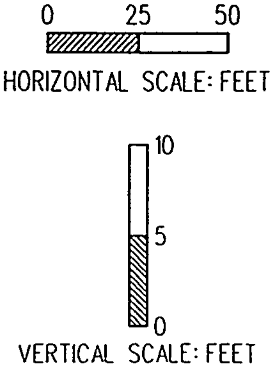
NO VALUE EXCEEDS CBC FOR SURFACE



N B-B'
BBLE PIT

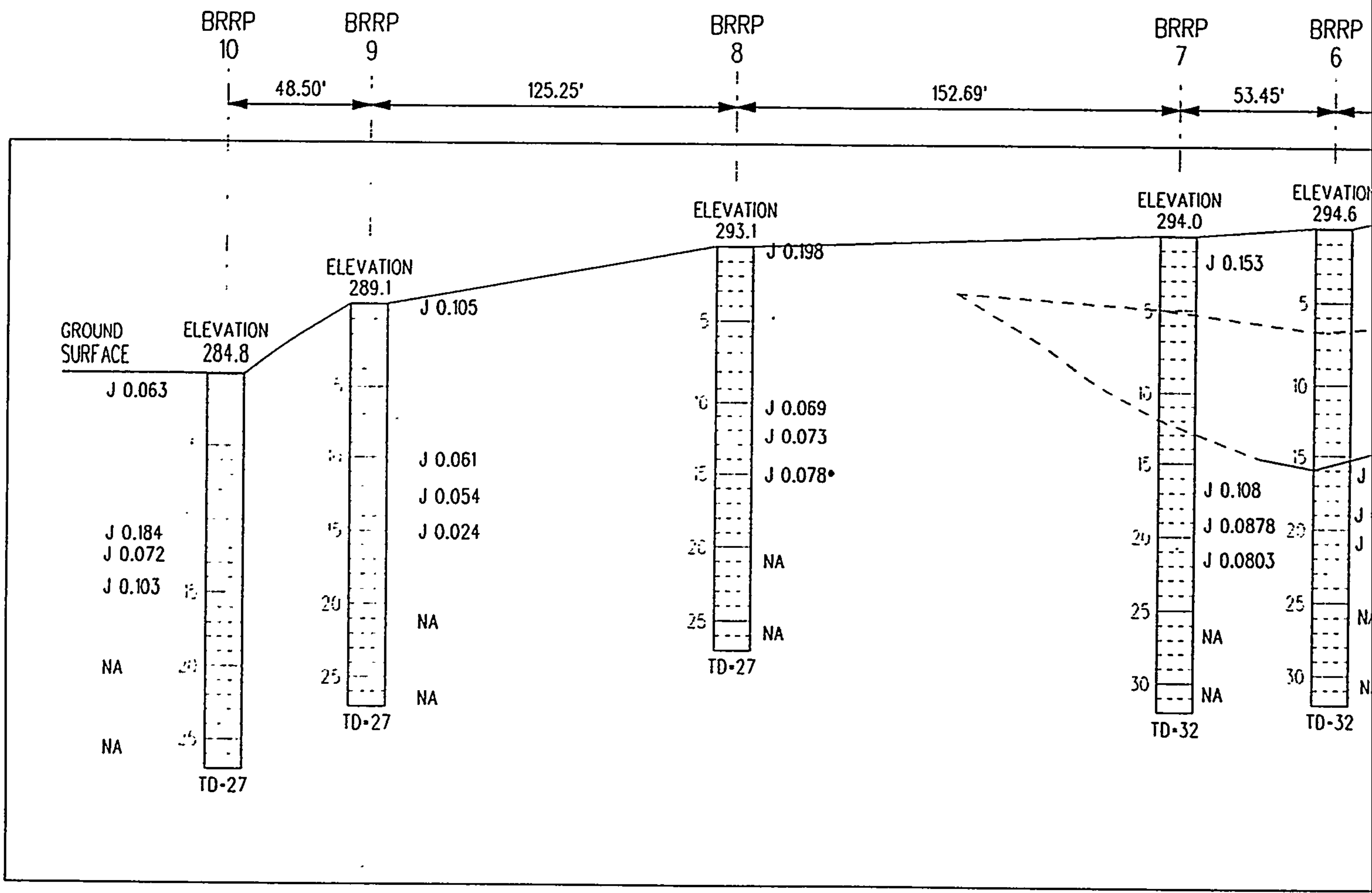






DWG NO. SS1822	REV. NO. 0	REV. DATE 6-8-95	AREA GSA
SAFETY • RESPONSIBILITY • SECURITY SRS SAVANNAH RIVER SITE	ENVIRONMENTAL RESTORATION "Restoring the Environment Today for a Cleaner Tomorrow"		
TITLE FIGURE 5-4 ARSENIC CONCENTRATION MG/KG (PPM) BURMA ROAD RUBBLE PIT CROSS SECTION B-B'			
CREATED BY TRACY HICKLEY	DATE 6-8-95	APPROVED BY NA	DATE NA
PREPARED BY TOM McADAMS	DATE 6-8-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE 5-37

CROSS-SE
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN PPM

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

• - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

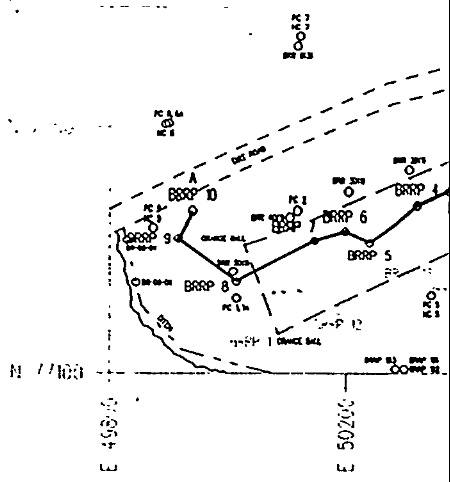
PIT CONTOUR SHOWN DASHED WHERE INFERRED

SURFACE SOIL CBC - 0.555 mg/kg

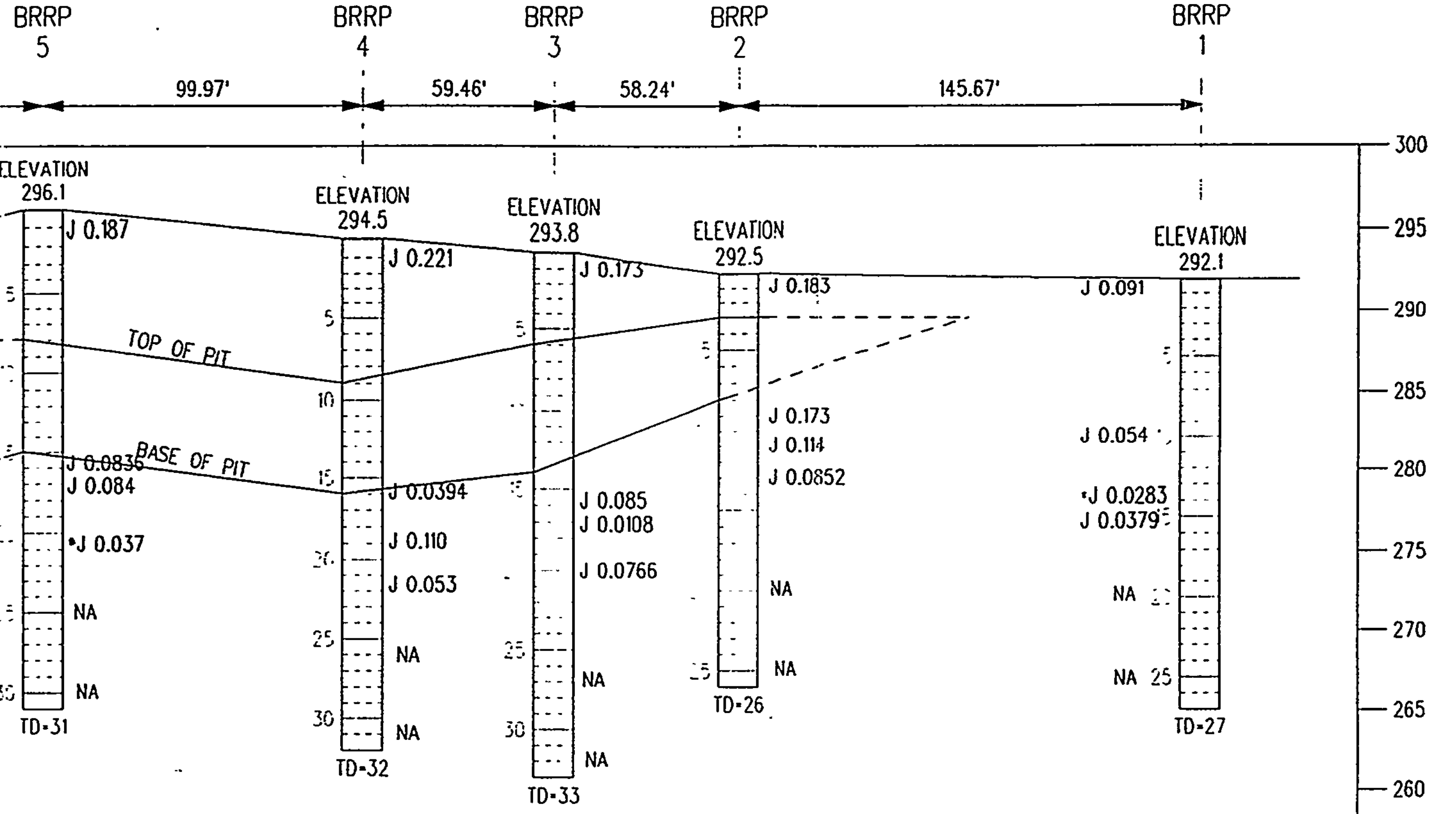
SUBSURFACE SOIL CBC - 0.1298 mg/kg

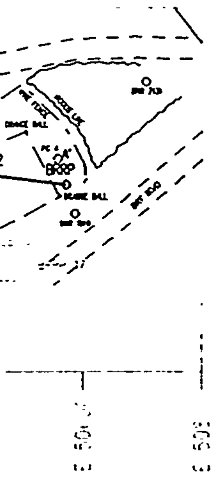
RBC LEVEL - 0.15 MG/KG

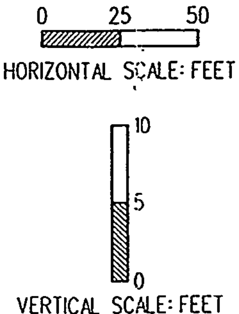
NO VALUES EXCEED CBC



ON A-A'
UBBLE PIT







DWG NO.	REV. NO.	REV. DATE	AREA
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TITLE
FIGURE 5-5
BERYLLIUM CONCENTRATION MG/KG (PPM)
BURMA ROAD RUBBLE PIT
CROSS SECTION A-A'

CREATED BY TRACY L. MICKLEY	DATE 06-29-95	APPROVED BY NA	DATE 95
REVIEWED BY TOM MCADAMS	DATE 06-29-95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95

Table 5-20 Arsenic Concentrations in Soil Samples

Sample	Depth (ft)	Concentration (mg/kg)
BRRP 06	0 - 2	3.45
BRRP 15	0 - 2	4.33
BRRP 12	6 - 8	3.79
BRRP 02	8 - 10	3.23
BRRP 12	8 - 10	4.77
BRRP 02	10 - 12	1.76
BRRP 10	10 - 12	1.71
BRRP 15	10 - 12	2.61

Barium

Barium was detected in all surface and subsurface soil samples. **The maximum value detected was 30.2 mg/kg in the surface soil and 18.3 mg/kg in the subsurface soil. The maximum value detected in the surface soil is below the CBC of 139.9 mg/kg; however, the maximum value detected in the subsurface soils is above the CBC of 6.60 mg/kg. Both the maximum surface and subsurface soil values are below the RBC level (noncarcinogenic) of 5500 mg/kg. Therefore, barium was not considered as a contaminant at the BRRP.**

Beryllium

Beryllium was detected in all surface and subsurface soil samples. **The maximum value detected was 0.221 mg/kg in the surface soil and 0.198 mg/kg in the subsurface soil. The maximum value detected in the surface soil is below the CBC of 0.555 mg/kg; although, the maximum value detected in the subsurface soils is above the CBC of 0.1298 mg/kg. Both of the maximum values are above the RBC level (carcinogenic) of 0.15 mg/kg. The values above detection limits for all soil borings are plotted on cross sections (see Figures 5-5 and 5-6). Although, beryllium is considered a potential contaminant in the RFI/RI Report, it did not pose any risk in the BRA.**

Cadmium

Cadmium was not detected in any surface soil samples. Cadmium was detected in three subsurface soil samples: BRRP 03 at a depth of 10 - 12 feet (0.344 mg/kg), BRRP 05 at a depth of 10 - 12 feet (0.34 mg/kg), and BRRP 03 at a depth of 26 - 28 feet (0.255 mg/kg). **No CBC exists for this compound as the background data were below quantification limits. The maximum concentration**

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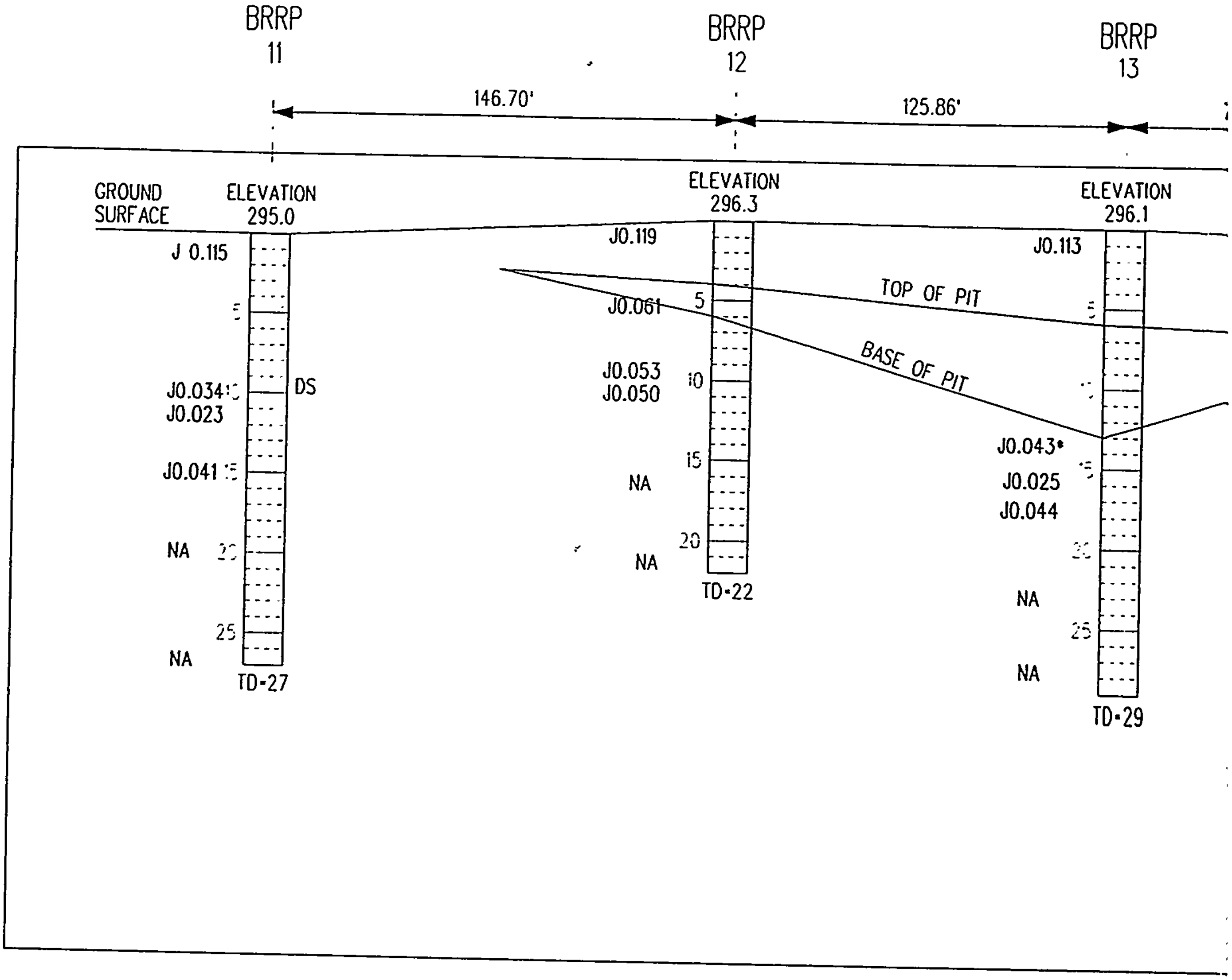
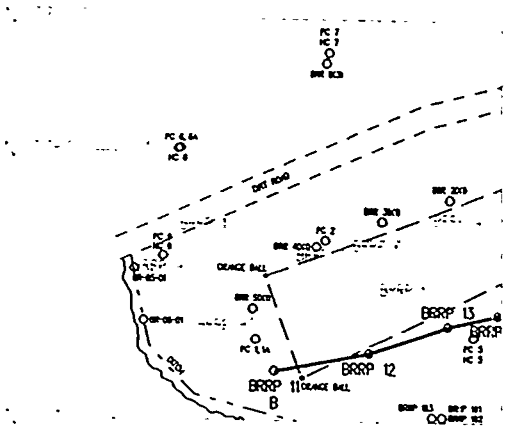
CROSS-SECT
BURMA ROAD



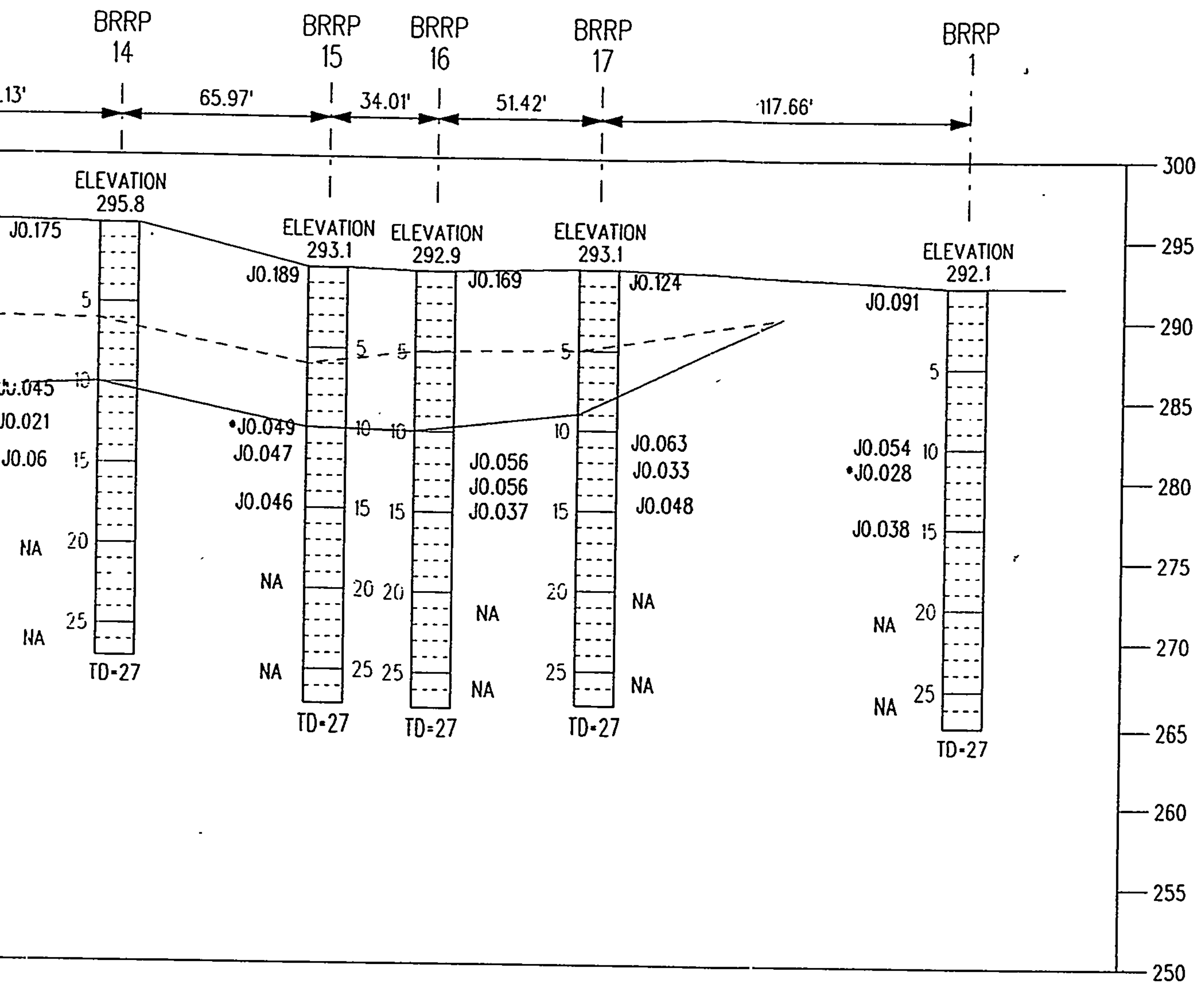


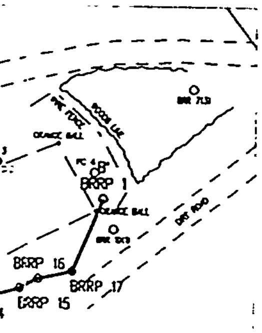
NOTES:

CONTAMINANT VALUES NOTED ARE IN PPM
CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE
U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT
J - RESULT IS AN ESTIMATED VALUE
DS = DISTURBED SOIL
NA - NOT ANALYZED FOR THIS CONTAMINANT
* - MAXIMUM VALUE OF DUPLICATE ANALYSIS
: - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)
PIT CONTOUR SHOWN DASHED WHERE INFERRED

SURFACE SOIL CBC = 0.555 mg/kg
SUBSURFACE SOIL CBC = 0.1298 mg/kg } VALUES WHICH EXCEED CBS - UNDERLINED
RBC LEVEL - 0.15 MG/KG

ON B-B'
UBBLE PIT





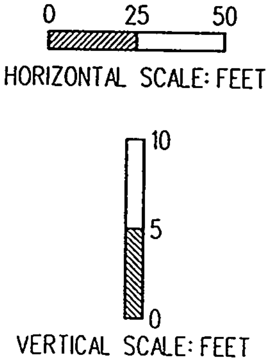


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FIGURE 5-6
BERYLLIUM CONCENTRATION MG/KG (PPM)
BURMA ROAD RUBBLE PIT
CROSS SECTION B-B'

	DATE	APPROVED BY	DATE
CREATED BY TRACY L. MICKLEY	06-29-95	NA	95
PREPARED BY TOM MCADAMS	06-29-95	NA	95
APPROVED BY NA	95	NA	95
APPROVED BY NA	95	NA	95

was below the RBC level (noncarcinogenic) of 39 mg/kg. Therefore, cadmium was not considered for further evaluation as a potential contaminant at the BRRP.

Calcium

Calcium was detected in all surface samples and in all but one subsurface sample. The maximum value detected was 360 mg/kg in the surface soils and 408 mg/kg in the subsurface soils. The maximum value detected in the surface soil is below the CBC of 867 mg/kg; however, the maximum value detected in the subsurface soils is above the CBC of 50.6 mg/kg. No RBC level has been set for calcium. Calcium is noted as being one of six essential elements in the BRA. A comparison of these six essential elements with their respective recommended dietary allowance (RDA) and/or estimated safe and adequate daily dietary intakes (ESADDI) was made in the BRA. The comparison demonstrated that the concentration detected would not exceed the RDAs or ESADDIs if site-specific soil concentrations were ingested. Therefore, calcium was not considered further as a potential contaminant at BRRP.

Chromium

Chromium was detected in all surface and subsurface samples. The maximum value detected was 33.5 mg/kg in the surface soil and 29.9 mg/kg in the subsurface soil. Both of these values are above the CBCs for surface (14.25 mg/kg) and subsurface (19.72 mg/kg) soil samples. All of the values are below the RBC level (noncarcinogenic) of 390 mg/kg. Therefore, chromium was not considered a potential contaminant at the BRRP.

Cobalt

Cobalt was detected in all surface samples and in 32 subsurface samples. The maximum value detected was 1.2 mg/kg in the surface soil and 1.08 mg/kg in the subsurface soil. The maximum value detected in the surface soil is below the CBC of 2.44 mg/kg. However, the maximum value detected in the subsurface soils is above the CBC of 0.834 mg/kg. All of the values are below the RBC (noncarcinogenic) level of 4700 mg/kg. Therefore, cobalt is not considered a potential soil contaminant at the BRRP.

Copper

Copper was detected in all the surface and subsurface samples. The maximum values detected were 5.95 mg/kg and 34.6 mg/kg for surface and subsurface soils, respectively. The maximum CBC values were exceeded for both surface (5.27 mg/kg) and subsurface (8.42 mg/kg) soils. However, the RBC (noncarcinogenic) level of 2900 mg/kg was not exceeded. Copper is noted as being one of six essential elements in the BRA. A comparison of these six essential elements with their respective RDA and/or ESADDI was made in the BRA. The comparison demonstrated that the concentration detected would not exceed the RDAs or ESADDIs if site-specific soil concentrations were ingested. Therefore, copper was not considered further as a potential contaminant at BRRP.

Cyanide

Cyanide was detected in 8 of 17 surface soil samples and 29 of 51 subsurface samples. The maximum values detected in the surface (0.493 mg/kg) soil and subsurface (0.353 mg/kg) soil were above their respective CBC values - surface (0.372 mg/kg) and subsurface (0.152 mg/kg). Both values are below the RBC (noncarcinogenic) level of 1600 mg/kg. Therefore, cyanide is not considered a potential contaminant at the BRRP.

Iron

Iron was detected in all subsurface and surface soils analyzed. The maximum value detected was 28200 mg/kg in the surface soil and 26700 mg/kg in the subsurface soil. Both of these values are above the CBC of 9.20 mg/kg for surface soil and 15750 mg/kg for subsurface soil. No regulatory (RBC) level has been set for iron. Iron is noted as being one of six essential elements in the BRA. A comparison of these six essential elements with their respective RDA and/or ESADDI was made in the BRA. The comparison demonstrated that the concentration detected would not exceed the RDAs or ESADDIs if site-specific soil concentrations were ingested. Therefore, iron was not considered further as a potential contaminant at BRRP.

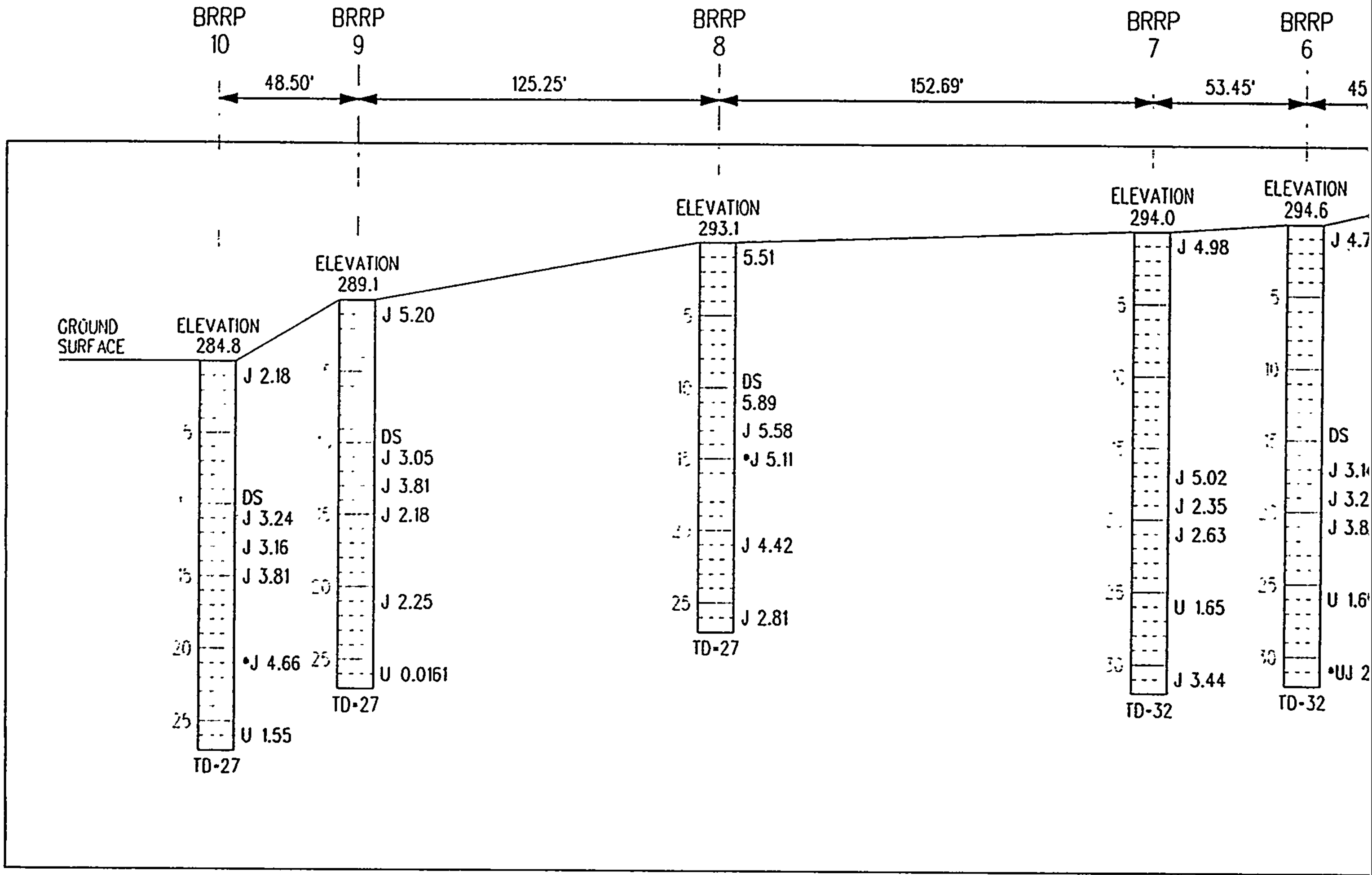
Lead

Lead was detected in all surface soil samples with a maximum concentration of 6.54 mg/kg. Lead was also detected in 72 of the 85 subsurface soil samples with a maximum concentration of 9.04 mg/kg. Both of these values are below the surface soil CBC of 18.31 mg/kg and the subsurface soil CBC of 9.38 mg/kg. No RBC level exists for lead in soil. All the soil boring values are posted on cross sections (see Figures 5-7 and 5-8).

Magnesium

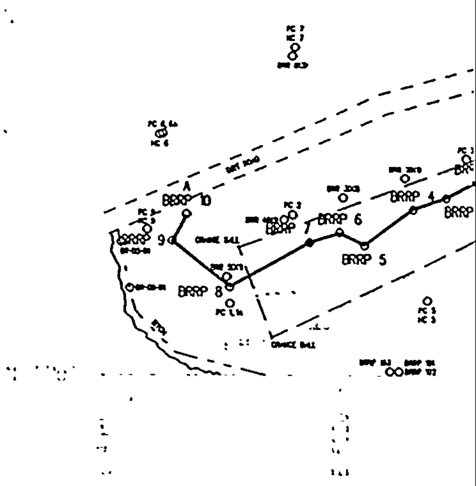
Magnesium was detected in all the surface soils and subsurface samples. The maximum value detected was 224 mg/kg in the surface soil and 332 mg/kg in the subsurface soil. The maximum value detected for the surface soils is below the CBC of 356.4 mg/kg. However, the maximum

CROSS-SECT
BURMA ROAD

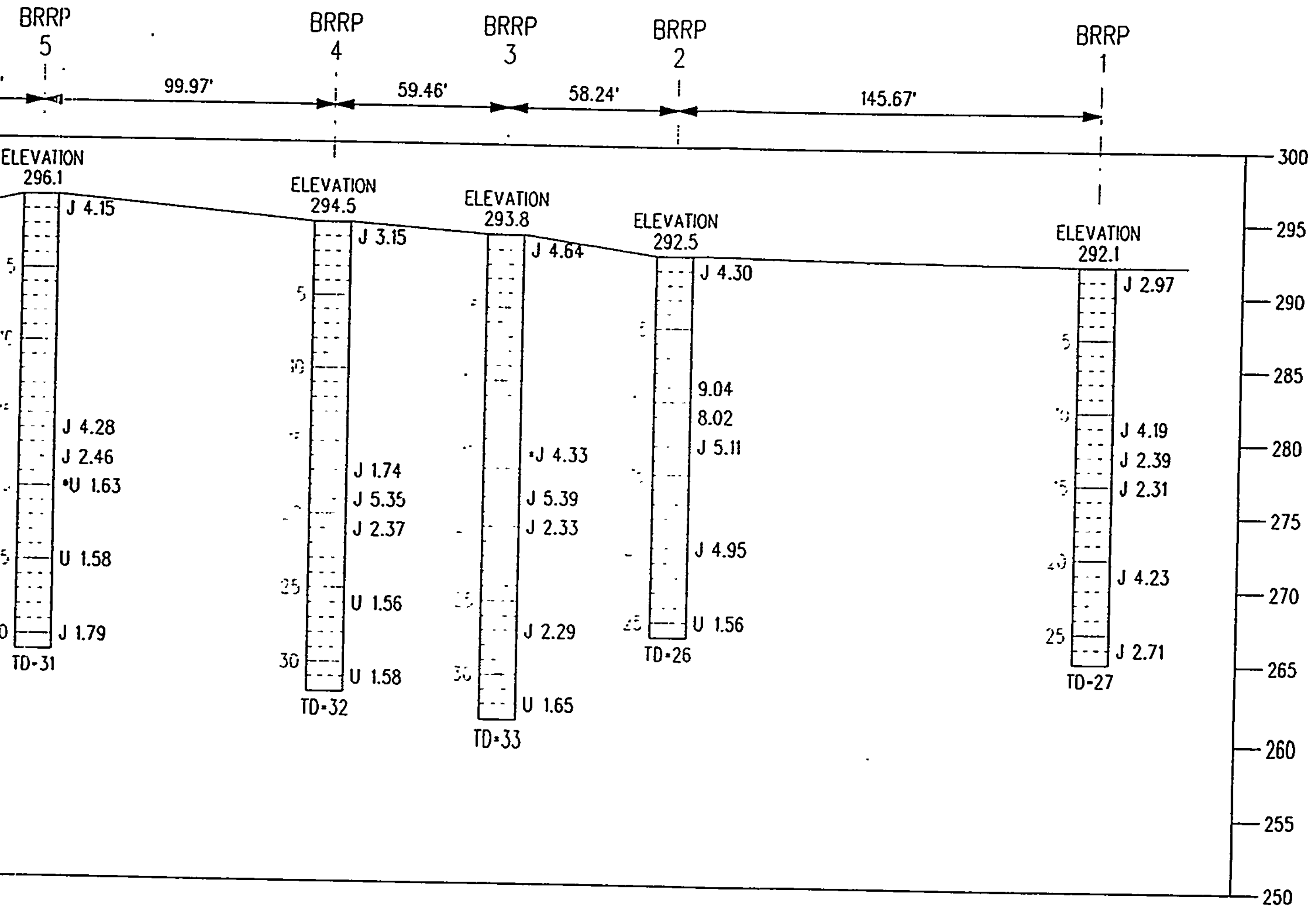


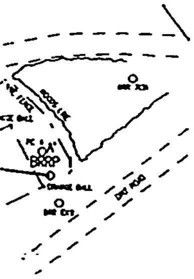
NOTES:

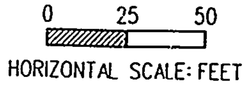
CONTAMINANT VALUES NOTED ARE IN PPM
CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE
U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT
J - RESULT IS AN ESTIMATED VALUE
DS - DISTURBED SOIL
NA - NOT ANALYZED FOR THIS CONTAMINANT
• - MAXIMUM VALUE OF DUPLICATE ANALYSIS
▪ - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)
SURFACE CBC - 18.31 mg/kg
SUBSURFACE CBC - 9.38 mg/kg
RBC LEVEL - N/A
NO CBC'S EXCEEDED



ON A-A'
UBBLE PIT







HORIZONTAL SCALE: FEET

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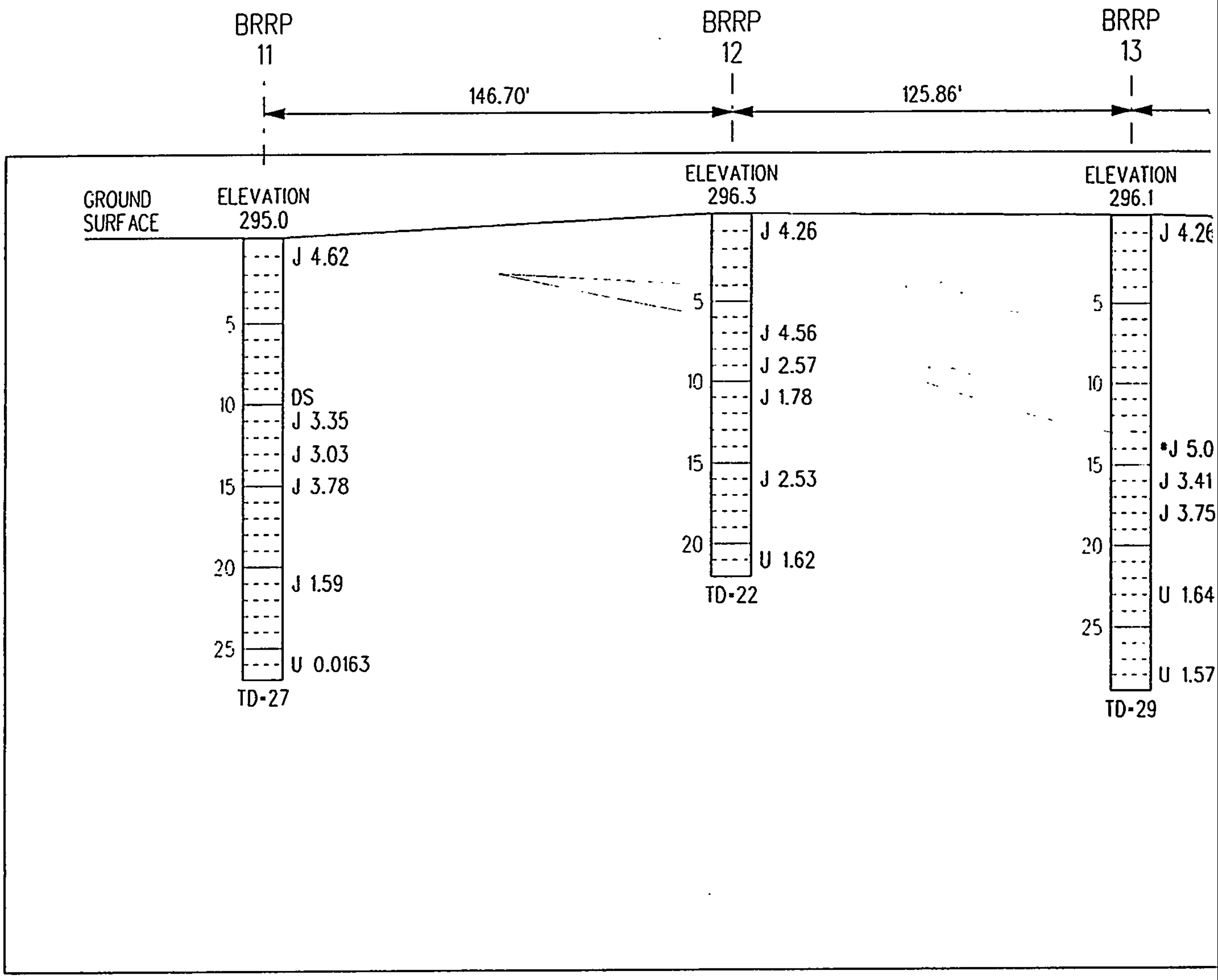
FIGURE 5-7
LEAD CONCENTRATION MG/KG (PPM)
BURMA ROAD RUBBLE PIT
CROSS SECTION A-A'

CREATED BY ET ALEXANDER	DATE 5-10-95	APPROVED BY NA	DATE NA
PREPARED BY TOM McADAMS	DATE 5-10-95	APPROVED BY NA	DATE NA
APPROVED BY	DATE	APPROVED BY	DATE

CROSS-SEC
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN PPM

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

* - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

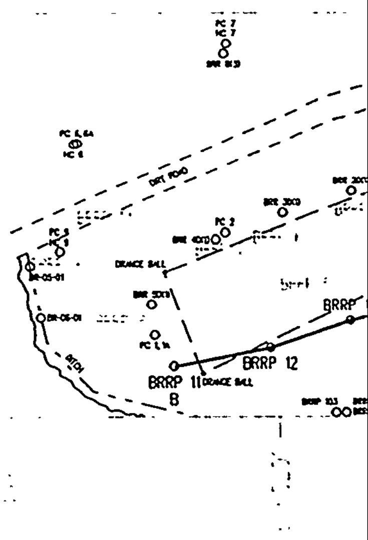
PIT CONTOUR SHOWN DASHED WHERE INFERRED

SURFACE CBC - 18.31 mg/kg

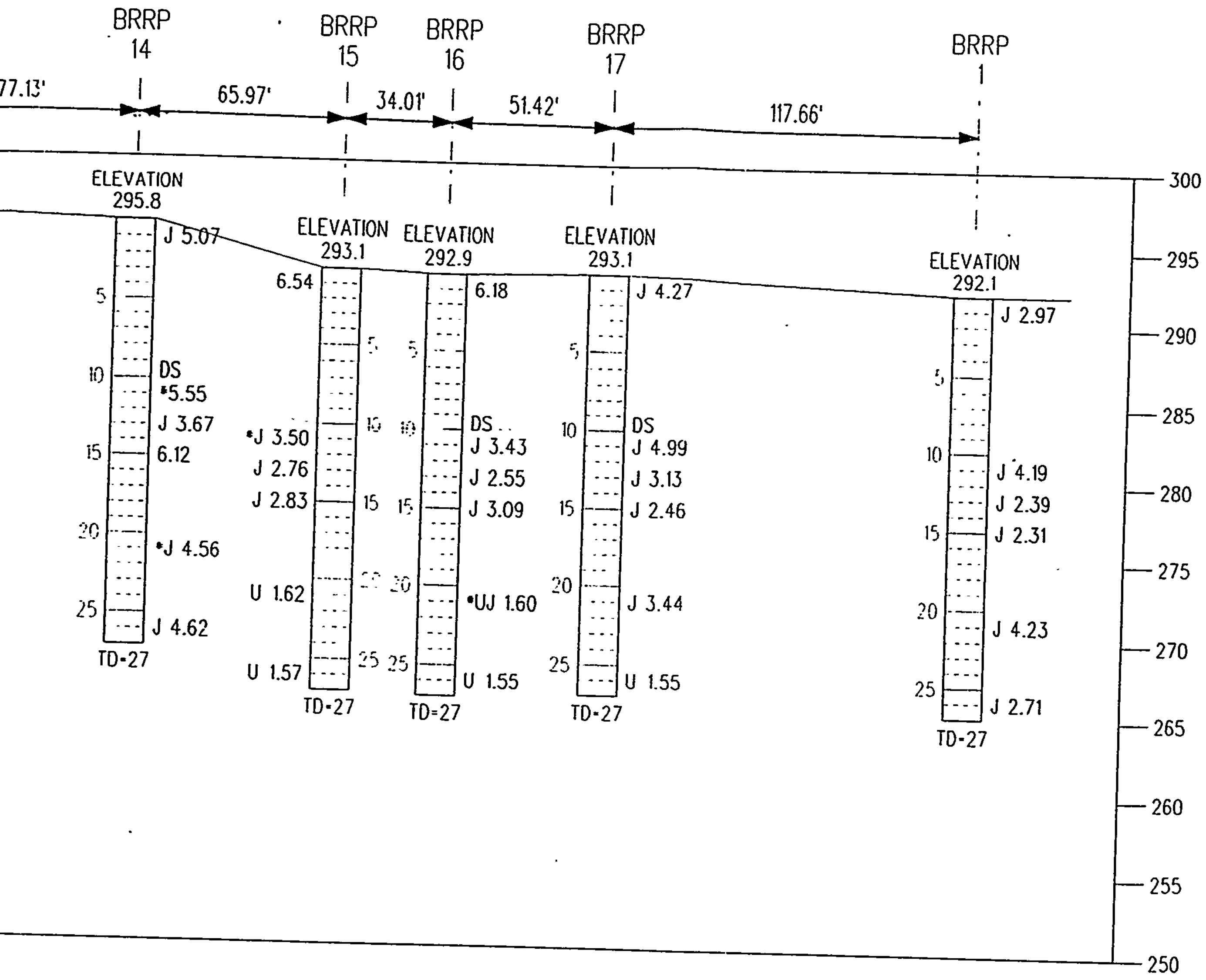
SUBSURFACE CBC - 9.38 mg/kg

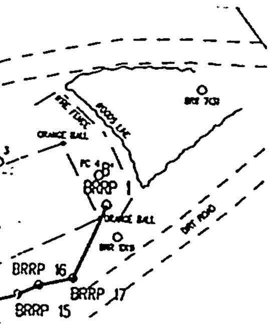
RBC LEVEL - N/A

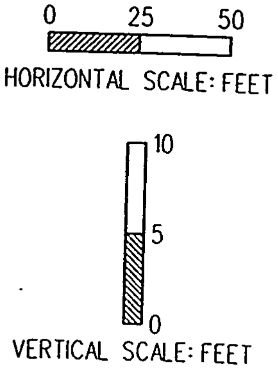
NO CBS'S EXCEEDED



ION B-B'
RUBBLE PIT







HORIZONTAL SCALE: FEET

VERTICAL SCALE: FEET

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FIGURE 5-8
LEAD CONCENTRATION MG/KG (PPM)
BURMA ROAD RUBBLE PIT
CROSS SECTION B-B'

	DATE		DATE
CREATED BY ET ALEXANDER	DATE 5-10-95	APPROVED BY NA	DATE NA
PREPARED BY TOM McADAMS	DATE 5-10-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE 5-49

value detected for subsurface soil samples is above the CBC of 56.2 mg/kg. No regulatory level has been set for magnesium in soil. Magnesium is noted as being one of six essential elements in the BRA. A comparison of these six essential elements with their respective RDA and/or ESADDI was made in the BRA. The comparison demonstrated that the concentration detected would not exceed the RDAs or ESADDIs if site-specific soil concentrations were ingested. Therefore, magnesium was not considered further as a potential contaminant at BRRP.

Manganese

Manganese was detected in all the surface and subsurface soil samples. The maximum value detected in the surface soil samples was 139 mg/kg which is below the CBC of 569 mg/kg. The maximum value detected in the subsurface soil samples is 52.1 mg/kg which is above the CBC of 19.44 mg/kg. All values are below the RBC (noncarcinogenic) level of 390 mg/kg. Therefore, manganese was not considered as a potential contaminant at BRRP.

Mercury

Mercury was detected in 15 of 17 surface samples and in 32 of 85 subsurface samples. The maximum value detected was 0.395 mg/kg in the surface soil and 0.204 mg/kg in the subsurface soil. Both of these values are above their respective CBC - surface (0.1168 mg/kg) and subsurface (0.024 mg/kg). Both maximum values are below the RBC (noncarcinogenic) level of 2.3 mg/kg. Therefore, mercury was not considered as a poential contaminant at BRRP.

Nickel

Nickel was detected in 16 of 17 surface samples and in 32 of 85 of the subsurface soil samples. The maximum value detected was 17.6 mg/kg in the surface soil and 73.8 mg/kg in the subsurface soil. Both of these values are above the CBC of 3.86 mg/kg in the surface soil and 1.79 mg/kg in the subsurface soil. Both maximum values are below the RBC level of 1600 mg/kg.

Potassium

Potassium was detected in 16 of 17 of the surface soil samples and in 16 of 51 subsurface soil samples. The maximum value detected was 136 mg/kg in the surface soil and 158 mg/kg in the subsurface soil samples. The maximum value in the surface soil samples is below the CBC of 225.3 mg/kg. The maximum value in the subsurface soil samples is above the CBC of 41.4 mg/kg. No regulatory level has been set for potassium in soil. Potassium is noted as being one of six essential elements in the BRA. A comparison of these six essential elements with their respective RDA and/or ESADDI was made in the BRA. The comparison demonstrated that the concentration detected would not exceed the RDAs or ESADDIs if site-specific soil concentrations were ingested. Therefore, potassium was not considered further as a potential contaminant at BRRP.

Selenium

Selenium was not detected in any surface soil samples. Selenium was detected in only one of the 85 subsurface soil sample (BRRP 12 at a depth of 8 - 10 feet, with a concentration of 4 mg/kg). No CBC exists for this compound as the background data were below quantification limits. This value is below the RBC level of 390 mg/kg. Therefore, selenium was not considered a potential contaminant at the BRRP.

Silver

Silver was not detected in any surface soil samples. Silver was detected in one subsurface soil sample (BRRP 15 at a depth of 24 - 26 feet, with a concentration of 0.313 mg/kg). No CBC exists for this compound as the background data were below quantification limits. The subsurface soil concentration is below the RBC level of 390 mg/kg. Therefore, silver was not considered a potential contaminant at the BRRP.

Sodium

Sodium was detected in 7 of 17 surface soil samples and in 21 of 51 subsurface soil samples. The maximum value detected was 22.5 mg/kg in the surface soil and 55.2 in the subsurface soil. The maximum value detected for the surface soil is above the CBC of 16.58 mg/kg. No CBC exists for this compound in the subsurface soil samples as the background data were below quantification limits. No regulatory level has been set for sodium in soil. Sodium is noted as being one of six essential elements in the BRA. A comparison of these six essential elements with their respective RDA and/or ESADDI was made in the BRA. The comparison demonstrated that the concentration detected would not exceed the RDAs or ESADDIs if site-specific soil concentrations were ingested. Therefore, sodium was not considered further as a potential contaminant at BRRP.

Vanadium

Vanadium was detected in all the surface and subsurface soil samples. The maximum value detected was 65.1 mg/kg in the surface soil and 63.2 mg/kg in the subsurface soil. Both of these values are above their respective CBCs of 26.0 mg/kg for surface soil and 62.1 mg/kg for subsurface soil. However, these maximum values are below the RBC of 550 mg/kg. Vanadium was not considered as a potential contaminant at the BRRP.

Zinc

Zinc was detected in all the surface and subsurface soil samples. The maximum value detected was 11.1 mg/kg in the surface soil and 16.6 mg/kg in the subsurface soil. The maximum for the surface soil is below the CBC of 12.89 mg/kg; however, the maximum value for the subsurface soil is above the CBC of 4.90 mg/kg. Both maximum values are below the RBC of 23000 mg/kg. Based on this information, zinc was not considered as a contaminant at the BRRP.

5.3.1.1 Summary

Twenty-three TAL constituents were detected in either surface, subsurface, or both soil samples. Six of the twenty-three TAL constituents are classified as essential nutrients. These essential nutrients, calcium, copper, iron, magnesium, potassium, and sodium, are considered non-toxic, except in large amounts. A comparison of these six nutrients with their respective RDAs and/or ESADDI was made in the BRA. The comparison demonstrated that the concentrations detected would not exceed the RDAs or ESADDIs if site-specific concentrations were ingested. Therefore, these six essential nutrients were not considered as possible contaminants at the BRRP.

Ten (i.e., aluminum, barium, chromium, cobalt, cyanide, mercury, nickel, vanadium, and zinc) of the twenty-three constituents had at least one of the maximum concentrations in the surface or subsurface soil samples above their respective CBC. However, all of these constituents had maximum concentrations for both surface and subsurface soil samples below their respective RBC level. Four TAL constituents, antimony, cadmium, selenium, and silver, had no CBC level because the background concentration data were below quantification limits. These constituents, however, exhibited maximum concentrations in both surface and subsurface soil which were below the RBC levels for the constituent. Based on this information, these fourteen constiutents were not considered as potential contaminants at the BRRP.

The remaining three TAL constituents, arsenic, beryllium, and lead, were further evaluated as potential contaminants at the BRRP. The maximum values for arsenic surface and subsurface soil samples exceeded the RBC (carcinogenic) level. The maximum beryllium concentration exceeded the CBC for subsurface soils as well as the RBC (carcinogenic) level for surface and subsurface soil. Lead concentrations did not exceed their respective surface and subsurface CBCs. Cross sections depicting the concentrations and depths for these three constituents were drawn (see Figures 5-3 through 5-8).

5.3.2 *Volatile Organic Compounds*

Table 5-21 summarizes the results of laboratory analysis for volatile organic compounds detected in surface soils. Table 5-22 summarizes the results of laboratory analysis for volatile organic compounds detected in the subsurface soils. In order to determine the potential volatile organic compounds at BRRP, RBC levels were used to screen the detected contaminants. Per regulatory guidance, CBC was not used for volatile organic compounds.

1,1-Dichloroethane

1,1-Dichloroethane was not detected in any surface soils. 1,1-Dichloroethane was detected in one subsurface soil sample, BRRP 03 at a depth of 15 - 17 feet, at a concentration of 0.69 ug/kg (0.00069 mg/kg). This concentration is below the RBC of 7800 mg/kg. Therefore, 1,1-dichloroethane was not considered a potential contaminant at the BRRP.

1,2-Dichloroethane

1,2-Dichloroethane was detected in one surface soil sample, BRRP 03, at a concentration of 0.213 ug/kg (0.000213 mg/kg). 1,2-Dichloroethane was not detected in any subsurface soil samples. The concentration detected in the surface soil sample is below the RBC of 7 mg/kg. 1,2-Dichloroethane is not considered a potential contaminant at the BRRP.

Acetone

Acetone was detected in eight surface soil samples with a maximum concentration of 17.6 ug/kg (0.0176 mg/kg). Acetone was detected in 23 of 51 subsurface soil samples with a maximum concentration of 59.7 ug/kg (0.0597 mg/kg). Both of these values are below the RBC of 7800 mg/kg. Therefore, acetone was screened out as a potential contaminant of concern at the BRRP.

Benzene

Benzene was detected in three surface soil samples, BRRP 06, BRRP 07, and BRRP 10 at concentrations of 0.118 ug/kg (0.000118 mg/kg), 0.241 ug/kg (0.000241 mg/kg), and 0.0638 ug/kg (0.0000638 mg/kg), respectively. Benzene was detected in 14 of 85 subsurface samples with a maximum concentration of 0.993 ug/kg (0.000993 mg/kg). These values are below the RBC of 22 mg/kg. Therefore, benzene was screened out as a contaminant at the BRRP.

Table 5-21 - Summary of Surface Sampling Results - Volatile Organic Compounds

Volatile Organics	Frequency of Detection	Surface Soil Sample Concentration (ug/kg)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected			
1,1,1-Trichloroethane	0/17	ND	0/17	NA	NA
1,1,2,2-Tetrachloroethane	0/17	ND	0/17	NA	NA
1,1,2-Trichloroethane	0/17	ND	0/17	NA	NA
1,1-Dichloroethane	0/17	ND	0/17	NA	NA
1,1-Dichloroethylene	0/17	ND	0/17	NA	NA
1,2-Dichloroethane	1/17	0.213	0/17	NA	NA
1,2-Dichloroethylene	0/17	ND	0/17	NA	NA
1,2-Dichloropropane	0/17	ND	0/17	NA	NA
2-Hexanone	0/17	ND	0/17	NA	NA
Acetone	8/17	17.6	0/17	NA	NA
Benzene	3/17	0.241	0/17	NA	NA
Bromodichloromethane	0/17	ND	0/17	NA	NA
Bromoform	0/17	ND	0/17	NA	NA
Bromomethane	0/17	ND	0/17	NA	NA
Carbon disulfide	1/17	0.144	0/17	NA	NA
Carbon tetrachloride	0/17	ND	0/17	NA	NA
Chlorobenzene	0/17	ND	0/17	NA	NA
Chloroethane	0/17	ND	0/17	NA	NA
Chloroethene	0/17	ND	0/17	NA	NA
Chloroform	0/17	ND	0/17	NA	NA
Chloromethane	3/17	0.344	0/17	NA	NA
Cis-1,3-Dichloropropane	0/17	ND	0/17	NA	NA
Dibromochloromethane	0/17	ND	0/17	NA	NA
Dichloromethane	1/17	0.854	0/17	NA	NA
Ethyl benzene	1/17	0.216	0/17	NA	NA
Methyl ethyl ketone	0/17	ND	0/17	NA	NA
Methyl isobutyl ketone	0/17	ND	0/17	NA	NA
Styrene	0/17	ND	0/17	NA	NA
Tetrachloroethylene	1/17	0.427	0/17	NA	NA
Toluene	0/17	ND	0/17	NA	NA
Trans-1,2-Dichloroethylene					
Trans-1,3-Dichloroethylene	0/17	ND	0/17	NA	NA
Trichloroethylene	2/17	0.213	0/17	NA	NA
Trichlorofluoromethane					
Vinyl acetate	0/17	ND	0/17	NA	NA
Xylenes	3/17	1.03	0/17	NA	NA

NA = Not applicable
ND = Not detected (sample was below the quantification limit)
Blank spaces indicate that the samples were not tested for these compounds.

Table 5-22 - Summary of Subsurface Sampling Results - Volatile Organic Compounds

Volatile Organics	Frequency of Detection	Subsurface Soil Sample Concentration (ug/kg)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected			
1,1,1-Trichloroethane	0/85	ND	0/85	NA	NA
1,1,2,2-Tetrachloroethane	0/85	ND	0/85	NA	NA
1,1,2-Trichloroethane	0/85	ND	0/85	NA	NA
1,1-Dichloroethane	1/85	0.69	0/85	NA	NA
1,1-Dichloroethylene	0/85	ND	0/85	NA	NA
1,2-Dichloroethane	0/85	ND	0/85	NA	NA
1,2-Dichloroethylene	0/51	ND	0/51	NA	NA
1,2-Dichloropropane	0/85	ND	0/85	NA	NA
2-Hexanone	0/51	ND	0/51	NA	NA
Acetone	23/51	59.7	0/51	NA	NA
Benzene	14/85	0.993	0/85	NA	NA
Bromodichloromethane	0/85	ND	0/85	NA	NA
Bromoform	0/85	ND	0/85	NA	NA
Bromomethane	0/85	ND	0/85	NA	NA
Carbon disulfide	8/51	0.516	0/51	NA	NA
Carbon tetrachloride	0/85	ND	0/85	NA	NA
Chlorobenzene	0/85	ND	0/85	NA	NA
Chloroethane	0/85	ND	0/85	NA	NA
Chloroethene	1/85	0.155	0/85	NA	NA
Chloroform	1/85	0.0562	0/85	NA	NA
Chloromethane	7/85	0.538	0/85	NA	NA
Cis-1,3-Dichloropropane	0/85	ND	0/85	NA	NA
Dibromochloromethane	0/85	ND	0/85	NA	NA
Dichloromethane	3/85	21.6	0/85	NA	NA
Ethyl benzene	2/85	0.157	0/85	NA	NA
Methyl ethyl ketone	3/51	6.28	0/51	NA	NA
Methyl isobutyl ketone	0/51	ND	0/51	NA	NA
Styrene	0/51	ND	0/51	NA	NA
Tetrachloroethylene	0/85	ND	0/85	NA	NA
Toluene	10/85	0.153	0/85	NA	NA
Trans-1,2-Dichloroethylene	0/34	ND	0/34	NA	NA
Trans-1,3-Dichloroethylene	0/85	ND	0/85	NA	NA
Trichloroethylene	0/85	ND	0/85	NA	NA
Trichlorofluoromethane	9/34	1.95	0/34	NA	NA
Vinyl acetate	0/51	ND	0/51	NA	NA
Xylenes	9/51	1.13	0/51	NA	NA

NA = Not applicable
ND = Not detected (sample was below the quantification limit)

Carbon Disulfide

Carbon disulfide was detected in surface soil sample (BRRP 04) at a concentration of 0.144 ug/kg **(0.000144 mg/kg).** Carbon disulfide was detected in 8 of 51 subsurface samples with a maximum concentration of 0.516 ug/kg **(0.000516 mg/kg),. These values are below the RBC of 7800 mg/kg.**

Chloroform

Chloroform was not detected in any surface soil samples. Chloroform was detected in only one subsurface soil sample, BRRP 15 at a depth of 20 - 22 feet, at a concentration of 0.0562 ug/kg **(0.0000562 mg/kg). The RBC level for chloroform is 100 mg/kg, much higher than the level detected on site.**

Chloromethane

Chloromethane was detected in three subsurface soil samples: BRRP 02 (0.225 ug/kg **(0.000225 mg/kg)**), BRRP 04 (0.344 ug/kg **(0.000334 mg/kg)**), and BRRP 10 (0.0532 ug/kg **(0.0000532 mg/kg)**). Chloromethane was detected in seven subsurface samples with a maximum detection of 0.538 ug/kg **(0.000538 mg/kg). All of these values are below the RBC of 49 mg/kg. Therefore, chloromethane was not considered a contaminant of concern when discussing the nature and extent of contamination at the BRRP.**

Dichloromethane (Methylene Chloride)

Dichloromethane was detected in one surface sample, BRRP 15 at a concentration of 0.854 ug/kg **(0.000854 mg/kg).** Dichloromethane was detected in three subsurface samples: BRRP 15 at a depth of 10 - 12 feet with a concentration of 0.373 ug/kg **(0.000373 mg/kg)**, BRRP 15 at a depth of 20 - 22 feet with a concentration of 0.337 ug/kg **(0.000337 mg/kg)**, and BRRP 11 at a depth of 25 - 27 feet with a concentration of 21.6 ug/kg **(0.0216 mg/kg). All concentrations detected on site are less than the RBC level of 85 mg/kg.**

Ethyl benzene

Ethyl benzene was detected in one surface sample, BRRP 16 with a concentration of 0.216 ug/kg **(0.000216 mg/kg).** Ethyl benzene was detected in two subsurface samples: BRRP 13 at a depth of 13 - 15 feet and BRRP 16 at a depth of 14 - 16 feet, at concentrations of 0.157 ug/kg **(0.000157 mg/kg)** and 0.0778 ug/kg **(0.0000778 mg/kg)**, respectively. **The concentrations of ethyl benzene detected on site are orders of magnitude below the RBC (7800 mg/kg).**

Methyl ethyl ketone

Methyl ethyl ketone was not detected in any surface soil samples. Methyl ethyl ketone was detected in three subsurface samples: BRRP 03 at a depth of 15 - 17 feet (4.31 ug/kg **(0.00431 mg/kg)**), BRRP 14 at a depth of 10 -12 feet (4.81 ug/kg **(0.00481 mg/kg)**), and BRRP 10 at a depth of 14 - 16 feet (6.28 ug/kg **(0.00628 mg/kg)**). The concentrations detected are orders of magnitude below **the RBC (47000 mg/kg) for residential ingestion of soils.**

Tetrachloroethylene

Tetrachloroethylene was detected in one surface soil sample, BRRP 03, at a concentration of 0.427 ug/kg **(0.000427 mg/kg)**, below the **RBC (12 mg/kg). Tetracchloroethylene was not detected in any subsurface soil samples.**

Toluene

Toluene was not detected in any surface soil samples. Toluene was detected in ten subsurface soil samples from BRRP 01, BRRP 02, BRRP 03, and BRRP 15 at various depths. The maximum concentration detected was 0.153 ug/kg **(0.000153 mg/kg)**, below the RBC for soils **(16000 mg/kg)**.

Trichloroethylene

Trichloroethylene was detected in two surface soil samples, BRRP 02 and BRRP 03, at concentrations of 0.213 ug/kg **(0.000213 mg/kg)** and 1.52 ug/kg **(0.00152 mg/kg)**, respectively. The concentrations detected on site are below the **RBC (58 mg/kg) level for soils**. Trichloroethylene was not detected in any subsurface soil samples.

Trichloroflurometḥane

Surface soils were not analyzed for the presence of trichloroflurometḥane. Trichloroflurometḥane was detected in 8 of 34 subsurface samples. The maximum concentration of trichloroflurometḥane detected from soil samples was 1.95 ug/kg **(0.00195 mg/kg). The maximum value is below the RBC level for soils (23000 mg/kg).**

Xylenes

Xylene was detected in three surface soil samples and in nine of 51 subsurface samples. The maximum concentration of xylene detected in the surface soil was 1.03 ug/kg **(0.00103 mg/kg)** and the maximum concentration detected in the subsurface soil was 1.13 ug/kg **(0.00113 mg/kg)**, orders of magnitude below the **RBC level of 160000 mg/kg.**

5.3.2.1 Summary

Small concentrations of volatile organic compounds were detected on site in both surface and subsurface soils. The most frequently detected compounds detected on site were acetone, benzene, chloromethane, toluene, and xylene. No volatile organic compounds were detected in concentrations greater than the regulatory guidelines. Indeed, most compounds were detected in concentrations several orders of magnitude below the regulatory guidelines. **Therefore, volatile organic compounds are not considered potential contaminants as far as the nature and extent of contamination is concerned at the BRRP waste unit.**

It should be noted that during drilling the OVA detected organic vapors at concentrations as high as 600 ppm and turpentine-like orders were smelled by the field crew. Volatile organic compounds may be present in the pit, but the analytical results suggest that for the most part they have not migrated to the soils below the pit.

5.3.3 *Semi-Volatile Organic Compounds*

Table 5-23 summarizes the laboratory analytical results for semi-volatile organic compounds detected in surface soils on site. **Table 5-24 summarizes the laboratory analytical results for semi-volatile organic compounds detected in the subsurface soils on site.**

1,3-Dichlorobenzene

1,3-Dichlorobenzene was not detected in any surface soil samples. 1,3-Dichlorobenzene was detected in one subsurface soil sample, BRRP 13 from a depth of 13 - 15 feet, at a concentration of 18.3 ug/kg **(0.0183 mg/kg)**. The concentration of this compound was found to be below the detection limit in this duplicate for this sample. **The CBC for subsurface soil samples could not be determined since the background analyte concentrations were below quantification limits. The concentration was then compared to the RBC level (7000 mg/kg) for soils and was found to be well below the RBC level.**

1,4-Dichlorobenzene

1,4-Dichlorobenzene was detected in the two surface soil samples and three subsurface samples. The highest concentration detected **in the surface soil samples** was 25.8 ug/kg **(0.0258 mg/kg)**. The highest concentration detected **in the subsurface soil samples** was 30.2 ug/kg **(0.0302 mg/kg)**. Again, this compound was detected in sample BRRP 13 from a depth of 13 - 15 feet, but was below the detection

Table 5-23 - Summary of Surface Sampling Results - Semi-Volatile Organic Compounds

Semi-Volatiles	Frequency of Detection	Surface Soil Sample Concentration (ug/kg)	Number > CBC	Soil Boring Number	Depth (feet)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected						
1,2,4-Trichlorobenzene	0/17	ND	0/17	NA	NA	0/17	NA	NA
1,2-Dichlorobenzene	0/17	ND	0/17	NA	NA	0/17	NA	NA
1,3-Dichlorobenzene	0/17	ND	0/17	NA	NA	0/17	NA	NA
1,4-Dichlorobenzene	2/17	25.8	NC	NA	NA	0/17	NA	NA
2,4,5-Trichlorophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
2,4,6-Trichlorophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
2,4-Dichlorophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
2,4-Dimethylphenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
2,4-Dinitrophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
2,4-Dinitrotoluene	0/17	ND	0/17	NA	NA	0/17	NA	NA
2,6-Dinitrotoluene	0/17	ND	0/17	NA	NA	0/17	NA	NA
2-Chloronaphthalene	0/17	ND	0/17	NA	NA	0/17	NA	NA
2-Chlorophenol	3/17	6.67	NC	NA	NA	0/17	NA	NA
2-Methylnaphthalate	0/17	ND	0/17	NA	NA	0/17	NA	NA
2-Methyl-4,6-dinitrotoluene	0/17	ND	0/17	NA	NA	0/17	NA	NA
2-Nitrophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
3,3-Dichlorophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
4-Bromophenyl ether	0/17	ND	0/17	NA	NA	0/17	NA	NA
4-Chloroaniline	0/17	ND	0/17	NA	NA	0/17	NA	NA
4-Chlorophenol phenol ether	0/17	ND	0/17	NA	NA	0/17	NA	NA
4-Chloro-m-cresol	0/17	ND	0/17	NA	NA	0/17	NA	NA
4-Nitrophenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
Acenaphthylene	0/17	ND	0/17	NA	NA	0/17	NA	NA
Acenaphthene	1/17	5.9	NC	NA	NA	0/17	NA	NA
Anthracene	3/17	7.38	NC	NA	NA	0/17	NA	NA
Benzo(a)anthracene	2/17	32.1	NC	NA	NA	0/17	NA	NA
Benzo(a)pyrene	4/17	31.7	NC	NA	NA	0/17	NA	NA
Benzo(b)fluoranthene	4/17	59.7	1/17	BRRP 04	0 - 2	0/17	NA	NA
Benzo(g,h,i)perylene	1/17	11.4	NC	NA	NA	0/17	NA	NA
Benzo(k)fluoranthene	2/17	9.93	NC	NA	NA	0/17	NA	NA
Benzoic Acid	0/17	ND	0/17	NA	NA	0/17	NA	NA
Benzyl Alcohol	0/17	ND	0/17	NA	NA	0/17	NA	NA

NA = Not applicable
NC = No criterion background concentration
ND = Not detected (sample was below the quantification limit)

Table 5-23 - Summary of Surface Sampling Results - Semi-Volatile Organic Compounds (continued)

Semi-Volatiles	Frequency of Detection	Surface Soil Sample Concentration (ug/kg)	Number > CBC	Soil Boring Number	Depth (feet)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected						
Bis(2-chloroethoxyl) methane	0/17	ND	0/17	NA	NA	0/17	NA	NA
Bis (2-chloroethyl) ether	0/17	ND	0/17	NA	NA	0/17	NA	NA
Bis (2-ethylhexyl) phthalate	2/17	65.1	NC	NA	NA	0/17	NA	NA
Butylbenzyl phthalate	2/17	5.19	NC	NA	NA	0/17	NA	NA
Chrysene	2/17	33.6	NC	NA	NA	0/17	NA	NA
Cresol (m- and p- combined)	0/17	ND	0/17	NA	NA	0/17	NA	NA
Dibenzofuran	0/17	ND	0/17	NA	NA	0/17	NA	NA
Dibenzo(a,h)anthracene	0/17	ND	0/17	NA	NA	0/17	NA	NA
Diethyl phthalate	0/17	ND	0/17	NA	NA	0/17	NA	NA
Dimethyl phthalate	0/17	ND	0/17	NA	NA	0/17	NA	NA
Di-n-butyl phthalate	0/17	ND	0/17	NA	NA	NR	NA	NA
Di-n-octyl phthalate	2/17	498	NC	NA	NA	0/17	NA	NA
Fluoranthene	4/17	75.2	2/17	BRRP 04, 16	0 - 2	0/17	NA	NA
Fluorene	0/17	ND	NC	NA	NA	0/17	NA	NA
Hexachloroethane	0/17	ND	0/17	NA	NA	0/17	NA	NA
Hexachlorobenzene	0/17	ND	0/17	NA	NA	0/17	NA	NA
Hexachlorobutadiene	0/17	ND	0/17	NA	NA	0/17	NA	NA
Hexachlorocyclopentadiene	0/17	ND	0/17	NA	NA	0/17	NA	NA
Indeno(1,2,3-cd)pyrene	1/17	11.8	NC	NA	NA	0/17	NA	NA
Isophorone	0/17	ND	0/17	NA	NA	0/17	NA	NA
m-Nitroaniline	0/17	ND	0/17	NA	NA	0/17	NA	NA
Naphthalene	0/17	ND	NC	NA	NA	0/17	NA	NA
Nitrobenzene	0/17	ND	0/17	NA	NA	0/17	NA	NA
n-Nitrosodiphenylamine	0/17	ND	0/17	NA	NA	0/17	NA	NA
o-Cresol	0/17	ND	0/17	NA	NA	0/17	NA	NA
o-Nitroaniline	0/17	ND	0/17	NA	NA	0/17	NA	NA
Pentachlorophenol	2/17	90.1	0/17	NA	NA	0/17	NA	NA
Phenathrene	3/17	47.2	3/17	BRRP 02, 04, 16	0 - 2	0/17	NA	NA
Phenol	0/17	ND	0/17	NA	NA	0/17	NA	NA
Pyrene	5/17	66	1/17	BRRP 04	0 - 2	0/17	NA	NA
p-Nitroaniline	0/17	ND	0/17	NA	NA	0/17	NA	NA

NA = Not applicable NC = No criterion background concentration ND = Not detected (sample was below the quantification limit) NR = No regulatory level (RBC)

Table 5-24 - Summary of Subsurface Sampling Results - Semi-Volatile Organic Compounds

Semi-Volatiles	Frequency of Detection	Subsurface Soil Sample Concentration (ug/kg)	Number > CBC	Soil Boring Number	Depth (feet)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected						
1,2,4-Trichlorobenzene	0/51	ND	0/51	NA	NA	0/51	NA	NA
1,2-Dichlorobenzene	0/51	ND	0/51	NA	NA	0/51	NA	NA
1,3-Dichlorobenzene	1/51	18.3	NC	NA	NA	0/51	NA	NA
1,4-Dichlorobenzene	3/51	30.2	0/51	NA	NA	0/51	NA	NA
2,4,5-Trichlorophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
2,4,6-Trichlorophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
2,4-Dichlorophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
2,4-Dimethylphenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
2,4-Dinitrophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
2,4-Dinitrotoluene	0/51	ND	0/51	NA	NA	0/51	NA	NA
2,6-Dinitrotoluene	0/51	ND	0/51	NA	NA	0/51	NA	NA
2-Chloronaphthalene	0/51	ND	0/51	NA	NA	0/51	NA	NA
2-Chlorophenol	6/51	7.02	NC	NA	NA	0/51	NA	NA
2-Methylnaphthalate	2/51	9.02	NC	NA	NA	NR	NA	NA
2-Methyl-4,6-dinitrotoluene	0/51	ND	0/51	NA	NA	0/51	NA	NA
2-Nitrophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
3,3-Dichlorophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
4-Bromophenyl ether	0/51	ND	0/51	NA	NA	0/51	NA	NA
4-Chloroaniline	0/51	ND	0/51	NA	NA	0/51	NA	NA
4-Chlorophenol phenol ether	0/51	ND	0/51	NA	NA	0/51	NA	NA
4-Chloro-m-cresol	0/51	ND	0/51	NA	NA	0/51	NA	NA
4-Nitrophenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
Acenaphthylene	0/51	ND	0/51	NA	NA	0/51	NA	NA
Acenaphthene	2/51	14.7	NC	NA	NA	0/51	NA	NA
Anthracene	5/51	30.5	NC	NA	NA	0/51	NA	NA
Benzo(a)anthracene	0/51	ND	NC	NA	NA	0/51	NA	NA
Benzo(a)pyrene	6/51	29	NC	NA	NA	0/51	NA	NA
Benzo(b)fluoranthene	3/51	29.4	NC	NA	NA	0/51	NA	NA
Benzo(g,h,i)perylene	1/51	9.2	NC	NA	NA	0/51	NA	NA
Benzo(k)fluoranthene	5/51	50	NC	NA	NA	0/51	NA	NA
Benzoic Acid	2/51	22.4	NC	NA	NA	0/51	NA	NA
Benzyl Alcohol	0/51	ND	0/51	NA	NA	0/51	NA	NA

NA = Not applicable
NC = No criterion background concentration
ND = Not detected (sample was below the quantification limit)
NR = No regulatory level (RBC)

Table 5-24 - Summary of Subsurface Sampling Results - Semi-Volatile Organic Compounds (continued)

Semi-Volatiles	Frequency of Detection	Subsurface Soil Sample Concentration (ug/kg)	Number > CBC	Soil Boring Number	Depth (feet)	Number > RBC	Soil Boring Number	Depth (feet)
		Maximum Detected						
Bis(2-chloroethoxyl) methane	0/51	ND	0/51	NA	NA	0/51	NA	NA
Bis (2-chloroethyl) ether	0/51	ND	0/51	NA	NA	0/51	NA	NA
Bis (2-ethylhexyl) phthalate	4/51	545	NC	NA	NA	0/51	NA	NA
Butylbenzyl phthalate	3/51	51.5	NC	NA	NA	0/51	NA	NA
Chrysene	4/51	35.7	NC	NA	NA	0/51	NA	NA
Cresol (m- and p- combined)	0/51	ND	0/51	NA	NA	0/51	NA	NA
Dibenzofuran	3/51	12.8	NC	NA	NA	0/51	NA	NA
Dibenzo(a,h)anthracene	0/51	ND	0/51	NA	NA	0/51	NA	NA
Diethyl phthalate	0/51	ND	0/51	NA	NA	0/51	NA	NA
Dimethyl phthalate	0/51	ND	0/51	NA	NA	0/51	NA	NA
Di-n-butyl phthalate	1/51	52.2	0/51	NA	NA	NR	NA	NA
Di-n-octyl phthalate	5/52	545	NC	NA	NA	0/52	NA	NA
Fluoranthene	12/52	236	NC	NA	NA	0/52	NA	NA
Fluorene	3/52	22.9	NC	NA	NA	0/52	NA	NA
Hexachloroethane	0/51	ND	0/51	NA	NA	0/51	NA	NA
Hexachlorobenzene	0/51	ND	0/51	NA	NA	0/51	NA	NA
Hexachlorobutadiene	0/51	ND	0/51	NA	NA	0/51	NA	NA
Hexachlorocyclopentadiene	0/51	ND	0/51	NA	NA	0/51	NA	NA
Indeno(1,2,3-cd)pyrene	2/51	21.4	NC	NA	NA	0/51	NA	NA
Isophorone	0/51	ND	0/51	NA	NA	0/51	NA	NA
m-Nitroaniline	0/51	ND	0/51	NA	NA	0/51	NA	NA
Naphthalene	3/51	18.4	NC	NA	NA	0/51	NA	NA
Nitrobenzene	0/51	ND	0/51	NA	NA	0/51	NA	NA
n-Nitrosodiphenylamine	0/51	ND	0/51	NA	NA	0/51	NA	NA
o-Cresol	0/51	ND	0/51	NA	NA	0/51	NA	NA
o-Nitroaniline	0/51	ND	0/51	NA	NA	0/51	NA	NA
Pentachlorophenol	1/51	19.6	NC	NA	NA	0/51	NA	NA
Phenathrene	7/51	117	NC	NA	NA	0/51	NA	NA
Phenol	0/51	ND	0/51	NA	NA	0/51	NA	NA
Pyrene	11/51	111	4/51	BRRP 12 BRRP 12 BRRP 03, 13	6 - 8 8 - 10 15 - 17	0/51	NA	NA
p-Nitroaniline	0/51	ND	0/51	NA	NA	0/51	NA	NA

NA = Not applicable NC = No criterion background concentration ND = Not detected (sample was below the quantification limit) NR = No regulatory level (RBC) limit in the duplicate. **The CBC for surface soil samples could not be determined since the background analyte concentrations were below quantification limits. The subsurface soil sample was below the CBC (30.92 mg/kg) for subsurface soils. The maximum concentrations detected in both the surface and subsurface soils are below the RBC (27 mg/kg) level for 1,4-dichlorobenzene.**

2-Chlorophenol

2-Chlorophenol was detected in three surface soil samples and six subsurface soil samples at maximum concentrations of 6.67 ug/kg **(0.00667 mg/kg)** and 7.02 ug/kg **(0.00702 mg/kg)**, respectively. **2-chlorophenol background soil sample concentrations were below the quantification limits, therefore the CBC does not exist for either the surface or subsurface soils.** The RBC for soils **(390 mg/kg)** is orders of magnitude greater than the concentrations detected on site.

2-Methyl Naphthalate

2-Methyl naphthalate was detected in two subsurface soil samples, with a maximum concentration of 9.02 ug/kg **(0.00902 mg/kg). 2-Methyl naphthalate was not detected in any surface soil samples. 2-Methyl naphthalate background soil sample concentrations were below the quantification limits, therefore the CBC does not exist for either the surface or subsurface soils. An RBC level has not** been set for 2-methyl naphthalate.

Acenaphthene

Acenaphthene was detected in surface soil sample, BRRP 04 at a concentration of 5.9 ug/kg **(0.0059** mg/kg). Acenaphthene was detected in **two** subsurface soil samples **with a maximum concentration of** 14.7 ug/kg **(0.0147 mg/kg). Acenaphthene background soil sample concentrations were below the quantification limits, therefore the CBC does not exist for either the surface or subsurface soils. The RBC level for acenaphthene is 4700 mg/kg. Both of the maximum values detected at the BRRP are well below this concentration.**

Anthracene

Anthracene was detected in three surface soil samples and five subsurface soil samples. The maximum concentration of anthracene detected in **surface** soils was 7.38 ug/kg **(0.00738 mg/kg). The maximum concentration detected in subsurface soil samples was 30.5 ug/kg (0.0305 mg/kg). Anthracene background soil sample concentrations were below the quantification limits, therefore the CBC does not exist for either the surface or subsurface soils. The RBC level for anthracene is 23000 mg/kg. Both of the maximum values detected on site are below this level.**

Benzo(a)anthracene

Benzo(a)anthracene was detected in two surface soil samples, BRRP 04 and BRRP 05, at concentrations of 32.1 ug/kg (**0.0321 mg/kg**) and 13.2 ug/kg (**0.0132 mg/kg**), respectively. **Benzo(a)anthracene was not detected in any subsurface soil samples. Benzo(a)anthracene background soil sample concentrations were below the quantification limits, therefore the CBC does not exist for either the surface or subsurface soils. The maximum value detected in the surface soils does not exceed the RBC level of 0.88 mg/kg.**

Benzo(a)pyrene

Benzo(a)pyrene was detected in four surface soil and six subsurface soil samples:

Table 5-25 Benzo(a)pyrene Concentrations in Soil Samples

Sample	Depth (ft)	Concentration (ug/kg)
BRRP 04	0 - 2	31.7
BRRP 15	0 - 2	5.53
BRRP 16	0 - 2	18.7
BRRP 17	0 - 2	5.35
BRRP 12	6 - 8	4.68
BRRP 14	10 - 12	4.78
BRRP 10	12 - 14	8.04
BRRP 10	14 - 16	3.68
BRRP 03	15 - 17	29.0
BRRP 13	15 - 17	17.7

The maximum concentration detected in the surface soils was 31.7 ug/kg (0.0317 mg/kg). The maximum concentration detected in the subsurface soils was 29.0 ug/kg (0.0290 mg/kg). This constituent was not detected above sample quantification limits in the background surface or subsurface soil samples. Therefore, there are no CBCs for benzo(a)pyrene. The RBC level for benzo(a)pyrene is 0.088 mg/kg. The maximum values detected in the samples did not exceed the RBC level.

Benzo(b)fluoranthene

Benzo(b)fluoranthene was detected in four surface soil samples and three subsurface samples:

Table 5-26 Benzo(b)fluoranthene Concentrations in Soil Samples

Sample	Depth (ft)	Concentration (ug/kg)
BRRP 04	0 - 2	59.7
BRRP 05	0 - 2	4.91
BRRP 13	0 - 2	4.59
BRRP 15	0 - 2	6.27
BRRP 12	8 - 10	4.53
BRRP 10	12 - 14	9.14
BRRP 13	15 - 17	29.4

The CBC for surface soils is 7.73 ug/kg or 0.00773 mg/kg. The background subsurface samples were all below the sample quanitification limits; therefore, a CBC value for subsurface soils is not available. The CBC value for surface soils was exceeded at BRRP 04. The RBC level for benzo(b)fluoranthene is 0.88 mg/kg or 880 ug/kg. This value was not exceeded in any of the surface or subsurface soil samples.

Benzo(g,h,i)perylene

Benzo(g,h,i)perylene was detected in one surface soil sample (BRRP 16) at a concentration of 11.4 ug/kg **(0.0114 mg/kg)** and in one subsurface soil sample (BRRP 12 from a depth of 6 - 8 feet) at a concentration of 5.07 ug/kg **(0.00507 mg/kg). No CBC or RBC limit exists for benzo(g,h,i)perylene.**

Benzo(k)fluoranthene

Benzo(k)fluoranthene was detected in two surface soil samples and five subsurface soil samples:

Table 5-27 Benzo(k)fluoranthene Concentrations in Soil Samples

Sample	Depth (ft)	Concentration (ug/kg)
BRRP 15	0 - 2	4.79
BRRP 16	0 - 2	9.93
BRRP 12	6 - 8	5.07
BRRP 17	10 - 12	4.74
BRRP 10	12 - 14	10.2

Table 5-27 Benzo(k)fluoranthene Concentrations in Soil Samples (continued)

Sample	Depth (ft)	Concentration (ug/kg)
BRRP 10	14 - 16	4.42
BRRP 03	15 - 17	50

There is no CBC with which to compare the surface and subsurface soil samples. The RBC level for this constituent is 8.8 mg/kg or 8800 ug/kg. None of the concentrations detected exceeded the RBC level for benzo(k)fluoranthene.

Benzoic Acid

Benzoic acid was not detected in any surface soil samples. Benzoic acid was detected in two subsurface soil samples, with a maximum concentration of 22.4 ug/kg **(0.0224 mg/kg). There is no CBC for the subsurface soil samples since the background data was below quantification limits for benzoic acid. The RBC level for benzoic acid is 310000 mg/kg. None of the subsurface soil samples exceeded this value.**

Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate was detected in two surface soil samples and four subsurface soil samples:

Table 5-28 Bis(2-ethylhexyl)phthalate Concentrations in Soil Samples

Sample	Depth (ft)	Concentration (ug/kg)
BRRP 02	0 - 2	65.1
BRRP 04	0 - 2	38
BRRP 17	14 - 16	29.9
BRRP 03	15 - 17	545
BRRP 04	20 - 22	74.5
BRRP 06	20 - 22	51.5

There is no CBC for screening purposes. The background data, surface and subsurface, were all below the quanitfication limit for this compound. All concentrations detected in soils are less than the RBC for soils (46 mg/kg or 46000 ug/kg).

Butylbenzene phthalate

Butylbenzene phthalate was detected in two surface soil samples and in three subsurface soil samples. The maximum concentration detected in the surface soils was 5.19 ug/kg (0.00519 mg/kg). The maximum concentration detected in the subsurface soils was 51.5 ug/kg (0.0515 mg/kg). The background data, surface and subsurface, were all below the quantification limit for butylbenzene phthalate. All concentrations detected in the soil are below the RBC for soils (16000 mg/kg).

Chrysene

Chrysene was detected in two surface soils and four subsurface soils:

Table 5-29 Chrysene Concentrations in Soil Samples

Sample	Depth (ft)	Concentration (ug/kg)
BRRP 04	0 - 2	33.6
BRRP 16	0 - 2	16.1
BRRP 12	6 - 8	9.75
BRRP 12	8 - 10	5.66
BRRP 03	15 - 17	35.7
BRRP 13	15 - 17	16.2

Since the background analyte concentrations were all below the sample quanitfication limits, there is no CBC for surface or subsurface soils. The RBC level for chrysene is 88 mg/kg or 88000 ug/kg. None of the concentrations detected exceeded the RBC level for chrysene.

Di-n-butyl phthalate

Di-n-butyl phthalate was detected in one subsurface soil sample at a concentration of 52.2 ug/kg. It was not detected in any surface soil samples. The CBC for subsurface soil, 26.1 ug/kg, was not exceeded in the sample. There is no RBC level for di-n-butyl phthalate.

Di-n-octyl phthalate

Di-n-octyl phthalate was detected in two surface soil samples and five subsurface soil samples. The maximum concentration detected in the surface soil samples was 498 ug/kg (0.498 mg/kg). The maximum concentration detected in the subsurface soil samples was 545 ug/kg (0.545 mg/kg). There is no CBC to screen against for either the surface or subsurface soil samples. The CBC does

not exist because the background concentrations were all below sample quantification limits. The RBC level, 1600 mg/kg, was not exceeded in any of the soil samples.

Dibenzofuran

Dibenzofuran was detected in three subsurface soil samples. **It was not detected in any surface soil samples.** The maximum **subsurface sample** concentration detected was **12.8 ug/kg. No CBC for surface or subsurface soils exists for dibenzofuran. The RBC level, 310 mg/kg or 310000 ug/kg, was not exceeded in any of the subsurface soil samples.**

Fluoranthene

Fluoranthene was detected in four surface soil samples and twelve subsurface samples. The maximum concentration of fluroanthene detected was 236 ug/kg **(0.236 mg/kg) in the subsurface soils. The maximum value detected in the surface soils was 75.2 ug/kg (0.0752 mg/kg). The surface soil CBC is 5.92 ug/kg. This concentration was exceeded in two of the four surface soil samples (BRRP 04 and BRRP 16). There is no CBC for the subsurface soils. The RBC level (3100 mg/kg) for fluoranthene was not exceeded in any of the surface or subsurface samples.**

Fluorene

Fluorene was detected in three subsurface soil samples **and was not detected in any surface soil samples.** The maximum concentration of fluorene detected on site was 22.9 ug/kg **(0.0229 mg/kg). There is no CBC for the subsurface soils since the concentrations detected were all below the quanitfication limits. The maximum concentration detected in the subsurface soil samples does not exceed the RBC level of 3100 mg/kg.**

Indeno(1,2,3-c,d)pyrene

Indeno(1,2,3-c,d)pyrene was detected in one surface soil sample and in two subsurface soil samples. **The maximum concentrations detected were 11.8 ug/kg (0.0118 mg/kg) and 21.4 ug/kg, (0.0214 mg/kg) in the surface and subsurface soils, respectively. There are no CBC for either the surface or subsurface soils since the background soil sample concentrations were all below the sample quantification limits. The RBC level of 0.88 mg/kg was not exceeded in any of the soil samples.**

Napthalene

Napthalene was detected in three subsurface soil samples. **It was not detected in any surface soil samples.** The maximum concentration detected **in the subsurface soil** was 90.1 ug/kg **(0.0901 mg/kg). A CBC value does not exist for napthalene since the background soil sample concentrations were**

below the sample quantification limits. The maximum concentration detected in the subsurface soils was less than the RBC level of 3100 mg/kg.

Pentachlorophenol

Pentachlorophenol was detected in two surface soil samples and one subsurface soil sample. The maximum concentrations detected **in the surface and subsurface soils were** 90.1 ug/kg **(0.0901 mg/kg)** and 19.6 ug/kg **(0.0196 mg/kg)**, respectively. **The CBC for the surface soil, 19.55 ug/kg, was not exceeded. There is no CBC for the subsurface soils since all concentrations were below the sample quantification limit. Both the surface and subsurface values are less than the RBC (5.3 mg/kg).**

Phenanthrene

Phenanthrene was detected in three surface soil samples and seven subsurface samples. **The maximum concentration of phenanthrene detected in the surface soil was 47.2 ug/kg (0.0472 mg/kg).** The maximum concentration of phenanthrene detected **in the subsurface soil was** 117 ug/kg **(0.117 mg/kg). The CBC for phenanthrene in the surface soils is 4.72 ug/kg. This value was exceeded in all three surface samples. There is no CBC for the subsurface soils since the background concentrations were below the sample quantification limit. The detected surface and subsurface soil concentrations are below the RBC level of 5.3 mg/kg.**

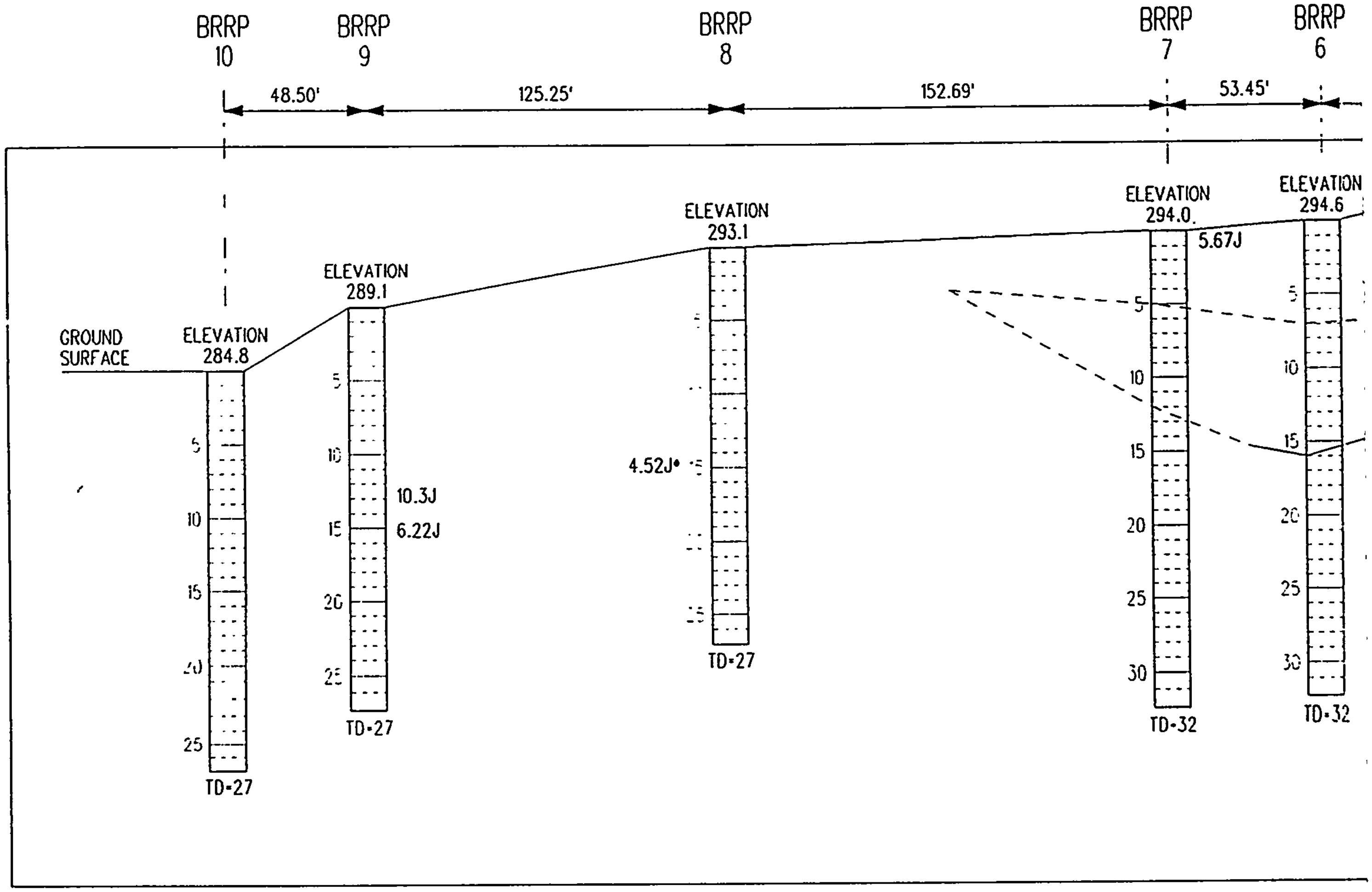
Pyrene

Pyrene was detected in five surface soil samples and 11 subsurface samples. **The maximum concentration of pyrene detected in the surface soils was 66 ug/kg (0.066 mg/kg).** The maximum concentration of pyrene detected **in the subsurface soils was** 111 **ug/kg (0.111 mg/kg). The CBC for pyrene were 13.82 ug/kg and 22.37 ug/kg for surface and subsurface soils, respectively. The maximum values for the surface and subsurface samples exceeded these CBCs. However, the RBC level (2300 mg/kg) for pyrene was not exceeded. Figures 5-9 and 5-10 have been plotted to show the concentrations of pyrene.**

5.3.3.1 Summary

Laboratory analysis revealed that the concentrations of four contaminants at the BRRP, benzo(b)fluoranthene, **fluoranthene, phenanthrene, and pyrene,** exceeded the CBC for the **contaminants. Benzo(b)fluoranthene, fluoranthene, and phenanthrene exceeded the CBC for the** surface soils. **Pyrene exceeded the CBC for both the surface and subsurface soils. However, these**

CROSS-SEC
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN UG/KG-PPB

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

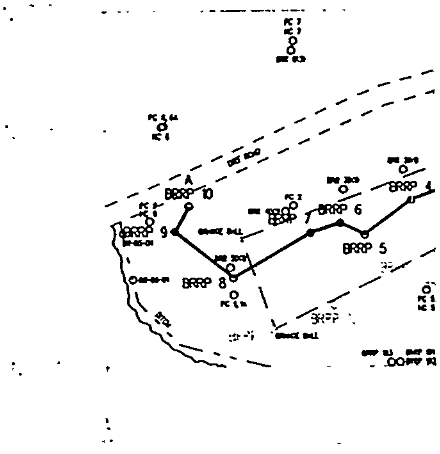
• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

• - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

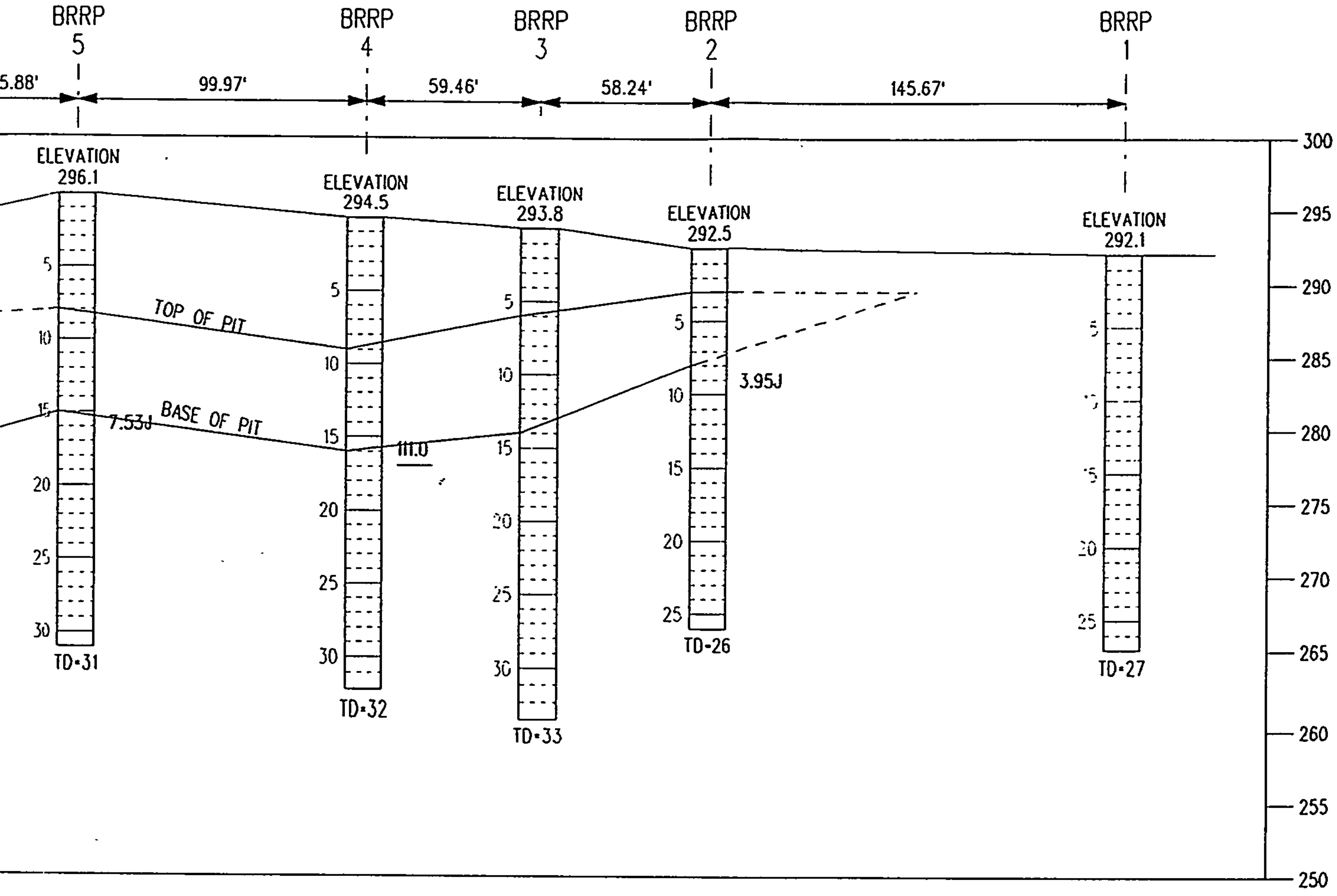
PIT CONTOUR SHOWN DASHED WHERE INFERRED

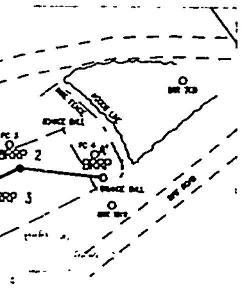
SURFACE CBC - 13.82 UG/KG
SUBSURFACE CBC - 22.37 UG/KG } VALUES WHICH EXCEED CBS - UNDERLINED

RBC LEVEL- 2300 UG/KG NO VALUES EXCEEDED RBC



TION A-A'
RUBBLE PIT





0 25 50
HORIZONTAL SCALE: FEET

10
5
0
VERTICAL SCALE: FEET

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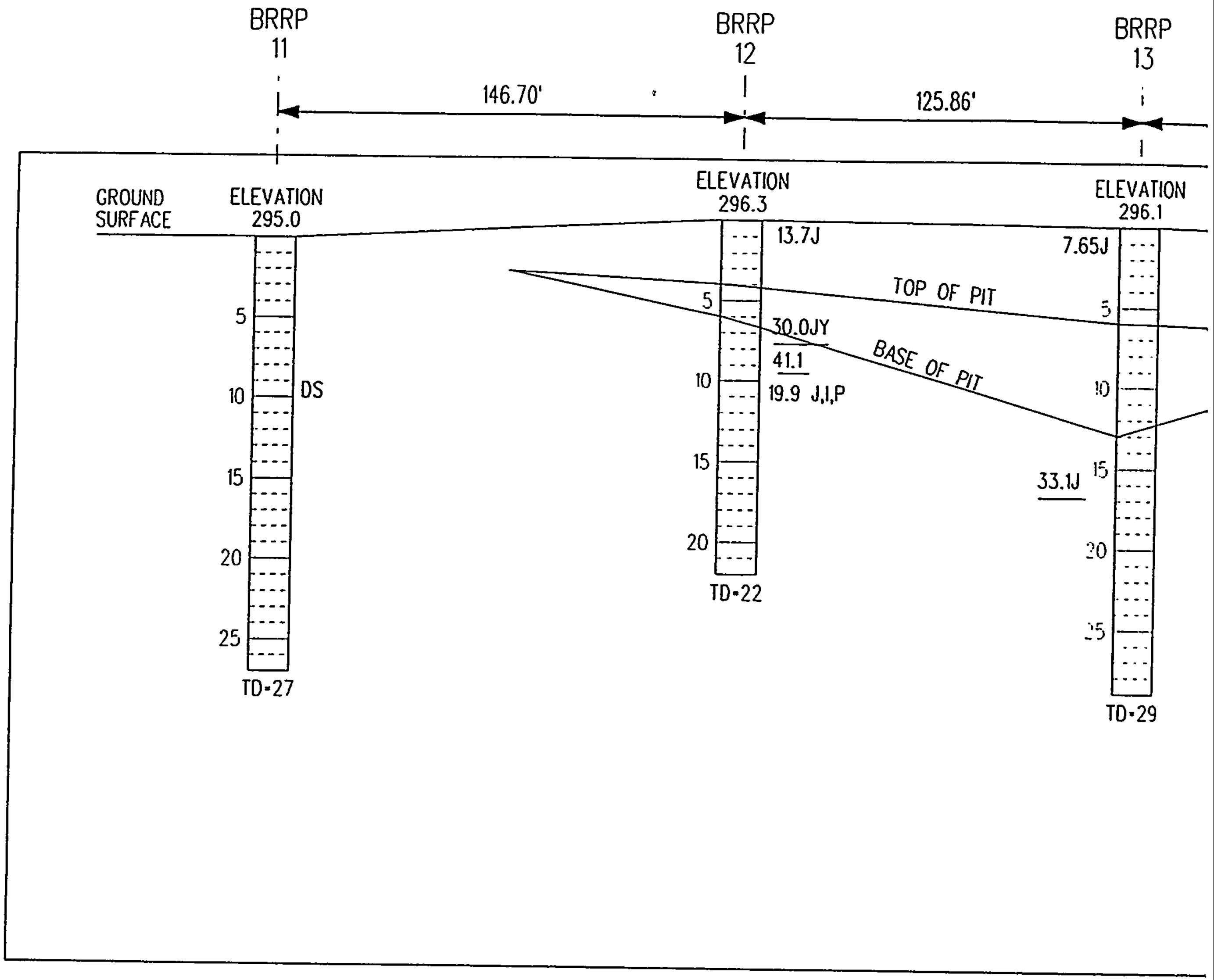
FIGURE 5-39
PYRENE CONCENTRATION UG/KG (PPB)
BURMA ROAD RUBBLE PIT
CROSS SECTION A-A'

CREATED BY TRACY L. MICKLEY	DATE 06-29-95	APPROVED BY NA	DATE 95
PREPARED BY TOM MCADAMS	DATE 06-29-95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95

CROSS-SEC
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN UG/KG=PPB

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

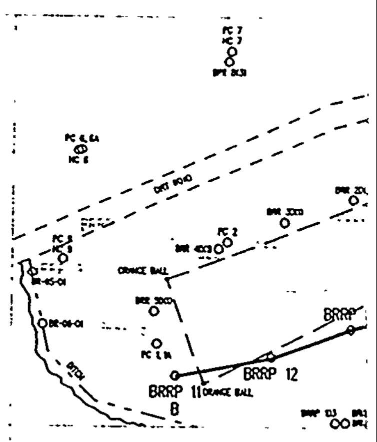
• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

* - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

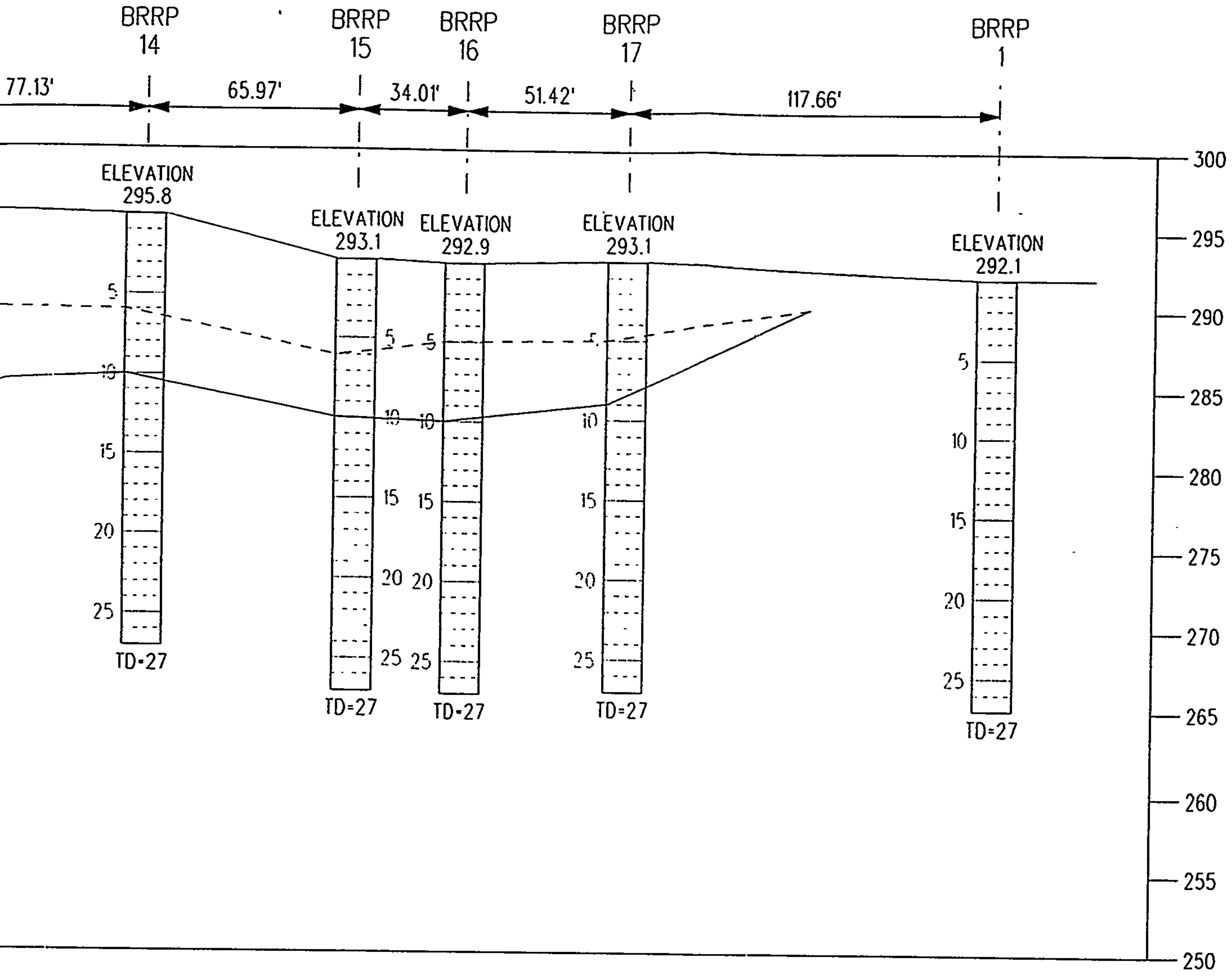
PIT CONTOUR SHOWN DASHED WHERE INFERRED

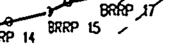
SURFACE CBC - 13.82 UG/KG }
SUBSURFACE CBC - 22.37 UG/KG } VALUES WHICH EXCEED CBS - UNDERLINED

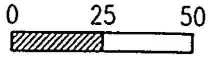
RBC LEVEL= 2300 UG/KG NO VALUES EXCEEDED RBC



ION B-B'
RUBBLE PIT







HORIZONTAL SCALE: FEET

VERTICAL SCALE: FEET

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TITLE
FIGURE 5-10
PYRENE CONCENTRATION UG/KG (PPB)
BURMA ROAD RUBBLE PIT
CROSS SECTION B-B'

CREATED BY TRACY L. MICKLEY	DATE 06-29-95	APPROVED BY NA	DATE 95
PREPARED BY TOM MCADAM	DATE 06-29-95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95

contaminants were below their respective RBC levels. Di-n-octyl phthalate had no CBC, but was detected below the RBC level. The following compounds for which no CBC nor RBC value exists were detected on site: 2-methyl naphthalene and benzo(g,h,i)perylene. The remaining constituents may have exceeded their respective CBC, but were below the RBC level for the constituent. Therefore, they were not considered as contaminants of concern at the BRRP.

5.3.4 *Pesticides, PCBs, and Dioxins/Furans*

Only one compound in this group was detected in soil samples. Aldrin was detected in a sample from BRRP 01 from a depth of 12 - 14 feet at a concentration of 0.694 ug/kg (0.000694 mg/kg). No other pesticides, PCBs, or dioxins/furans for which the samples were tested were detected in soils.

There were no pesticides, PCBs, or dioxins/furans detected in any surface or subsurface background samples above detection limits. The concentration of aldrin detected at BRRP 01 is below the residential RBC level of 0.038 mg/kg. Therefore, aldrin was not considered as a potential contaminant at the BRRP.

5.3.5 *Radionuclides and Radionuclide Indicators*

Tables 5-30 and 5-31 summarizes the laboratory analytical results for radionuclides in surface and subsurface soils on site, respectively. The CBC and/or PRGs were exceeded by the maximum concentrations noted in actinium-228 (surface and subsurface), cobalt-60 (subsurface), europium-154 (subsurface), europium-155 (subsurface), lead-212 (surface and subsurface), manganese-54 (surface and subsurface), neptunium-239 (surface and subsurface), zinc-65 (subsurface), and zirconium-95 (subsurface). There were three constituents in which the maximum concentrations exceeded the CBC; however, a PRG was not available for these constituents. These three constituents were gross alpha, nonvolatile beta, and promethium-146. Promethium-144 has no CBC level nor does a PRG exist for it. It should be noted that gross alpha, nonvolatile beta, actinium-228, and lead-212 are considered naturally occurring radionuclides.

Figures 5-11 and 5-12 show the lead-212 concentrations as found in the soil boring samples. Figures 5-13 and 5-14 show the neptunium-239 concentrations as found in the soil boring samples. Values which exceed the CBC are underlined. Those that exceed the RBC are highlighted.

Table 5-30 Summary of Surface Soil Samples - Radionuclides and Radionuclide Indicators

Radionuclides & Radionuclide Indicators	Frequency of Detection	Surface Soil Sample Concentration (pCi/g)	Number > CBC	Soil Boring Number	Depth (feet)	Number > PRG	Soil Boring Number	Depth (feet)
		Maximum Detected						
Actinium-228	16/17	2.23	1/17	BRRP 08	0 - 2	16/17	BRRP 01 - 04; 06-17	0 -2
Antimony-124	0/17	ND	NC	NA	NA	0/17	NA	NA
Antimony-125	2/17	0.0171	NC	NA	NA	0/17	NA	NA
Barium-133	0/17	ND	NC	NA	NA	0/17	NA	NA
Cerium-144	3/17	0.0525	NC	NA	NA	0/17	NA	NA
Cesium-134	0/17	ND	NC	NA	NA	0/17	NA	NA
Cesium-137	16/17	0.0809	0/17	NA	NA	12/17	BRRP 02 - 05, 07 - 13, 15	0 - 2
Cobalt-57	0/17	ND	0/17	NA	NA	0/17	NA	NA
Cobalt-58	1/17	0.0125	NC	NA	NA	0/17	NA	NA
Cobalt-60	0/17	ND	NC	NA	NA	0/17	NA	NA
Europium-152	0/17	ND	0/17	NA	NA	0/17	NA	NA
Europium-154	0/17	ND	0/17	NA	NA	0/17	NA	NA
Europium-155	17/17	0.544	0/17	NA	NA	0/17	NA	NA
Gross alpha	16/17	17.8	3/17	BRRP 08, 11, 12	0 - 2	NR	NA	NA
Lead-212	17/17	2.25	8/17	BRRP 01, 07, 08, 11, 15, 16, 17	0 - 2	8/17	BRRP 01, 07, 08, 11, 15, 16, 17	0 - 2
Manganese-54	16/17	0.0394	12/17	BRRP 03, 07 - 17	0 -2	12/17	BRRP 03, 07 - 17	0 -2
Neptunium-239	17/17	1.32	10/17	BRRP 08 - 17	0 - 2	10/17	BRRP 08 - 17	0 - 2
Nonvolatile beta	17/17	11.1	2/17	BRRP 03, 12	0 - 2	NR	NA	NA
Potassium-40	17/17	1.49	0/17	NA	NA	0/17	NA	NA
Promethium-144	0/17	ND	NC	NA	NA	NR	NA	NA
Promethium-146	12/17	0.0153	0/17	NA	NA	NR	NA	NA
Ruthenium-106	1/17	0.0585	NC	NA	NA	0/17	NA	NA
Sodium-22	0/17	ND	NC	NA	NA	0/17	NA	NA
Thorium-234	14/17	1.72	0/17	NA	NA	0/17	NA	NA
Tin 113	0/17	ND	NC	NA	NA	0/17	NA	NA
Tritium	6/17	10.4	NC	NA	NA	0/17	NA	NA
Yttrium-88	1/17	0.00972	NC	NA	NA	NR	NA	NA
Zinc-65	0/17	ND	NC	NA	NA	0/17	NA	NA
Zirconium-95	0/17	ND	0/17	NA	NA	0/17	NA	NA

NA = Not applicable
NC = No criterion background concentration
ND = Not detected (sample was below the quantification limit)

Table 5-31 Summary of Subsurface Soil Samples - Radionuclides and Radionuclide Indicators

Radionuclides & Radionuclide Indicators	Frequency of Detection	Subsurface Soil Sample Concentration (pCi/g)	Number > CBC	Soil Boring Number	Depth (feet)	Number > PRG	Soil Boring Number	Depth (feet)
		Maximum Detected						
Actinium-228	40/51	4.39	4/51	BRRP 01, 15-17	14 - 16	4/51	BRRP 01, 15-17	14 - 16
Antimony-124	1/51	0.00509	NC	NA	NA	0/51	NA	NA
Antimony-125	4/51	0.0171	NC	NA	NA	0/51	NA	NA
Barium-133	3/51	0.223	NC	NA	NA	0/51	NA	NA
Cerium-144	2/51	0.153	NC	NA	NA	0/51	NA	NA
Cesium-134	1/51	0.00429	1/51	BRRP 08	14-16	0/51	NA	NA
Cesium-137	7/51	0.0186	1/51	BRRP 10	10 - 12	0/51	NA	NA
Cobalt-57	0/51	ND	0/51	NA	NA	0/51	NA	NA
Cobalt-58	2/51	0.0233	1/50	BRRP 17	14 - 16	0/51	NA	NA
Cobalt-60	3/51	0.00644	NC	NA	NA	1/51	BRRP 17	14 - 16
Europium-152	0/51	ND	0/51	NA	NA	0/51	NA	NA
Europium-154	1/51	0.0117	NC	NA	NA	1/51	BRRP 15	14-16
Europium-155	45/51	1.18	4/51	BRRP 15 - 17 BRRP 03	14 - 16 17 - 19	4/51	BRRP 15 - 17 BRRP 03	14 - 16 17 - 19
Gross alpha	40/51	34.8	10/51	BRRP 02 BRRP 02 BRRP 11 BRRP 01, 16 BRRP 05 BRRP 05 BRRP 03, 05 BRRP 06	8 - 10 10 -12 12 - 14 14 - 16 15 - 17 17 - 19 19 - 21 22 - 24	NR	NA	NA
Lead-212	44/51	4.39	4/51	BRRP 01, 15-17	14 - 16	4/51	BRRP 01, 15-17	14 - 16
Manganese-54	45/51	0.0755	3/51	BRRP 08 BRRP 15 - 16	12 - 14 14 - 16	38/51	BRRP 02 BRRP 01-02, 08-12, 14-17 BRRP 01-02, 08, 10, 11, 14-17 BRRP 09-11, 14-17 BRRP 05, 13 BRRP 07-08 BRRP 05 BRRP 07 BRRP 03, 05 BRRP 04, 07	8 - 10 10 - 12 12 - 14 14 - 16 15 - 17 16 - 18 17 - 19 18 - 20 19 - 21 20 - 22
Neptunium-239	45/51	2.84	3/51	BRRP 15-17	14 - 16	3/51	BRRP 15-17	14-16
Nonvolatile beta	45/51	25.8	NC	NA	NA	NR	NA	NA

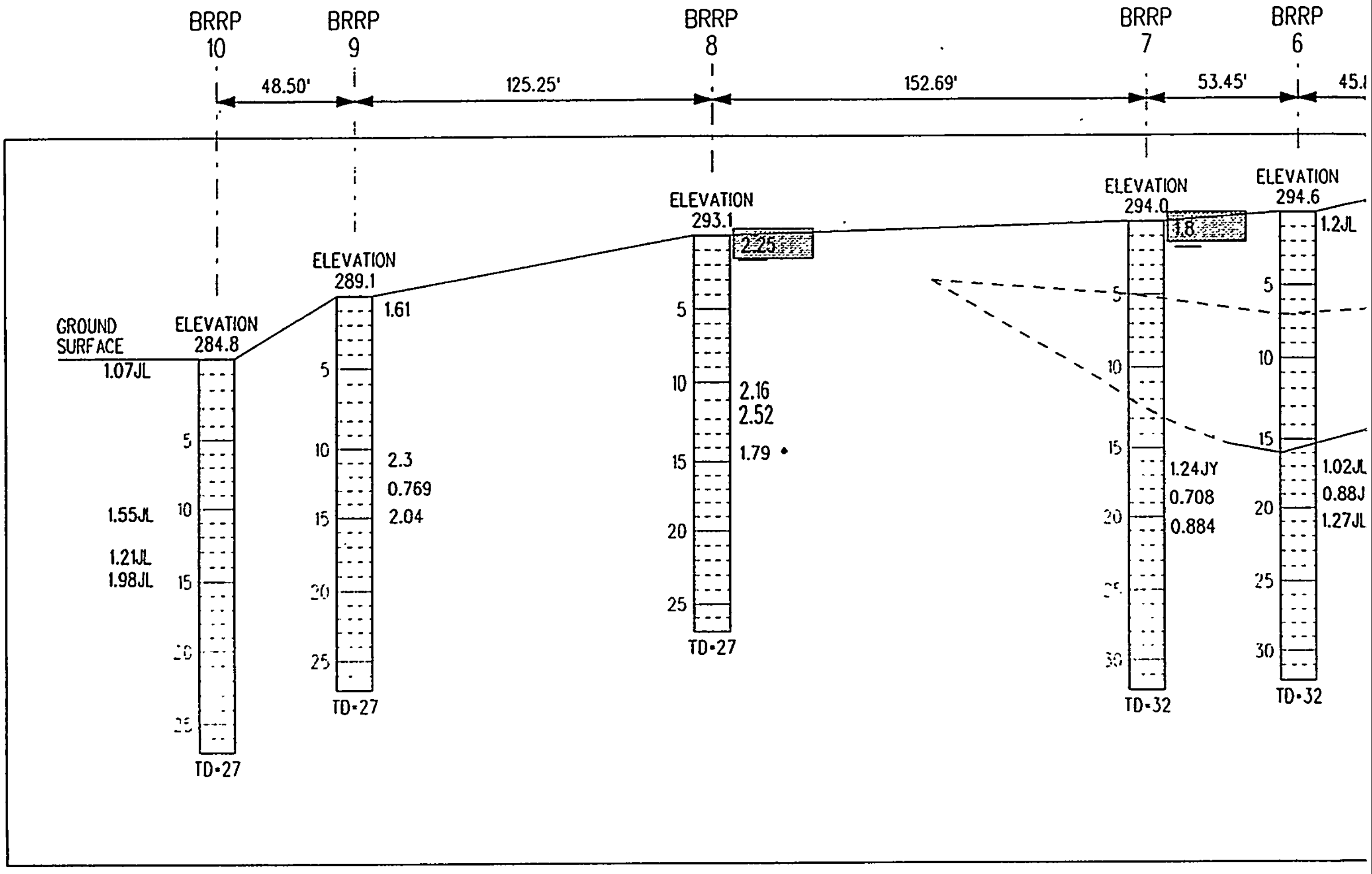
NA = Not applicable
NC = No criterion background concentration
ND = Not detected (sample was below the quantification limit)

Table 5-31 Summary of Subsurface Soil Samples - Radionuclides and Radionuclide Indicators (continued)

Radionuclides & Radionuclide Indicators	Frequency of Detection	Subsurface Soil Sample Concentration (pCi/g)	Number > CBC	Soil Boring Number	Depth (feet)	Number > PRG	Soil Boring Number	Depth (feet)
		Maximum Detected						
Potassium-40	48/51	1.82	0/51	NA	NA	48/51	BRRP 02 BRRP 01-02, 08-12, 14-17 BRRP 01-02, 08-11, 14-17 BRRP 01, 08-11, 14-17 BRRP 03, 05, 13 BRRP 04, 06-07 BRRP 03, 05, 13 BRRP 04, 06, 07 BRRP 03,05 BRRP 04, 06, 07	8-10 10-12 12-14 14-16 15-17 16-18 17-19 18-20 19-21 20-22
Promethium-144	2/51	1.79	NC	NA	NA	NR	NA	NA
Promethium-146	42/51	0.0284	8/51	BRRP 01, 08 BRRP 01, 15, 16-17 BRRP 13 BRRP 03	12-14 14-16 15-17 19-21	NR	NA	NA
Ruthenium-106	5/51	0.102	5/51	BRRP 11 BRRP 01, 13, 16 BRRP 13	12-14 14-16 17-19	0/51	NA	NA
Sodium-22	3/51	0.0052	NC	NA	NA	0/51	NA	NA
Thorium-234	36/51	2.17	9/51	BRRP 09 BRRP 02, 08 BRRP 01, 15, 16 BRRP 05 BRRP 03 BRRP 04	10-12 12-14 14-16 15-17 19-21 20-22	0/51	NA	NA
Tin 113	1/51	0.00174	0/51	NA	NA	0/51	NA	NA
Tritium	17/51	8.7	NC	NA	NA	0/51	NA	NA
Yttrium-88	5/51	0.00503	0/51	NA	NA	NR	NA	NA
Zinc-65	6/51	0.0299	4/51	BRRP 16 BRRP 11 BRRP 11, 17	10-12 12-14 14-16	1/51	BRRP 17	14-16
Zirconium-95	35/51	0.105	23/51	BRRP 01, 08, 11-12, 14-16 BRRP 01, 09, 11, 16-17 BRRP 01, 08, 09, 10-11, 15-17 BRRP 07 BRRP 07 BRRP 07	10-12 12-14 14-16 16-18 18-20 20-22	22/51	BRRP 01, 08, 11-12, 14-16 BRRP 01, 11, 16-17 BRRP 01, 08, 09, 10-11, 15-17 BRRP 07 BRRP 07 BRRP 07	10-12 12-14 14-16 16-18 18-20 20-22

NA = Not applicable NC = No criterion background concentration ND = Not detected (sample was below the quantification limit)

CROSS-SECT
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN pCi/l

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

▪ - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

PIT CONTOUR SHOWN DASHED WHERE INFERRED

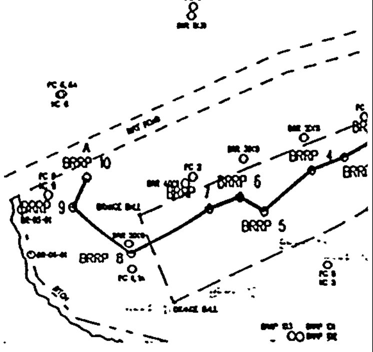
SURFACE CBC - 1.62

SUBSURFACE CBC - 0.1298

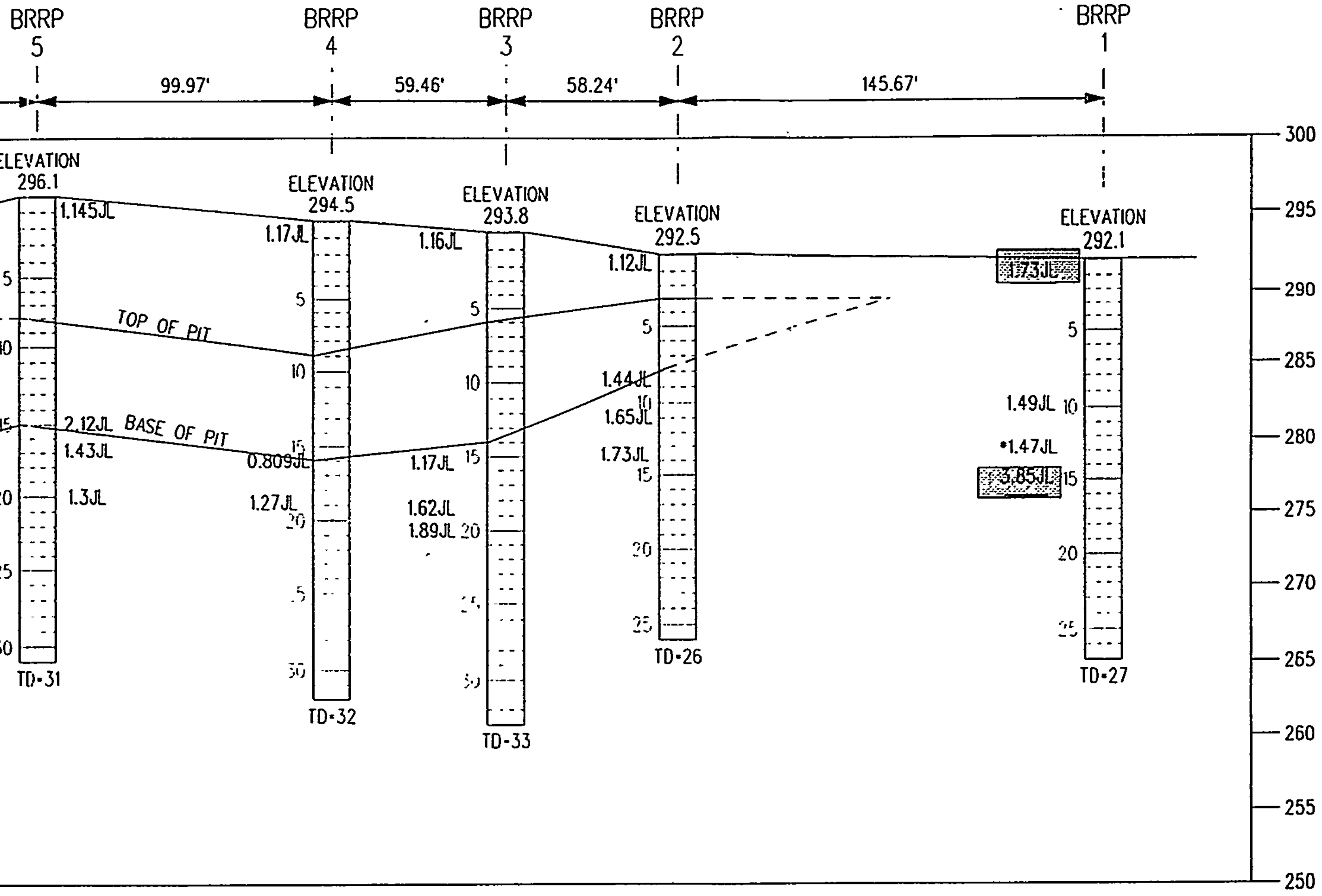
Residential PRG - 0.149

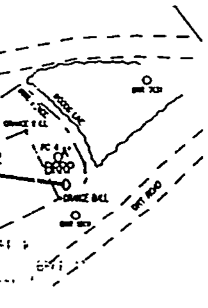
VALUES WHICH EXCEED CBS - UNDERLINED

VALUES WHICH EXCEED CBS & PRG - SHADED 3.85 JL



ON A-A'
UBBLE PIT





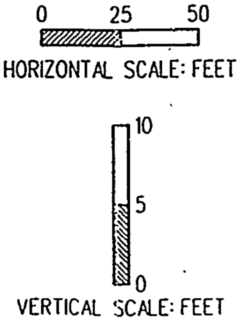


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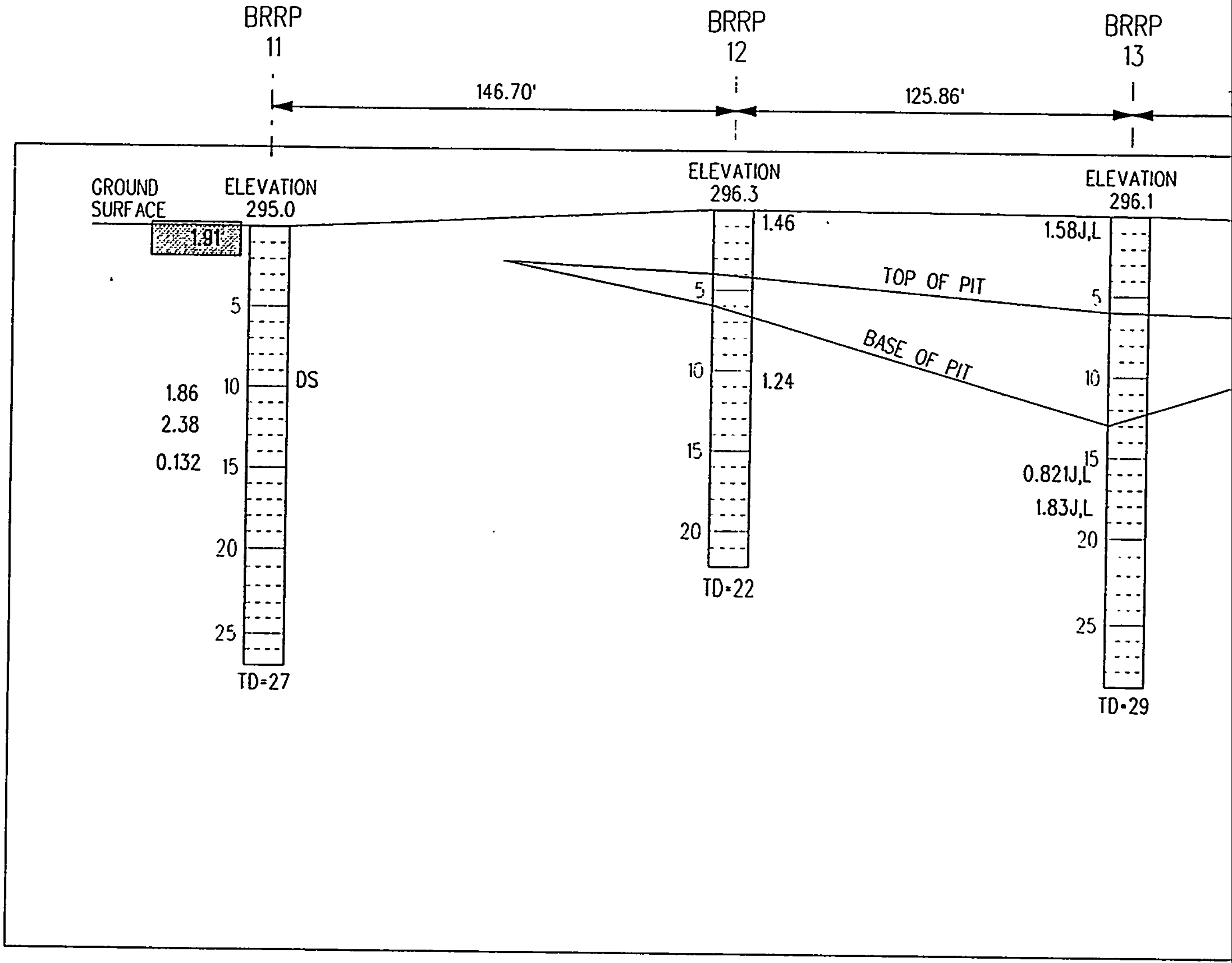
FIGURE 5-11
LEAD 212 CONCENTRATION pCi/g
BURMA ROAD RUBBLE PIT
CROSS SECTION A-A'

	DATE		DATE
CREATED BY TRACY L. MICKLEY	06-29-95	APPROVED BY NA	95
PREPARED BY TOM MCADAMS	06-29-95	APPROVED BY NA	95
APPROVED BY NA	95	APPROVED BY NA	95
APPROVED BY NA	95	APPROVED BY NA	95

CROSS-SECT
BURMA ROAD



NOTES:

CONTAMINANT VALUES NOTED ARE IN pCi/g

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

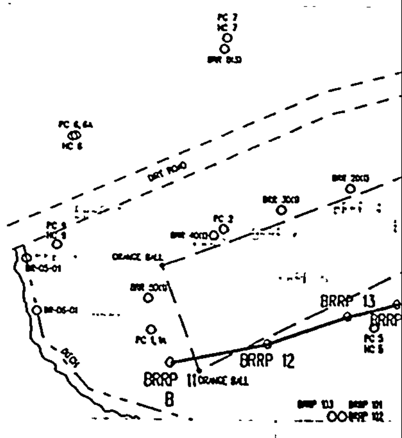
* - MAXIMUM VALUE OF DUPLICATE ANALYSIS

* - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17) (IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

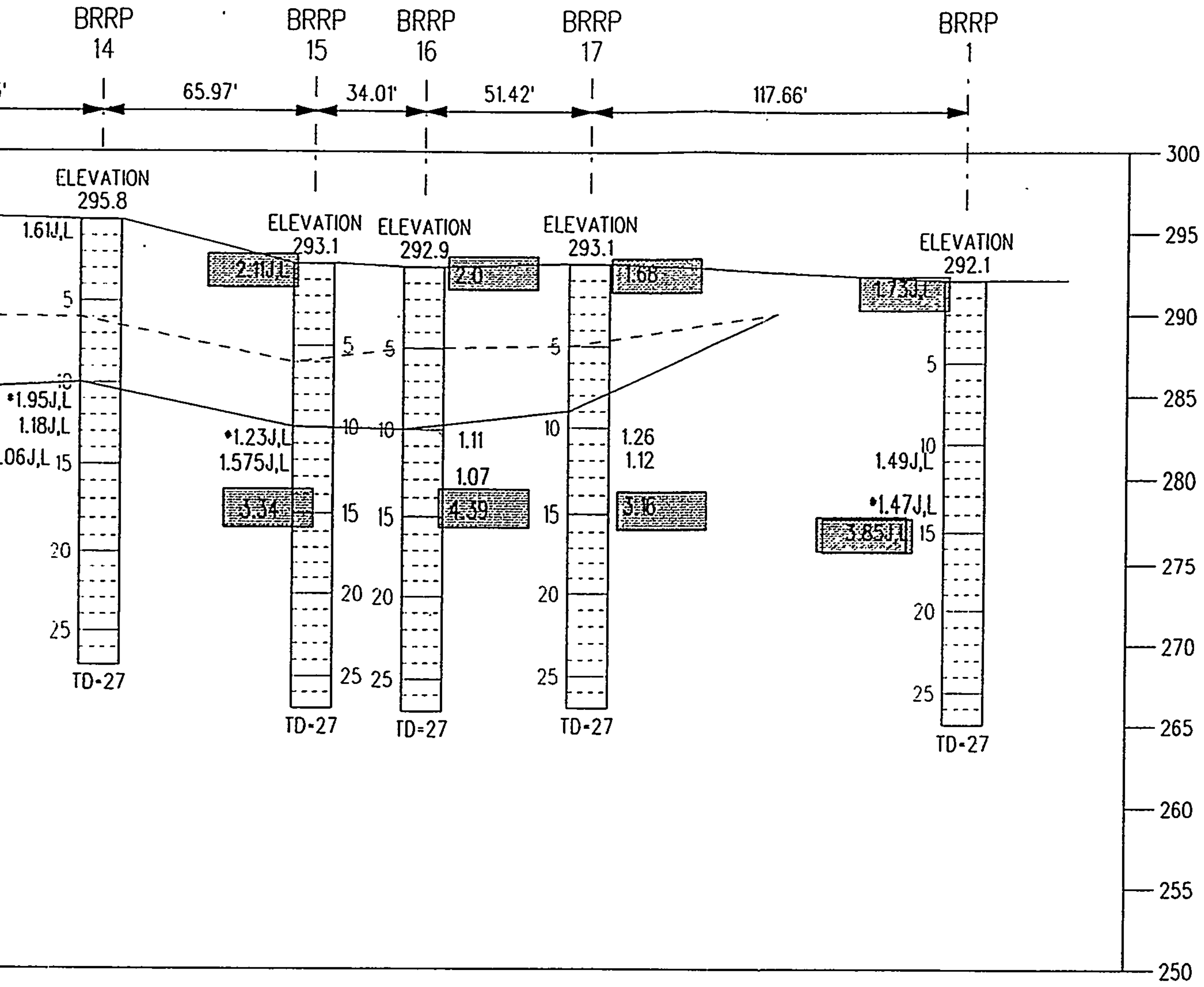
PIT CONTOUR SHOWN DASHED WHERE INFERRED

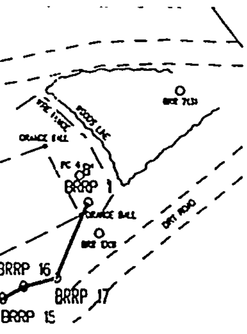
SURFACE CBC - 1.62
SUBSURFACE CBC - 0.1298
Residential PRG - 0.149

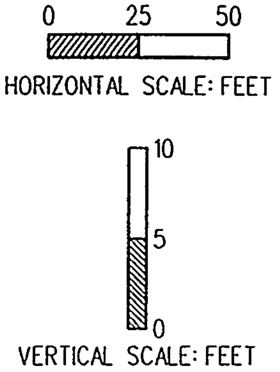
VALUES WHICH EXCEED CBS - UNDERLINED
VALUES WHICH EXCEED CBS & PRG - SHADED ▨ 3.85 JL



N B-B'
BBLE PIT







DWG NO.	REV. NO.	REV. DATE	AREA
SS1851	0	06-29-95	GSA

SAVANNAH RIVER SITE
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ENVIRONMENTAL RESTORATION
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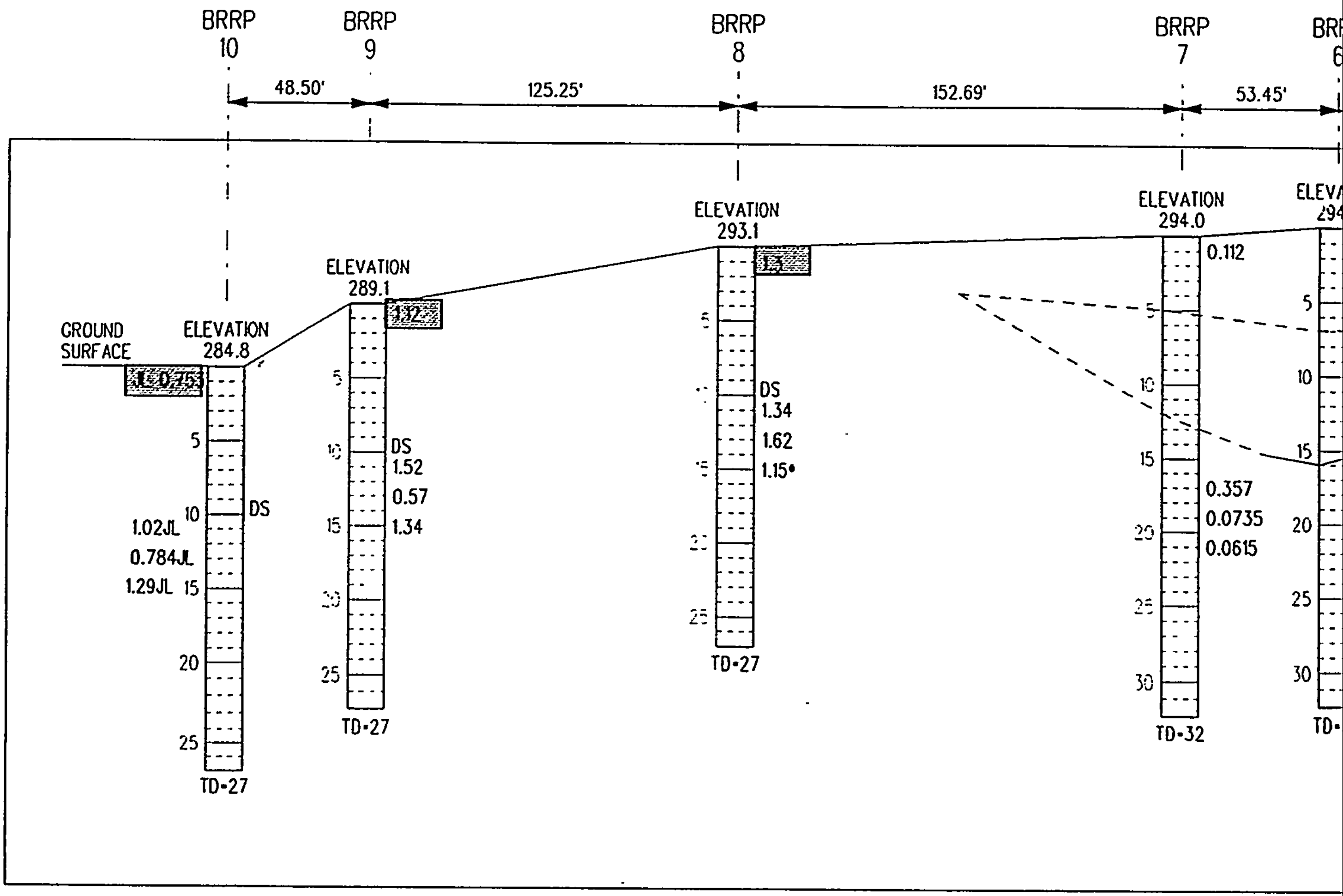
TITLE
FIGURE 5-12
LEAD 212 CONCENTRATION PCI/G
BURMA ROAD RUBBLE PIT
CROSS SECTION B-B'

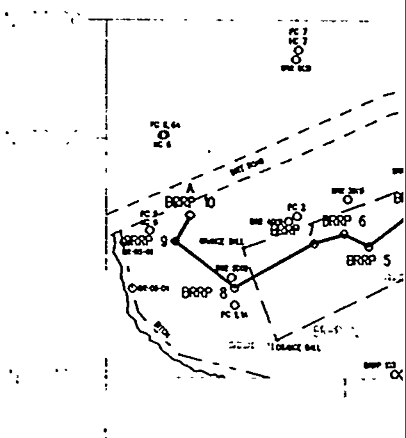
	DATE		DATE
CREATED BY TRACY L. MICKLEY	06-29-95	APPROVED BY NA	95
PREPARED BY TOM MCADAMS	06-29-95	APPROVED BY NA	95
APPROVED BY NA	95	APPROVED BY NA	95
APPROVED BY NA	95	APPROVED BY NA	95

CROSS-S
BURMA RO

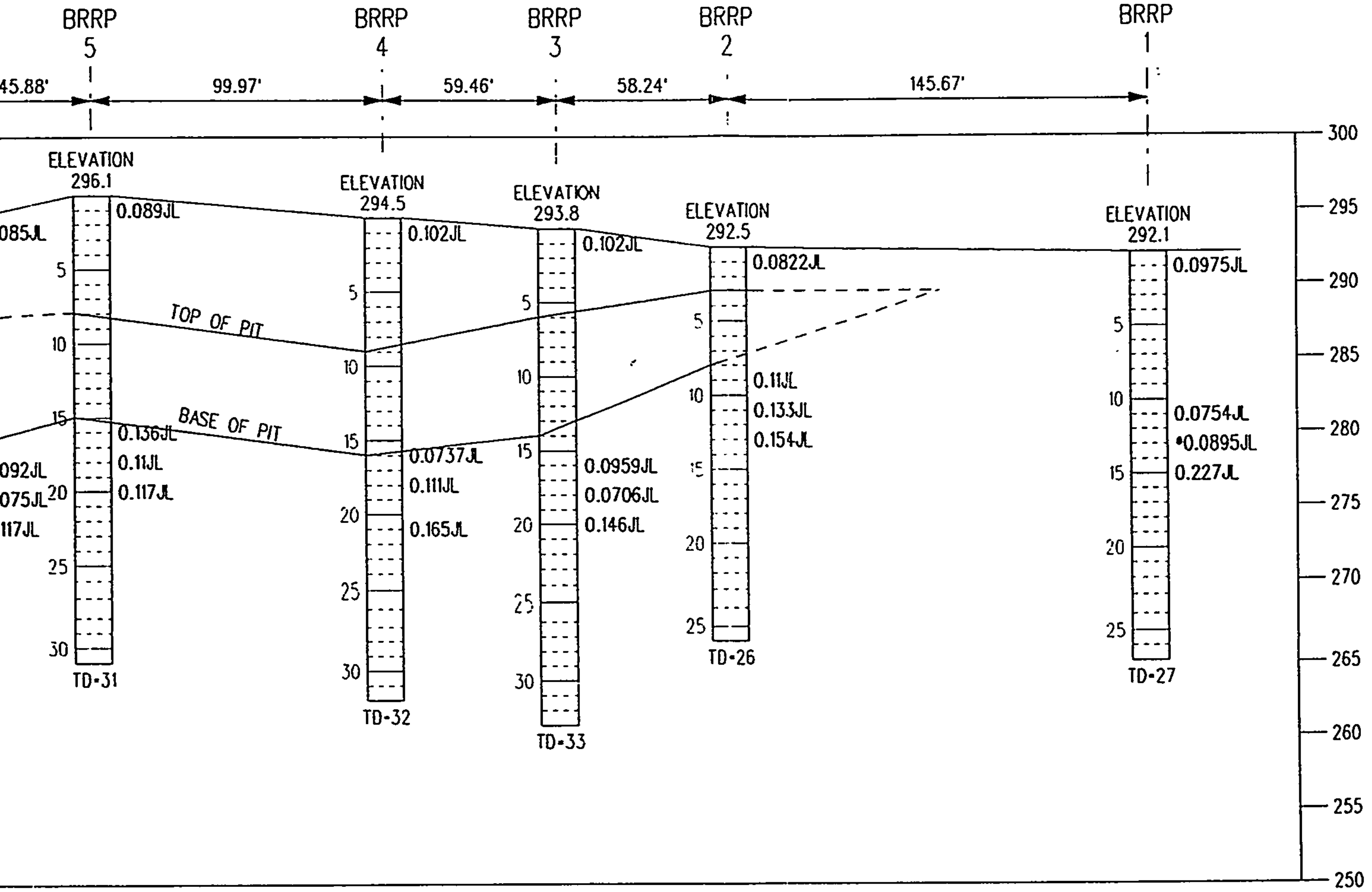


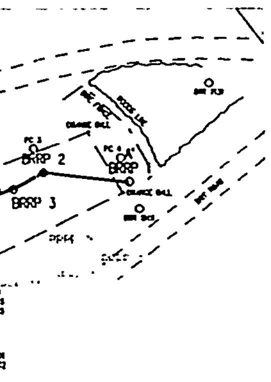
NOTES:

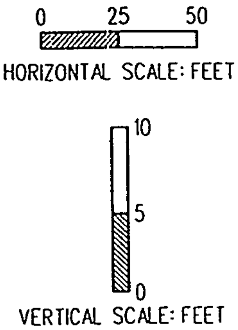
CONTAMINANT VALUES NOTED ARE IN pci/g
CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE
U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT
J - RESULT IS AN ESTIMATED VALUE
DS - DISTURBED SOIL
NA - NOT ANALYZED FOR THIS CONTAMINANT
• - MAXIMUM VALUE OF DUPLICATE ANALYSIS
• - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17)
(IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)
PIT CONTOUR SHOWN DASHED WHERE INFERRED
SURFACE CBC - 0.120
SUBSURFACE CBC - 1.68 } VALUES WHICH EXCEED CBC - UNDERLINED
(RESIDENTIAL) PRG - 0.181
NEPTUNIUM 239 pci/g } VALUES WHICH EXCEED PRG - SHADED ▨ 1.12



TION A-A'
RUBBLE PIT







DWG NO.	REV. NO.	REV. DATE	AREA
SS1844	0	06-29-95	GSA

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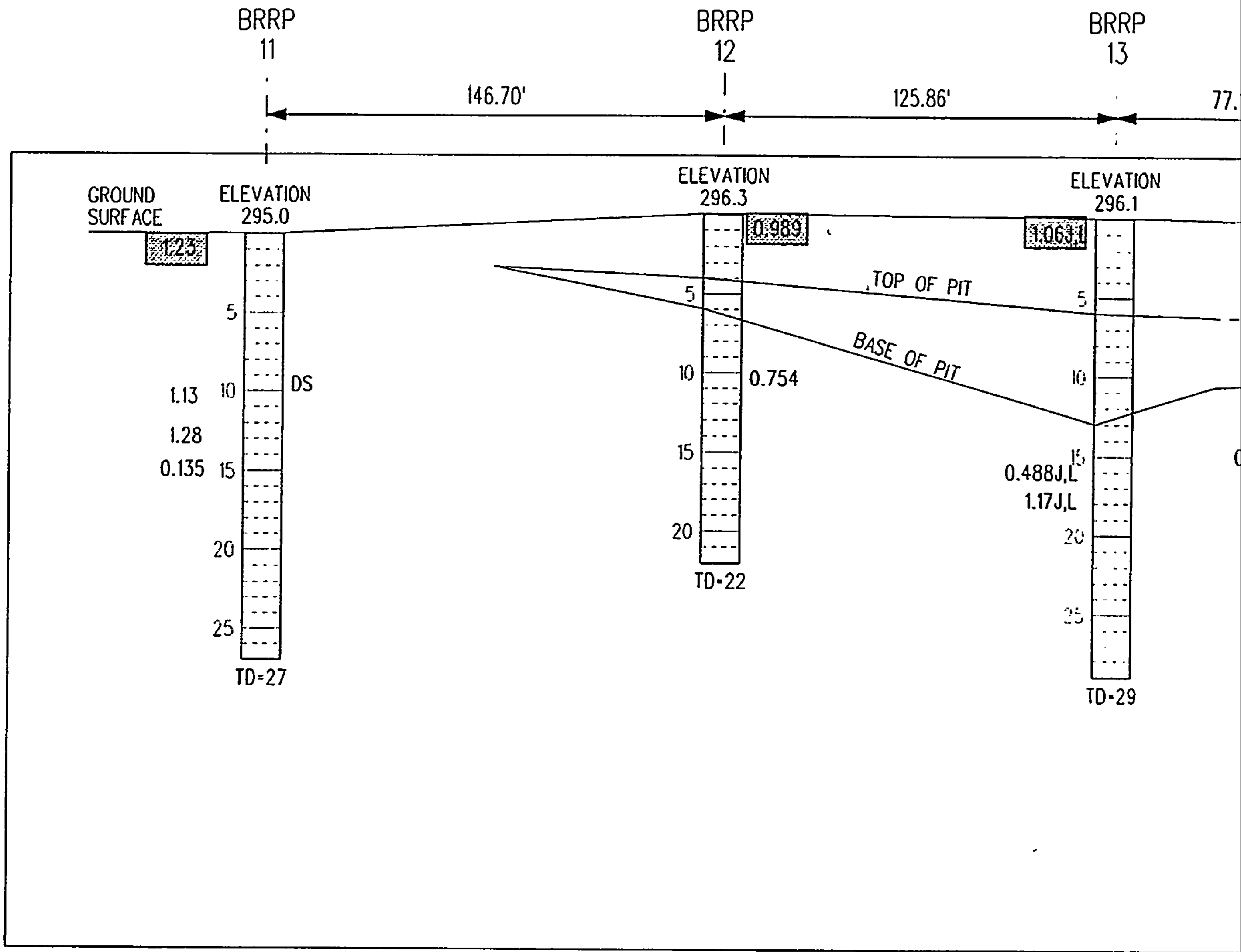
TITLE
FIGURE 5-13
NEPTUNIUM 239 CONCENTRATION (pci/g)
BURMA ROAD RUBBLE PIT
CROSS SECTION A-A'

	DATE	APPROVED BY	DATE
CREATED BY TRACY L. MICKLEY	06-29-95	NA	95
PREPARED BY TOM MCADAMS	06-29-95	NA	95
APPROVED BY NA	95	NA	95
APPROVED BY NA	95	NA	95

CROSS-SECTIO
BURMA ROAD R



NOTES:

CONTAMINANT VALUES NOTED ARE IN PCi/g

CONTAMINANT VALUES NOTED ARE AT MIDPOINT OF SAMPLE RANGE

U - RESULT IS BELOW SAMPLE QUANTIFICATION LIMIT

J - RESULT IS AN ESTIMATED VALUE

DS - DISTURBED SOIL

NA - NOT ANALYZED FOR THIS CONTAMINANT

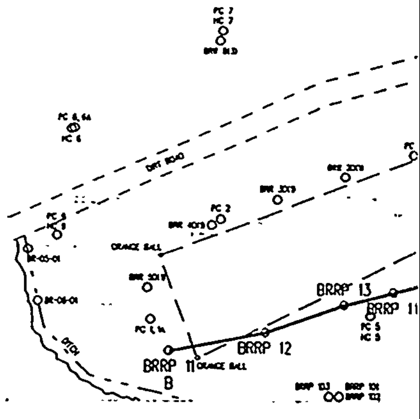
• - MAXIMUM VALUE OF DUPLICATE ANALYSIS

: - DEPTH INTERVAL IS A COMBINATION OF TWO SAMPLES (14-16, 16-17) (IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS)

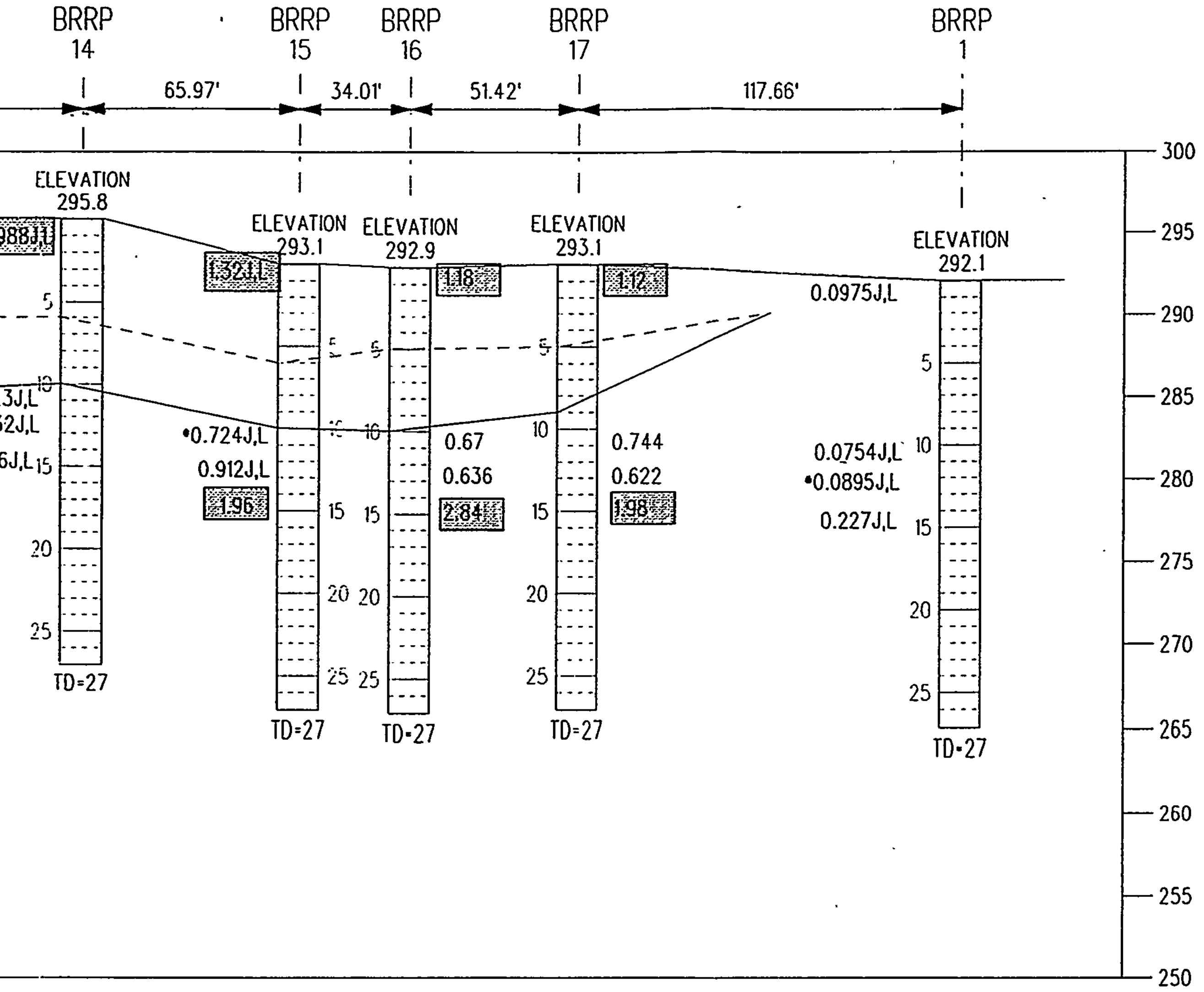
PIT CONTOUR SHOWN DASHED WHERE INFERRED

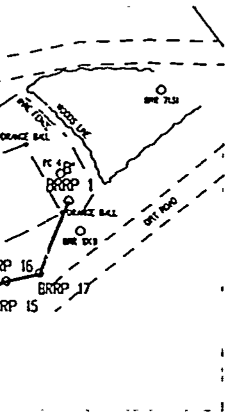
SURFACE CBC - 0.120
SUBSURFACE CBC - 1.68 } VALUES WHICH EXCEED CBC - UNDERLINED

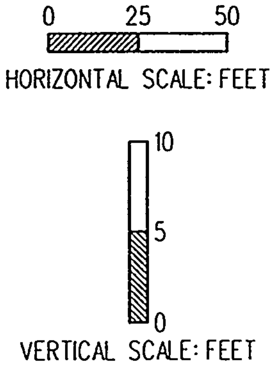
(RESIDENTIAL) PRG - 0.181
NEPTUNIUM 239 pci/g } VALUES WHICH EXCEED PRG - SHADED ▨ 1.12



B-B'
BBLE PIT







HORIZONTAL SCALE: FEET

VERTICAL SCALE: FEET

DWG NO.	REV. NO.	REV. DATE	AREA
SS1850	0	06-29-95	GSA

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TITLE
FIGURE 5-14
NEPTUNUIM 239 CONCENTRATION pCi/g
BURMA ROAD RUBBLE PIT
CROSS SECTION B-B'

CREATED BY	DATE	APPROVED BY	DATE
TRACY L. MICKLEY	06-29-95	NA	95
PREPARED BY TOM MCADAMS	DATE 06-29-95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95
APPROVED BY NA	DATE 95	APPROVED BY NA	DATE 95

5.3.6 *TCLP*

The TCLP is a laboratory procedure used to determine if a solid waste exhibits the characteristic of toxicity. If concentrations from the extract of the waste exceed or equal regulatory limits, the waste is considered to be hazardous. The TCLP was carried out on samples from all seventeen sampling locations. The laboratory analytical results are displayed in Appendix J. No samples tested had concentrations greater than the TCLP limits.

5.4 Groundwater

B and C monitoring wells are screened in the "Lower" aquifer zone of the Upper Three Runs Aquifer. Screens on the B designation wells are set within the lower portion of the "Lower" aquifer, while C wells are situated in the upper portion of the "Lower" aquifer. There are three nests of B and C wells (wells 6B, 6C, 7B, 7C, 8B, and 8C) siutated approximately 150 to 500 feet from the site. Monitoring wells designated D are screened in the "Upper" aquifer zone of the Upper Three Runs Aquifer. There are eight monitoring wells designated as D. Five wells (1D through 5D) surround the BRRP area and three (6D, 7D, and 8D) are nested with the corresponding B and C monitoring wells (see Figure 4-23 for monitoring wells locations). Groundwater samples were collected quarterly (from the fourth quarter of 1993 to the second quarter of 1994) from these 14 monitoring wells.

At the BRRP, monitoring wells 6B, 6C, 6D, 7B, 7C, and 7D are considered to be upgradient. However, the entire site is downgradient of the SRS F-Area Separation Facilities and the entire BRRP well network may be impacted by groundwater migration from the F-Area.

5.4.1 *Upper Aquifer Zone Monitoring Well Analytical Results*

Table 5-32 summarizes the results of groundwater sampling D wells.

5.4.1.1 Target Analyte List (TAL) Constituents

A total of 22 TAL constituents were detected in groundwater samples collected at the BRRP site. Three analytes (aluminum, iron, and manganese) had concentrations that surpassed SDWA standards. The other detected analytes did not exceed Maximum Contaminant Levels specified in SDWA.

Table 5-32 D Well Summary

GENERAL CHEMISTRIES		BRR 1D RANGE	BRR2D RANGE	BRR 3D RANGE	BRR 4D RANGE	BRR 5D RANGE	BRR 6D RANGE	BRR 7D RANGE	BRR 8D RANGE	Primary MCI	FREQ. DETECTED
Asbestos	MSL	U	U	U	U	U	no data	no data	no data	NR	0/5
Chloride		no data	no data	no data	no data	no data	4470–4640	4240–5510	2490–2490	NR	6/6
Fluoride		no data	no data	no data	no data	no data	U	U	U	4000	0/6
Nitrate–nitrite as nitrogen	ug/L	2000	4050	31000	2100	1250	990–1120	1960–2380	1840–1900	10000	11/11
pH	PH	5.63	5.24	5.53	6.05	5.51	5.87–6.03	5.87–6.08	5.45–5.57	NR	11/11
Phenols		no data	no data	no data	no data	no data	U	U	U	NR	0/6
Silica, total recoverable		no data	no data	no data	no data	no data	7540–7910	9130–9560	8040–8190	NR	6/6
Specific conductance	uS/c	56.5	76.8	121	104	124	80.3–104	81.6–108	39.7–40.2	NR	11/11
Sulfate		no data	no data	no data	no data	no data	3910–6220	3920–4580	U	NR	4/6
Total dissolved solids		no data	no data	no data	no data	no data	55000	55000–76000	33000–35000	NR	6/6
Total organic carbon	ug/L	U–1060	U	U–1260	U–1100	2000–2150	1780–75000	1560–2540	U	NR	8/16
Total organic halogens	ug/L	U–6	U	U–17	U	13.5–17.2	U–1090	U–10	9.2–12.7	NR	8/16
Total phosphates (as P)		no data	no data	no data	no data	no data	U	60–120	U	NR	2/6

NR – no regulatory level has been set
U = below sample qunatification limit

Table 5-32 D Well Summary (continued)

TAL		BRR 1D RANGE	BRR2D RANGE	BRR 3D RANGE	BRR 4D RANGE	BRR 5D RANGE	BRR 6D RANGE	BRR 7D RANGE	BRR 8D RANGE	Primary MCL (ppb)	FREQ. DETECTED
Aluminum, total recoverable	ug/L	106-154	193-947	411-464	117-296	34.9-44.5	75.4-131	1230-8280	38-52.1	NR	21/21
Antimony, total recoverable	ug/L	U	U	U	U	U	U	U-2.91	U	6	16/21
Arsenic, total recoverable	ug/L	U	U	U	U	U	U	U	U	50	0
Barium, total recoverable	ug/L	15.6-18.1	37.6-40.8	26.1-28.2	11.3-14.2	11.2-17	24.6-26.2	23-79.3	10.3-11.1	2000	21/21
Beryllium, total recoverable	ug/L	0.13-U	0.13-U	0.36-U	0.15-U	0.09-U	0.08-0.11	0.24-0.72	0.07-0.14	4	16/21
Boron, total recoverable	ug/L	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	34.1-U	31.4-U	U	NR	2/6
Cadmium, total recoverable	ug/L	U	0.73-U	0.63-U	0.74-U	U	U	U	U	5	4/21
Calcium, total recoverable	ug/L	3400-3630	3810-3820	3780-3830	2210-2460	1730-2340	2590-2930	2210-2800	1630-1650	NR	16/16
Chromium, total recoverable	ug/L	u	U-7.16	2.93-U	2.28-U	U	U	30.1-37.9	U	100	6/21
Cobalt, total recoverable	ug/L	1.66-1.85	U-2.21	1.7-2.19	1.63-2.29	2.1-3.66	2.79-3.42	5.08-6.16	1.39-1.75	NR	15/16
Copper, total recoverable	ug/L	4.43-6.27	5.34-41.7	37.3-68.6	2.88-4.55	2.56-U	2.92-8.43	6.78-12.4	3.36-9.53	1300	19/21
Cyanide	ug/L	1.7-U	1.7-U	4-U	1.7-U	U-1.7-U	U-1.7	U-1.7	U-1.7	200	8/21
Iron, total recoverable	ug/L	313-470	406-1910	899-1110	471-958	360-505	34.3-134	2920-7870	21.9-32.8	NR	16/16
Lead, total recoverable	ug/L	U-36.9	U-31.8	11.8-21.4	U-4.77	9.6-13.6	1.04-11.4	10.4-10.8	6.29-11.3	15	18/21
Lithium, total recoverable	ug/L	no data	no data	no data	no data	no data	U	5.59-24.1	U	NR	2/6
Magnesium, total recoverable	ug/L	1160-1280	1200-1280	2160-2190	369-452	340-432	268-309	281-544	684-708	NR	16/16
Manganese, total recoverable	ug/L	30.7-32	31.6-59.8	29-30.5	42.8-48.6	33.9-34.7	117-121	55-83.8	31.1-33.4	NR	16/16
Mercury, total recoverable	ug/L	0.08-.1	U-.06	0.06-0.07	U-0.05	0.05-U	U-0.06	U	U	2	10/21
Nickel, total recoverable	ug/L	5.12-8.26	5.45-13.1	5.37-5.73	4.06-7.79	9.09-11.9	5.02-6	29.3-32	U-3.04	100	19/21
Potassium, total recoverable	ug/L	700-711	2640-2830	6370-8270	1620-1890	2130-2360	665-678	3370-6830	105-218	NR	16/16
Selenium, total recoverable	ug/L	U	U	U	U	U	U	U	U	50	0/16
Silver, total recoverable	ug/L	U	U	U	U	U	U	U	U	NR	0/16
Sodium, total recoverable	ug/L	3750-4230	7360-7790	12700-1490	14800	12300-1480	12300-1760	9990-12900	3770-3970	NR	16/16
Thallium, total recoverable	ug/L	U	U	U	U	U	U	U	U	2	0/16
Vanadium, total recoverable	ug/L	.73-1.08	0.92-4.49	2.52-2.78	0.81-1.56	U-1.83	0.62-1.01	6.28-21.1	U-0.4	NR	14/16
Zinc, total recoverable	ug/L	14.6-43	39.5-80.5	49-59.5	16.9-33.5	23.9-58.7	47.7-58.9	61.4-85.4	11.9-17.4	NR	21/21

Table 5-32 D Well Summary (continued)

SEMIVOLATILE AND VOLATILE ORGANIC		BRR 10 RANGE	BRR 20 RANGE	BRR 30 RANGE	BRR 40 RANGE	BRR 50 RANGE	BRR 60 RANGE	BRR 70 RANGE	BRR 80 RANGE	Primary MCL (ppb)
1,2,4-Trichlorobenzene	ug/L	U	U	U	U	U	U	U	U	70
1,2-Dichlorobenzene	ug/L	U	U	U	U	U	U	U	U	600
1,2-Diphenylhydrazine	ug/L	U	U	U	U	U	NO DATA	NO DATA	NO DATA	NR
1,3-Dichlorobenzene	ug/L	U	U	U	U	U	U	U	U	600
1,4-Dichlorobenzene	ug/L	U	U	U	U	U	U	U	U	75
2,4,5-Trichlorophenol	ug/L	U	U	U	U	U	U	U	U	NR
2,4,6-Trichlorophenol	ug/L	U	U	U	U	U	U	U	U	NR
2,4-Dichlorophenol	ug/L	U	U	U	U	U	U	U	U	NR
2,4-Dimethyl phenol	ug/L	U	U	U	U	U	U	U	U	NR
2,4-Dinitrophenol	ug/L	U	U	U	U	U	U	U	U	NR
2,4-Dinitrotoluene	ug/L	U	U	U	U	U	U	U	U	NR
2,6-Dinitrotoluene	ug/L	U	U	U	U	U	U	U	U	NR
2-Chloroethyl vinyl ether	ug/L	U	U	U	U	U	NODATA		NO DATA	NR
2-Chloronaphthalene	ug/L	U	U	U	U	U	U	U	U	NR
2-Chlorophenol	ug/L	U	0.16-U	U	U	U-0.12-U	U-0.11	U-0.13	U	NR
2-Methylnaphthalene	ug/L	U	U	U	U	U	U	U	U	NR
2-Methyl-4,6-dinitrophenol	ug/L	U	U	U	U	U	U	U	U	NR
2-Nitrophenol	ug/L	U	U	U	U	U	U	U	U	NR
3,3'-Dichlorobenzidine	ug/L	U	U	U	U	U	U	U	U	NR
4-Chloroaniline	ug/L	U	U	U	U	U	U	U	U	NR
4-Chlorophenyl phenyl ether	ug/L	U	U	U	U	U	U	U	U	NR
4-Chloro-m-cresol	ug/L	U	U	U	U	U	U	U	U	NR
4-Nitrophenol	ug/L	U	U	U	U	U	U	U	U	NR
Acenaphthene	ug/L	U	U	U	U	U	U	U	U	NR
Acenaphthylene	ug/L	U	U	U	U	U	U	U	U	NR
Acrolein	ug/L	U	U	U	U	U	NO DATA	NO DATA	NO DATA	NR
Acrylonitrile	ug/L	U	U	U	U	U	NO DATA	NO DATA	NO DATA	NR
Anthracene	ug/L	U	U	U	U	U	U	U	U	NR
Benzidine	ug/L	U	U	U	U	U	NO DATA	NO DATA	NO DATA	NR
Benzoic acid	ug/L	U	U	U	U	U	U	U	U	NR
Benzo(a)anthracene	ug/L	U	U	U	U	U	U	U	U	NR
Benzo(a)pyrene	ug/L	U	U	U	U	U	U	U	U	0.2
Benzo(b)fluoranthene	ug/L	U	U	U	U	U	U	U	U	0.2
Benzo(g,h,i)perylene	ug/L	U	U	U	U	U	U	U	U	NR
Benzo(k)fluoranthene	ug/L	U	U	U	U	U	U	U	U	0.2
Benzyl alochol	ug/L	U	U	U	U	U	U	U	U	NR
Bis(2-chloroethoxy) methane	ug/L	U	U	U	U	U	U	U	U	NR
Bis(2-chloroethyl) ether	ug/L	U	U	U	U	U	U	U	U	NR
Bis(2-chloroisopropyl) ether	ug/L	U	U	U	U	U	U	U	U	NR
Bis(2-ethylhexyl) phthalate	ug/L	0.37-U	0.38-U	0.62-U	1.16-U	0.25-U	U	1.45-1.07	U-0.22	NR
Butylbenzyl phthalate	ug/L	U	U	U	U	U	U	U	U	100
Chrysene	ug/L	U	U	U	U	U	U	U	U	0.2
Dibenzofuran	ug/L	U	U	U	U	U	U	U	U	NR
Dibenz(a,h)anthracene	ug/L	U	U	U	U	U	U	U	U	0.3
Diethyl phthalate	ug/L	U	U	U	U	U	U	U	U	NR
Dimethyl phthalate	ug/L	0.14-U	U	U	U	U	U	U	U	NR
Di-n-butyl phthalate	ug/L	U	U	U	U-0.53-U	U	U	U	U	NR
Di-n-octyl phthalate	ug/L	U	U	U	U	U	U	U	U	NR
1,1,1-Trichloroethane	ug/L	0.1-U	U	U	U-0.33-U	U-0.11-U	U	U	U	200
1,1,2,2-Tetrachloroethane	ug/L	U	U	U	U	U	U	U	U	NR
1,1,2-Trichloroethane	ug/L	U	U	U	U	U	U	U	U	5
1,1-Dichloroethane	ug/L	0.11-U	0.2-1	0.09-U	0.26-U	0.52-U	U	U	U	NR
1,1-Dichloroethylene	ug/L	U	U	U	U	U	U	U	U	7
1,2-Dichloroethane	ug/L	U	U	U	U	U	U	U	U	5
1,2-Dichloroethylene	ug/L	U	U	U	U	U	U	U	U	70
1,2-Dichloropropane	ug/L	0.11-U	0.72-U	0.09-0.13	0.25-U	U-0.52-U	U	U	U	5
2-Hexanone	ug/L	U	U	U	U	U	U	U	U-0.28	NR
4-Bromophenyl phenyl ether	ug/L	U	U	U	U	U	U	U	U	NR
Acetone	ug/L	U-4	U-3.86	U-3.9	U-3.17	U-3.82	U	U	U-4.48	NR
Benzene	ug/L	0.08-U	0.6-U	0.11-U	U-0.11-U	U	U	U	U	5
Bromodichloromethane	ug/L	U	U	U	U	U	U	0.1	U	100
Bromoform	ug/L	U	U	U	U	U	U	U	U	100
Bromomethane (Methyl bromide)	ug/L	U	U	U	U	U	U	U	U	NR
Carbon disulfide	ug/L	U	U-0.17	U	U	U	U	U	U	NR
Carbon tetrachloride	ug/L	U	U	U	U-0.06-U	U	U	0.15-0.36	3.64-4.45	5
Chlorobenzene	ug/L	U	U	U	U	U	U	U	U	NR
Chloroethane	ug/L	U	U	U	U	U	U	U	U	NR
Chloroethene (Vinyl chloride)	ug/L	U	U	U	U	U	U	U	U	2
Chloroform	ug/L	U	0.09-U	0.13-U	U-0.20-U	U	0.07-0.16	0.52-0.68	0.17	100
Chloromethane (Methyl chloride)	ug/L	0.16-U	0.21-U	0.15-U	U-0.15-U	U-0.18-U	U-0.08	U	U	NR
cis-1,3-Dichloropropene	ug/L	U	U	U	U	U	U	U	U	NR
Dibromochloromethane	ug/L	U	U	U	U	U	U	U	U	NR
Dichlorodifluoromethane	ug/L	1.1	U	0.39-U	U	U	U	NO DATA	NO DATA	NR
Dichloromethane (Methylene chloride)	ug/L	0.36-U	U-1.3	U	U	U	0.44	-0.09	U	5
Ethylbenzene	ug/L	U	U	U	U	U	U	U	U	700
Fluoranthene	ug/L	U	U	U	U	U	U	U	U	NR
Fluorene	ug/L	U	U	U	U	U	U	U	U	NR
Hexachlorobenzene	ug/L	U	U	U	U	U	U	U	U	[illegible]
Hexachlorobutadiene	ug/L	U	U	U	U	U	U	U	U	
Hexachlorocyclopentadiene	ug/L	U	U	U	U	U	U	U	U	[illegible]
Hexachloroethane	ug/L	U	U	U	U	U	U	U	U	NR
Indeno(1,2,3-c,d)pyrene	ug/L	U	U	U	U	U	U	U	U	0.4
Isophorone	ug/L	U	U	U	U	U	U-0.16	U	U	NR
m,p-Cresol	ug/L	U	U	U	U	U	U	U	U	NR
m-Nitroaniline	ug/L	U	U	U	U	U	U	U	U	[illegible]
Naphthalene	ug/L	U	U	U	U	U	U	U	U	[illegible]
Nitrobenzene	ug/L	U	U	U	U	U	U	U	U	NR
N-Nitrosodimethylamine	ug/L	U	U	U	U	U		no data	NO DATA	NR
N-Nitrosodiphenylamine	ug/L	U	U	U	U	U	U	U	U	NR
N-Nitrosodipropylamine	ug/L	U	U	U	U	U	U	U	U	NR
o-Cresol (2-Methylphenol)	ug/L	U	U	U	U	U	U	U	U	NR
o-Nitroaniline	ug/L	U	U	U	U	U	U	U	U	NR
Pentachlorophenol	ug/L	U	U	U	U	U	U	U	U	[illegible]
Phenanthrene	ug/L	U	U	U	U	U	U	U	U	[illegible]
Phenol	ug/L	U	U	U	U	U	U	U	U	[illegible]
Pyrene	ug/L	U-.23	U	U	U	U	U	U	U	NR
p-Nitroaniline	ug/L	U	U	U	U	U	U	U	U	[illegible]
Methyl ethyl ketone	ug/L	U	U	U	U	U	U	U	U	[illegible]
Methyl isobutyl ketone	ug/L	U	U	U	U	U	U	U	U	[illegible]
Styrene	ug/L	U	U	U	U	U	U	U	U	100
Tetrachloroethylene	ug/L	.36-.42	0.34-0.46	0.11-0.12	0.14-U	0.16-U	U	0.23-0.51	0.15-0.23	5
Toluene	ug/L	.09-.14	0.17-0.36	0.07-0.1	0.13-U	0.1-U	0.12-0.15	0.06-0.17	0.16-0.19	1000
trans-1,2-Dichloroethylene	ug/L	U	U	U	U	U	no data	no data	NO DATA	100
trans-1,3-Dichloropropene	ug/L	U	U	U	U	U	U	U	U	[illegible]
Trichloroethylene	ug/L	U	0.3-0.81	0.31-0.48	0.14-U	U	0.12-0.19	0.8-2.29	1.91-[illegible]	[illegible]
Trichlorofluoromethane	ug/L	U	U	4.1	0.15-U	U	no data	no data	NO DATA	NR
Vinyl acetate	ug/L	U	U	U	U	U	U	U	U	NR
Xylenes	ug/L	U	U	U	U	U	U	U	U-0.1	10000

Table 5-32 D Well Summary (continued)

PESTICIDES/PCBS		BRR 1D RANGE	BRR2D RANGE	BRR 3D RANGE	BRR 4D RANGE	BRR 5D RANGE	BRR 6D RANGE	BRR 7D RANGE	BRR 8D RANGE	Primary MCL (ppb)	FREQ. DETECTED
2,4,5-T	ug/L	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	0.36	0.38	U	NR	2/3
2,4,5-TP (Silvex)	ug/L	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	U	U	U	50	0/3
2,4-Dichlorophenoxyacetic acid	ug/L	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	U	U	U	70	0/3
Aldrin	ug/L	U	U	U	U	U	U	U	U	NR	0/21
alpha-Benzene hexachloride	ug/L	U	U	U	U	U	U	U	U	NR	0/21
alpha-Chlordane	ug/L	U	U	U	U	U	U	U	U	NR	0/16
beta-Benzene hexachloride	ug/L	U	U	U	U	U	U	U	U	NR	0/21
Chlordane	ug/L	U	U	U	U	U	NO DATA	NO DATA	NO DATA	2	0/5
delta-Benzene hexachloride	ug/L	U	U	U	U	U	U	U	U	NR	0/21
Dieldrin	ug/L	U	U	U	U	U	U	U	U	NR	0/21
Endosulfan I	ug/L	U	U	U	U	U	U	U	U	NR	0/21
Endosulfan II	ug/L	U	U	U	U	U	U	U	U	NR	0/21
Endosulfan sulfate	ug/L	U	U	U	U	U	U	U	U	NR	0/21
Endrin	ug/L	U	U	U	U	U	U	U	U	2	0/21
Endrin aldehyde	ug/L	U	U	U	U	U	NO DATA	NO DATA	NO DATA	NR	0/5
Endrin ketone	ug/L	U	U	U	U	U	U	U	U	NR	0/16
gamma-Chlordane	ug/L	U	U		U	U	U	U	U	NR	0/16
Heptachlor	ug/L	U	U	U	U	U	U	U	U	0.4	0/21
Heptachlor epoxide	ug/L	U	U	U	U	U	U	U	U	0.2	0/21
Lindane	ug/L	U	U	U	U	U	U	U	U	0.2	0/21
Methoxychlor	ug/L	U	U	U	U	U	U	U	U	40	0/21
p,p'-DDD	ug/L	U	U	U	U	U	U	U	U	NR	0/21
p,p'-DDE	ug/L	U	U	U	U	U	U	U	U	NR	0/21
p,p'-DDT	ug/L	U	U	U	U	U	U	U	U	NR	0/21
PCB 1016	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
PCB 1221	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
PCB 1232	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
PCB 1242	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
PCB 1248	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
PCB 1254	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
PCB 1260	ug/L	U	U	U	U	U	U	U	U	0.5	0/21
Toxaphene	ug/L	U	U	U	U	U	U	U	U	3	0/21

Table 5-32 D Well Summary (continued)

RADIONUCLIDES		BRR 1D RANGE	BRR2D RANGE	BRR 3D RANGE	BRR 4D RANGE	BRR 5D RANGE	BRR 6D RANGE	BRR 7D RANGE	BRR 8D RANGE	PRG (E-4)	FREQ. DETECTED	Primary MCL
Actinium-228	pCi/L	U	U	U	U	U	U	U	U	48.5	0/21	NR
Antimony-124	pCi/L	U	U	U	U	U	U	U	U	55.6	0/21	NR
Antimony-125	pCi/L	U	U	U	U	U-9.73-U	U	U-6	U	113	2/21	NR
Barium-133	pCi/L	U	U	U	U	U	U	U	U	323	0/21	NR
Cerium-144	pCi/L	U	U	U	U	U	U	U	U-19.7	3.71	1/21	NR
Cesium-134	pCi/L	U	U	U	U	U-2.07-U	U	U	U	32.5	1/21	NR
Cesium-137	pCi/L	U	U	U-10.2	U	U-2.19-U	U	U	U	47.9	3/21	NR
Cobalt-57	pCi/L	U	U	U	U	U	U-2.67	U	U	152	1/21	NR
Cobalt-58	pCi/L	U	U	U	U	U	U	U	U	124	0/21	NR
Cobalt-60	pCi/L	U	U	U	U	U	U	U-2.65	U-1.99	8.23	2/21	NR
Europium-152	pCi/L	U	U	U-6.63	U	U	U-7.68	U	U	11.5	2/21	NR
Europium-154	pCi/L	U	U	U	U	U	U-5.39	U	U	9	1/21	NR
Europium-155	pCi/L	U	U	U	U	U	U-13.4	U	U	69.9	1/21	NR
Gross alpha	pCi/L	1.61-U	U-2.92	7.66-9.64	0.92-U	0.97-U	U	1.46	1.33	NR	8/16	15 pCi/L
Lead-212	pCi/L	U	U	U-7.47	U	10.2-U	U-10.2	U-6.52	U-6.79	28.5	6/21	NR
Manganese-54	pCi/L	U	U	U	U	U	U	U	U	226	0/21	NR
Neptunium-239	pCi/L	U	U-6.9	U	U	U	U	U	U	724	1/16	NR
Nonvolatile beta	pCi/L	.81-1.49	3.18-4.42	9.19-13.5	U-3.72	U-2.97	3.4	9.15	1.56	NR	10/13	4 mrem
Potassium-40	pCi/L	U-30.7	U	U	U-45.3	20.7-U	U-68.6	U-41.3	U	120	0/21	NR
Promethium-144	pCi/L	U	U	U	U	U	U	U	U	NR	0/21	NR
Promethium-146	pCi/L	U	U	U	U	U	U	U	U	NR	0/21	NR
Radium, total alpha-emitting	pCi/L	1.3	1.5	9.4	U	1	U	0.7	0.3	NR	5/8	NR
Ruthenium-106	pCi/L	U	U	U	U	U	U	U	15.8-U	2.86	1/21	NR
Sodium-22	pCi/L	U-2.59	U-2.91	U	U	U	U	U	U	192	3/21	NR
Thorium-234	pCi/L	U	U-434	U	U	U-135	92.3-318	U-81.7	U	38.3	5/21	NR
Tin-113	pCi/L	U	U	U	U	U	U	U-4.12	U-3.96	132	2/16	NR
Tritium	pCi/ml	6.29-9.45	9.53-98.5	203-212	18.2-48.8	6.36-7.09	1.49	10.9	8	13.7	13/13	NR
Yttrium-88	pCi/L	U	U	U	U-4.5	U	U	U-2.6	U	NR	2/21	NR
Zinc-65	pCi/L	U	U	U	U-3.87	U	U	U-2.68	U	69.3	1/21	NR
Zirconium-95	pCi/L	U	U-3.45	U	U-3.93	U	U	U	U	123	2/16	NR

The secondary MCLs for aluminum, iron, and manganese were exceeded during the study. Although none of the wells had aluminum concentrations that exceeded the Secondary (2°) MCL in 1993, in the first quarter of 1994 seven of eight water table monitoring well had levels that exceeded the 2° MCL of 200 ug/L and aluminum was detected in all of the groundwater samples. The aluminum concentrations ranged from 34.9 ug/L (BRR 5D) to 8280 ug/L (BRR 7D) with only BRR 5D having a level less than the 2° MCL during the sampling in the second quarter of 1994. Aluminum was detected in each of the wells with concentrations detected ranging from 38 ug/L (BRR 8D) to 1230 ug/L (BRR 7D).

The presence of iron was not analyzed for during the 1993 fourth quarter sampling. Iron was detected in each monitoring well sample during the first and second quarter 1994 sampling, and levels exceeded 2° MCL (300 ug/L) in six of the wells. Only monitoring wells BRR 6D and BRR 8D had levels of iron below the standard. Iron concentrations ranged from 32.8 ug/L (BRR 8D) to 7870 ug/L (BRR 7D) during the first quarter and from 21.9 ug/L(BRR 8D) to 2920 ug/L (BRR 7D) during the second quarter.

Analysis for the TAL constituent manganese was not performed during the 1993 quarterly sampling. Analysis for manganese was included with the first and second quarter 1994 sampling, and manganese was detected. With the first quarter analysis, manganese concentrations exceeded the 2° MCL of 50 ug/L in three wells (BRR 2D, BRR 6D, and BRR 7D). Manganese was detected in each of the eight samples and the levels ranged from 29 ug/L (BRR-3D) to 121 ug/L (BRR 6D). Second quarter sampling showed that manganese levels exceeded the 2° MCL in two wells (BRR 6D and BRR 7D) while the constituent was present in all of the water table well samples. Concentrations ranged from 30.7 ug/L (BRR 1D) to 117 ug/L (BRR 6D).

Among the other TAL constituents that were detected were chromium, copper, lead, mercury, and nickel. Chromium was detected during the 1994 sampling events in wells BRR 3D, BRR 4D, and BRR 7D. The highest detected concentration of chromium was 37.9 ug/L in BRR 7D during the first quarter of 1994. Copper was detected in groundwater samples during each of the three quarters. It was detected in each of the eight water table wells during the sampling program. Well BRR 3D has the highest detected concentration of copper with a level of 68.6 ug/L during the second quarter of 1994. Lead was detected in sampling conducted during the third and fourth quarters of 1993. Lead was also detected during the first and second quarters of 1994. **Detected lead concentrations were compared to the SDWA standard, a nonenforceable, "at the tap" action level of 15 ug/L. Concentrations in wells BRR 1D, BRR 2D, and BRR 3D exceeded the "at the tap" action level for lead.** The highest concentration of lead detected was 36.9 ug/L in well **BRR 1D** during second quarter 1994. Mercury was detected in the groundwater from wells BRR 1D through BRR 6D, but only during the 1994 sampling events. The highest concentration detected was 0.1 ug/L in BRR 1D during the second quarter of 1994. Nickel was present in samples collected during each sampling quarter and was found in each of the water table wells during the sampling program. The highest concentration detected in the samples was 32 ug/L in BRR 7D during the second quarter of 1994.

Among the TAL constituents detected, two analytes could be potentially migrating from the BRRP site into the groundwater. These two (copper and lead) are present in upgradient wells BRR 6D and BRR 7D, but were detected in mush greater levels in the downgradient wells.

5.4.1.2 Base/Neutral/Acid (BNAs)

No BNAs were detected during the 1993 sampling event. Groundwater sampling results for the first and second quarters of 1994 showed the presence of six BNAs. Detected in the samples were bis(2-ethylhexyl) phthalate, 2-chlorophenol, dimethyl phthalate, di-n-butyl phthalate, isophorone, and pyrene. None of these compounds had concentrations that exceeded MCLs. 2-Chlorophenol was detected in samples collected during the first quarter of 1994 from four wells (from BRR 2D and from BRR 5D through BRR 7D), and was present at a highest concentration of 0.16 ug/L. Isophorone was detected at a concentration of 0.16 ug/L in a sample collected from BRR 6D during the first quarter of 1994. Pyrene was present at a concentration of 0.23 ug/L in the BRR 1D sample collected during the second quarter of 1994. Bis(2-ethylhexyl) phthalate was detected in each of the wells, while dimethyl phthalate and di-n-butyl phthalate were present on one sample each. Bis(2-ethylhexyl) phthalate concentrations detected ranged from 0.25 ug/L (BRR 5D) to 4.63 ug/L (BRR 4D). Dimethyl phthalate was found in BRR 1D at a concentration of 0.14 ug/L and di-n-butyl phthalate was present in the BRR 4D sample with a concentration of 0.53 ug/L.

5.4.1.3 Volatile Organics

During the three quarters of groundwater sampling, 18 volatile organic compounds were detected in the water table monitoring wells. Among the compounds present were benzene, carbon tetrachloride, chloroform, dichloromethane, tetrachloroethylene (PCE), toluene, 1,1,1-trichloroethane (TCA), trichloroethylene (TCE),and xylenes. None of the detected volatile organic compounds had concentrations that exceeded an MCL. Benzene was found in samples from wells BRR 1D through BRR 4D with the highest concentrationsin BRR 3D and BRR 4D (0.11 ug/L). Carbon tetrachloride was detected at concentrations up to 4.45 ug/L (BRR 8D) and was present in samples from BRR 4D, BRR 7D, and BRR 8D. Chloroform was detected at concentrations ranging from 0.06 ug/L (BRR 4D) to 0.68 ug/L

(BRR 7D) and was present in wells BRR 2D through BRR 4D and BRR 6D through BRR 8D. Dichloromethane was detected in wells BRR 1D, BRR 2D, BRR 6D, and BRR 7D with detected concentrations ranging from 0.33 ug/L (BRR 7D) to 1.3 ug/L (BRR 2D). Detected PCE concentrations ranged from 0.11 ug/L (BRR 3D) to 0.51 ug/L (BRR 7D) and the compound was presnet in all of the monitoring wells except BRR 6D. Toluene was detected in samples collected from each well during the sampling program with the highest concentration (0.6 ug/L) found in well BRR 5D. TCA was found in samples collected from BRR 1D, BRR 4D, and BRR 5D with the highest concentration being 0.33 ug/L. TCE was found in wells BRR 2D through BRR 4D and BRR 6D through BRR 8D with the highest concentration (2.44 ug/L) detected in BRR 8D. Xylene compounds were detected in well BRR 8D only at a concentration of 0.1 ug/L.

Several volatile organic compounds present in the groundwater may be attributable to contamination arising from the BRRP site. Three compounds (1,1-dichloroethane, 1,2-dichloropropane, and 1,1,1-trichloroethane) were detected in downgradient groundwater well samples, but were not present in the upgradient (BRR 6D and BRR 7D) groundwater samples. This suggests that the BRRP site may be contributing to the contamination of groundwater. Another compound, carbon tetrachloride, is present in upgradient and downgradient groundwater samples, although the concentration is mush greater in the downgradient than upgradient samples. However, the presence of carbon tetrachloride may not be attributable to the BRRP since groundwater in the upgradient wells also contained the compound. The increased level of carbon tetrachloride in the downgradient wells may be the result of contaminant plume migration from an off-site upgradient area. The results of the Hydrocone groundwater sampling also suggest this interpretation.

5.4.1.4 Pesticides/PCBs

The only pesticide detected in the groundwater samples was 2,4,5-T which was present in 1994 samples from monitoring wells BRR 6D and BRR 7D. The concentrations were 0.36 ug/L in BRR 6D and 0.38 ug/L in BRR -7D and neither of these levels exceeed the MCL for 2,4,5-T. No PCBs were detected in any of the groundwater samples.

5.4.1.5 Radionuclides and Radionuclide Indicators

A total of 20 radionuclides and two radionuclide indicators were detected in the water table aquifer groundwater sampling program. Among those detected were lead-212, neptunium-239, radium (total alpha-emitting), tritium, the gross alpha particle activity indicator, and the nonvolatile beta particle activity indicator. During the first and second quarters of 1994, lead-212 was detected in samples from wells BRR 3D and BRR 5D through BRR 8D with the highest detected value (10.2 pCi/L) found in BRR 5D and BRR 6D. Neptunium-239 was detected once, in well BRR 2D, at an activity of 6.9 pCi/L during the 1994 second quarter sampling. Detected during the fourth quarter of 1993 and the first quarter of 1994 in wells BRR 1D through BRR 3D and BRR 5D through BRR 8D, total alpha-emitting radium was present at activity levels ranging from 0.3 pCi/L (BRR 8D) to 9.4 pCi/L (BRR 3D). Tritium was present in each of the samples collected during 1993 and the first quarter of 1994 with activities ranging from 6.29 pCi/ml (BRR 1D) to 212 pCi/ml (BRR 3D). Analysis for the gross alpha particle activity was performed in 1993 and the first quarter of 1994. Alpha particle activity was detected in all of the wells except BRR 6D with the highest level (9.64 pCi/L) present in BRR 3D. Nonvolatile beta particle activity was detected in each of the wells with the highest level (13.5 pCi/L) present in BRR 3D.

Risk based preliminary remediation goals (PRGs) for radionuclides were compared to the radionuclide concentrations detected in groundwater. The PRGs are for residential water use and correspond to a screening level associated with a risk of 1E-06. Cerium-144 was detected in a sample from BRR 8D from the first quarter of 1994 at a concentration of 19.7 pCi/L which exceeds the PRG of 0.0371 pCi/L. However, it should be noted that a laboratory error of +/- 16.5 pCi/L level is associated with the measured concentration. Ruthenium-106 was detected in the BRR 8D sample from the second quarter of 1994 at a concentration (15.8 pCi/L +/- 12 pCi/L) that exceeds the PRG of 0.0286 pCi/L. Five samples contained thromium-234 in concentrations that exceeded the PRG of 0.383 pCi/L. It should be noted that the samples from BRR 6D, considered to be an upgradient well, contained high concentrations (92.3 pCi/L and 318 pCi/L), suggesting that the BRRP is not the source of thromium-234 in the groundwater. Tritium was detected in upgradient as well as downgradient wells. Some of the concentrations in downgradient wells were an order of magnitude greater than in upgradient wells, suggesting that the BRRP may contribute to tritium contamination in the groundwater.

5.4.1.6 General Chemistries

Groundwater samples from the BRRP site were also analyzed for several general chemistry parameters, and two general chemistry standards were exceeded. The MCL for nitrate and nitrite (as nitrogen) is set as 10,000 ug/L. A groundwater sample collected from BRR-3D during the first quarter of 1994 had nitrate/nitrite (as nitrogen) concentation of 31,000 ug/L. Nitrate/nitrite (as nitrogen) was present in each of the eight wells at concentrations ranging from 990 ug/L to 31,000 ug/L. This analysis was only performed on samples collected during the first quarter of 1994. Although it was detected in upgradient wells, the level of nitrate/nitrite (as nitrogen) is much greater in downgradient well BRR 3D. This may suggest that the BRRP site has contributed to the contamination of the site, although it may also be the result of contaminant plume migration from the upgradient groundwater wells.

The 2° MCL pH range for water is set as 6.5 to 8.5. Each groundwater samples analyzed for its pH value during the investigation (five in 1993, three each in the first and seond quarters of 1994) had a pH value less than the lower limit of the 2° MCL range. Values for pH ranged from 5.24 to 6.08.

5.4.1.7 Summary

In the "upper zone" (D screen) of the Upper Three Runs Aquifer, **four** analyses showed contaminant levels that exceeded primary MCLs. Analyses performed for nitrate/nitrite (as nitrogen) had concentrations exceeding the SDWA standards in monitoring well BRR 3D (for nitrate/nitrite). Nitrate/nitrite (as nitrogen) has a primary MCL of 10,000 ug/L. The MCL was exceeded in the sample collected from well BRR 3D during the first quarter of 1994 with a detected concentration of 31,000 ug/L. Concentrations of four radionuclides, cerium-144, ruthenium-106, thorium-234, and tritium, exceeded PRGs. Only gross alpha (BRR 3D, 3Q93), thorium-234 (BRR 2D, 1Q94), and tritium (various wells) exceeded the primary SDWA standards. Table 5-33 summarizes the groundwater contamination concentrations for the D monitoring wells. Planar maps (Figures 5-15 and 5-16) depict the analyte concentrations that exceed MCLs.

Lead was detected in 1994 samples collected from BRR 1D (with concentrations of 16 ug/L and 36.9 ug/L). Lead was present in groundwater collected from BRR 3D during all **four** quarters and concentrations ranged from 17.9 ug/L to 21 ug/L. The lead SDWA standard is **15 ug/L**.

5.4.2 *Lower Aquifer Zone Monitoring Well Analytical Results - Upper Portion*

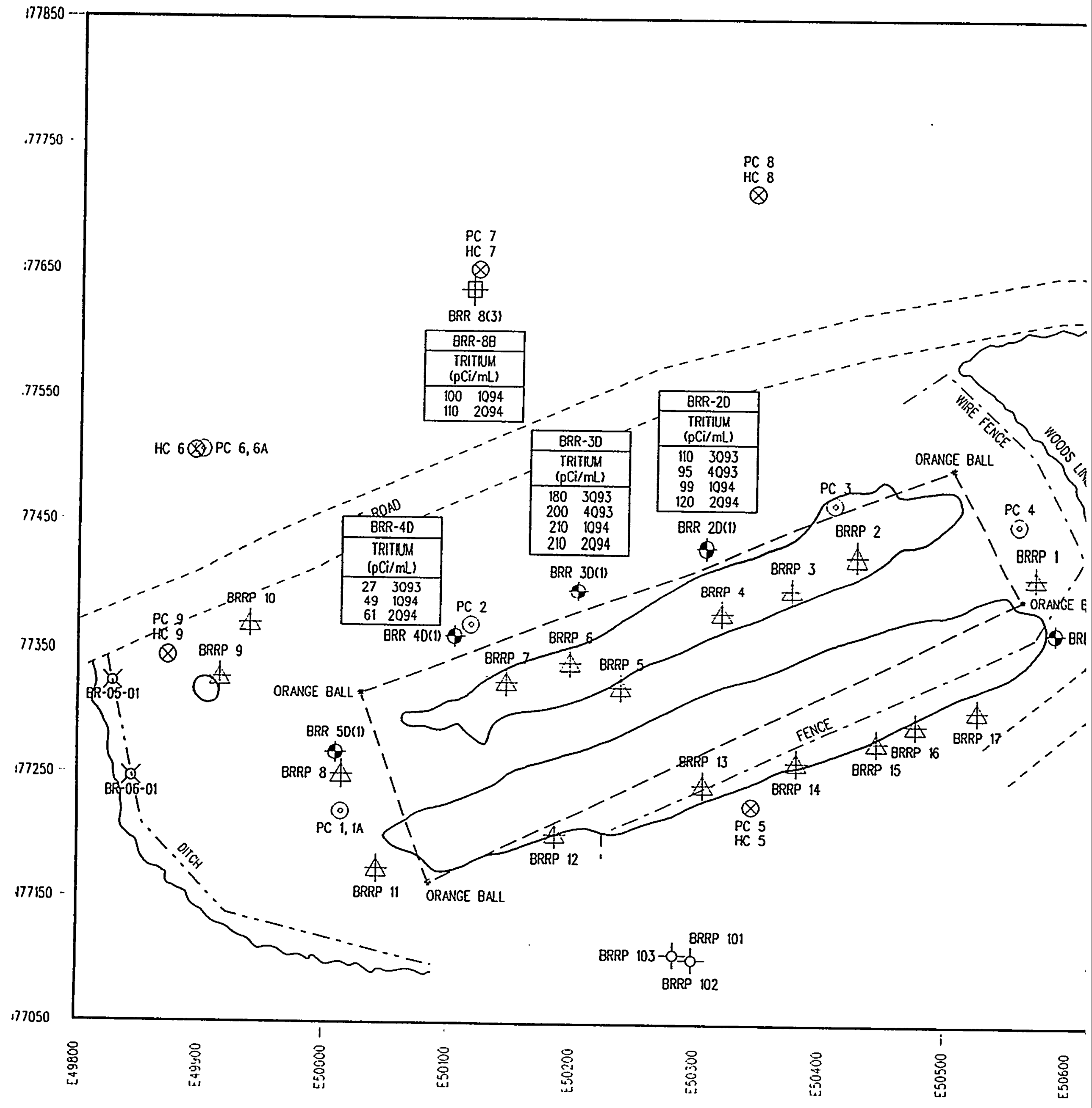
Six wells (BRR 6B, BRR 7B, BRR 8B, BRR 6C, BRR 7C, and BRR 8C) are screened within the Lower Aquifer Zone of the Upper Three Runs Aquifer. Monitoring wells BRR 6C, BRR 7C, and BRR 8C are screened within the upper portion of the Lower Aquifer Zone (UP-LAZ) of the Upper Three Runs Aquifer. Groundwater sampling was conducted for these wells during the first and second quarters of 1994. Table 5-34 presents a summary of the analytes detected in UP-LAZ monitoring wells.

Table 5-33 - Groundwater Contamination Concentrations

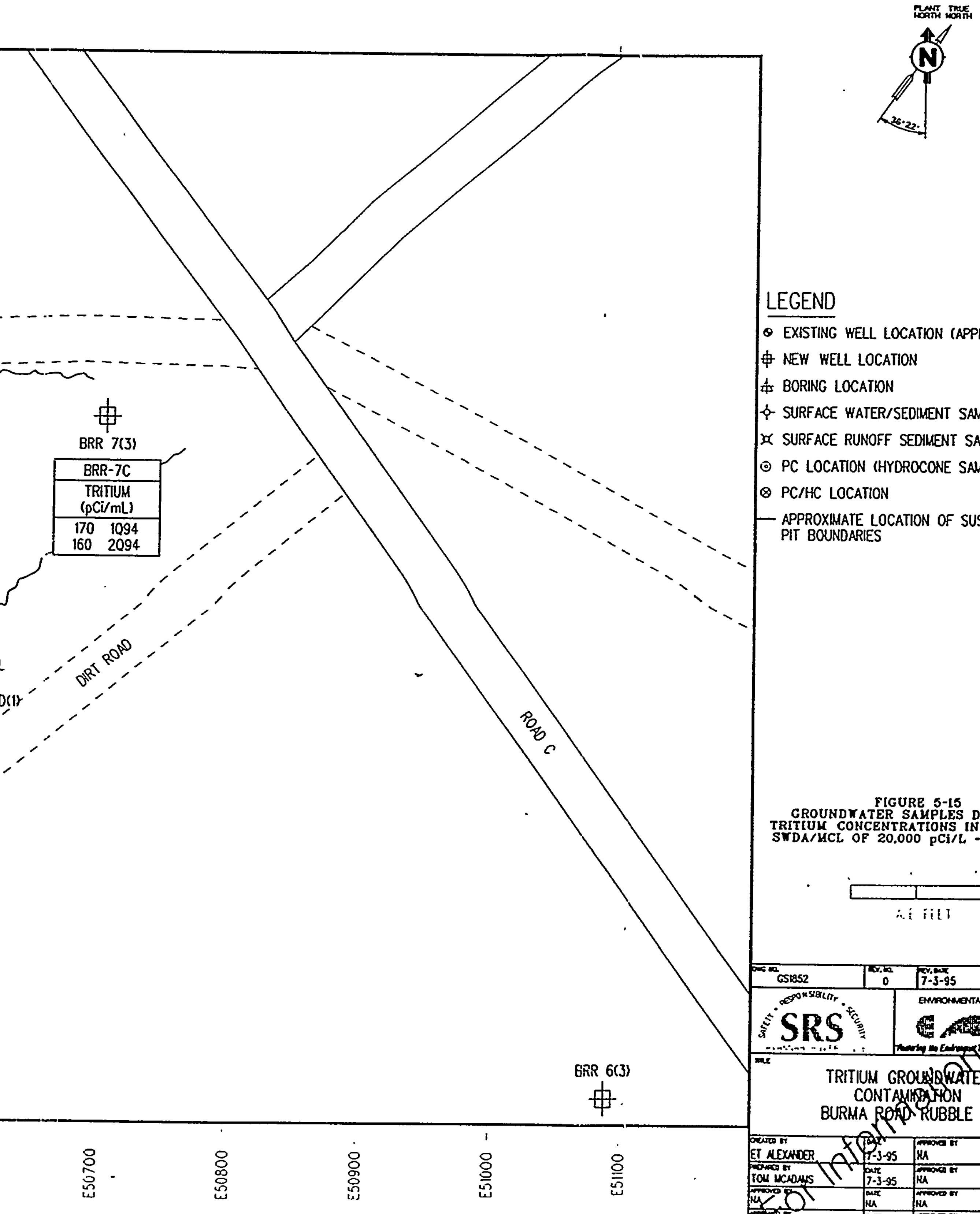
ANALYTE	LEAD* (ug/L)	MERCURY (ug/L)	NITRATE/ NITRITE (as NITROGEN) (ug/L)	CARBON TETRACHLORIDE (ug/L)	GROSS ALPHA (pCi/L)	TRITIUM (pCi/mL)	THORIUM-234 (pCi/L)
MCL	15	2	10000	5	15	20	400
WELL NUMBER							
BRR 1D	**36**; U; **16**; **37**	U; U; 0.08; 0.1	NA; NA; 2000; NA	U	<2; <2; 1.6; 0.0057	6.2; 8.3; 9.5; 11	NA; <13; 67; 4
BRR 2D	3.3; U; **31.8**; 5.1	U; U; 0.06; U	NA; NA; 4050; NA	U	2.3; <2.0; 2.9; 1.8	**110**; **95**; **99**; **120**	NA; NA; **430**; 69
BRR 3D	**16**; **21**; 12; **18**	U; U; 0.062; U	NA; NA; **31000**; NA	U	**1200**; 7.7; 9.6; 7.9	**180**; **200**; **210**; **210**	NA; <13; 89; 35
BRR 4D	3.1; 10; 4.77; 2.9	U; U; 0.054; 0.05	NA; NA; 2100; NA	U; U; 0.06; U	<2.0; <2.0; 0.0092; 0.0041	**27**; 18; **49**; **61**	NA; <13; 24; 18
BRR 5D	U; 10; 9.6; 14	U; U; 0.09; 0.05	NA; NA; 1250: NA	U	<2.0; <2.0; 0.0097; 1.6	7.2; 6.4; 7.1; 7.3	NA; <13; 140; 17
BRR 6D	NA; NA; 11; 11.4	NA; NA; U; 0.06	NA; NA; 990; 1120	NA; NA; U; U	NA; NA; 0.0014; 0.0045	NA; NA; 15; 14	NA; NA; 320; 92
BRR 7D	NA; NA; 11; 10	NA; NA; U; U.	NA; NA; 2380; 1960	NA; NA; 0.36; 0.15	NA; NA; 1.5; 0.0013	NA; NA; 11; 12	NA; NA; 82; 110
BRR 8D	NA; NA; 11; 6.3	NA; NA; U; U	NA; NA; 1840; 1900	NA; NA; 3.64; 4.5	NA; NA; 1.3; 0.0031	NA; NA; 8.0; 9.8	NA; NA; 110; 47
BRR 8B	NA; NA; 1.1; 1.6	NA; NA; U; 0.041	NA; NA; 4080; 3760	NA; NA; 0.19; 0.18	NA; NA; 0.019; 0.79	NA; NA; **100**; **110**	NA; NA; 240; 19
BRR 7C	NA; NA; 2.5; 4.0	NA; NA; U; 0.048	NA; NA; 910; 930	NA; NA; U; U	NA; NA; 2.7; 2.4	NA; NA; **170**; **160**	NA; NA; 95; 150

Samples dates: 3Q93 (08/28/93); 4Q93 (12/03/93); 1Q94 (03/20/94 to 03/31/94); and 2Q94 (04/17/94 to 04/18/94).
Bolded concentrations represent those which exceeded the MCL, or in the case of lead, the "at the tap" action level.
None of the other samples collected from wells BRR 6B, BRR 7B, BRR 6C, and BRR 8C had analyte concentrations that exceeded the primary MCLs.
* The SDWA standard for lead is a nonenforceable "at the tap" action level.
NA = No analysis
U = Below the detection limit

SOIL/GROUNDWATER SAMPLE LOCATIONS AT THE



BURMA ROAD RUBBLE PIT



LEGEND

⊘	EXISTING WELL LOCATION (APPROXIMATE)
⌖	NEW WELL LOCATION
⌖	BORING LOCATION
⌖	SURFACE WATER/SEDIMENT SAMPLE LOCATION
⌖	SURFACE RUNOFF SEDIMENT SAMPLE LOCATION
⊙	PC LOCATION (HYDROCONE SAMPLE)
⊗	PC/HC LOCATION
—	APPROXIMATE LOCATION OF SUSPECTED PIT BOUNDARIES

FIGURE 5-15
GROUNDWATER SAMPLES DEPICTING TRITIUM CONCENTRATIONS IN EXCESS OF SWDA/MCL OF 20,000 pCi/L - 20 pCi/mL

DWG NO.	REV. NO.	REV. DATE	AREA
GS1852	0	7-3-95	SITE

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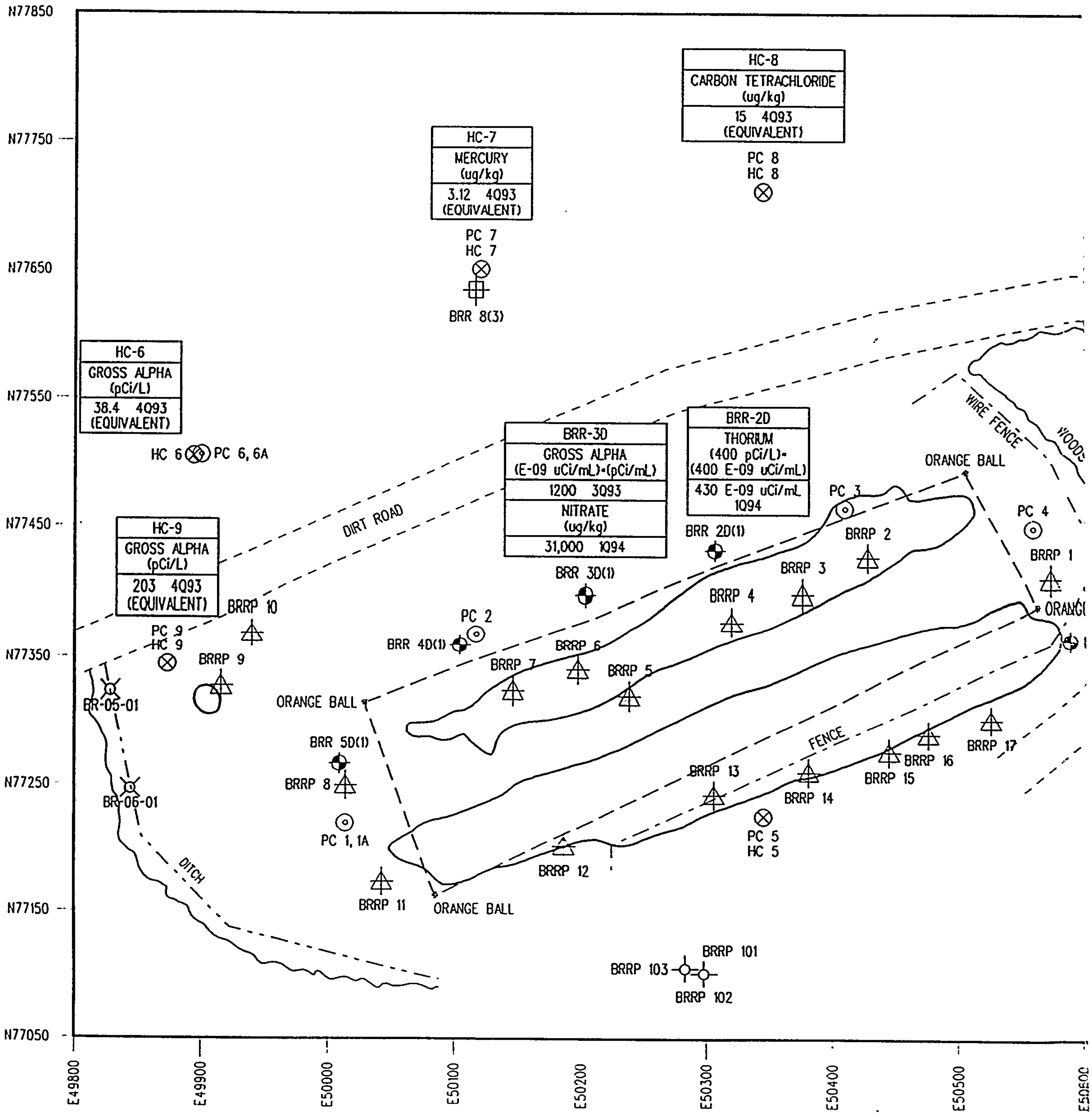
ENVIRONMENTAL RESTORATION
Restoring the Environment Today for a Cleaner Tomorrow

TITLE
TRITIUM GROUNDWATER
CONTAMINATION
BURMA ROAD RUBBLE PI

CREATED BY ET ALEXANDER	DATE 7-3-95	APPROVED BY NA	DATE NA
PREPARED BY TOM MCADAMS	DATE 7-3-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA

SOIL/GROUNDWATER SAMPLE LOCATIONS AT TH



BURMA ROAD RUBBLE PIT

LEGEND

- ⊖ EXISTING WELL LOCATION (APPROXIMATE)
- ⊕ NEW WELL LOCATION
- ✣ BORING LOCATION
- ✧ SURFACE WATER/SEDIMENT SAMPLE LOCATION
- ⌘ SURFACE RUNOFF SEDIMENT SAMPLE LOCATION
- ⊙ PC LOCATION (HYDROCONE SAMPLE)
- ⊗ PC/HC LOCATION
- — APPROXIMATE LOCATION OF SUSPECTED PIT BOUNDARIES

FIGURE 5-16
GROUNDWATER SAMPLES DEPICTING GROSS ALPHA (15 pCi/L), MERCURY (2 ug/kg), CARBON TETRACHLORIDE (5 ug/kg), NITRATE (10,000 ug/kg) AND THORIUM (400 pCi/L) CONCENTRATIONS IN EXCESS OF SWDA/MCL SHOWN ABOVE

0 50 100
SCALE FEET

DWG NO.	REV. NO.	REV. DATE	AREA
GS1853	0	7-3-95	SITE

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SAVANNAH RIVER SITE

ENVIRONMENTAL RESTORATION
ER
Restoring the Environment Today for a Cleaner Tomorrow

TITLE
GROSS ALPHA, MERCURY,
CARBON TETRACHLORIDE, NITRATE
AND THORIUM CONTAMINATION
BURMA ROAD RUBBLE PIT

CREATED BY ET ALEXANDER	DATE 7-3-95	APPROVED BY NA	DATE NA
PREPARED BY TOM MCADAMS	DATE 7-3-95	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA
APPROVED BY NA	DATE NA	APPROVED BY NA	DATE NA

Table 5-34 Analyte Concentration Summary for the UP-LAZ Monitoring Wells

ANALYTE	FREQUENCY DETECTED	BRR 6C RANGE	BRR 7C RANGE	BRR 8C RANGE	MCL
VOLATILE ORGANICS (ug/L)					
Acetone	1/6	U	U - 6.96	U	NR
Benzene	2/6	U.	0.06 - 0.07	U	5
Carbon Tetrachloride	4/6	0.06	U	0.12 - 0.14	5
Chloroform	6/6	0.16 - 0.22	0.17 - 0.22	0.05 - 0.07	100
Dichloromethane	4/6	U - 0.35	0.3 - 0.48	U - 0.48	5
1,1,2,2-Tetrachloroethane	1/6	U	U - 0.06	U	NR
Tetrachloroethylene	4/6	U	0.25 - 0.3	0.08	5
Toluene	6/6	0.11 - 0.13	0.1 - 0.16	0.14 - 0.15	1000
Trichloroethylene	6/6	2.68 - 3.12	2.02 - 2.1	0.53 - 0.77	5
SEMI-VOLATILE ORGANICS (ug/L)					
Bis(2-ethylhexyl)phthalate	3/6	U	0.65 - 13	U - 0.35	NR
2-Chlorophenol	1/6	U	U - 0.17	U	NR
Di-n-butyl phthalate	1/6	U	U - 1.39	U	NR
Isophorone	1/6	U	U - 15.2	U	NR
Pyrene	1/6	U	U	U - 0.18	NR
PESTICIDES/PCBs (ug/L)					
2,4,5-T	2/3	0.2	0.39	U	NR
TARGET ANALYTE LIST (ug/L)					
Aluminum	6/6	33.9 - 1590	106 - 473	52.5 - 52.9	NR
Arsenic	1/6	U	U - 2.32	U	50

U = Not detected
NR = No regulatory level (MCL)

Table 5-34 Analyte Concentration Summary for the UP-LAZ Monitoring Wells (continued)

ANALYTE	FREQUENCY DETECTED	BRR 6C RANGE	BRR 7C RANGE	BRR 8C RANGE	MCL
TARGET ANALYTE LIST (ug/L)					
Barium	6/6	6.81	16.5 - 19.4	8.42 - 9.38	2000
Beryllium	6/6	0.14 - 0.48	0.04 - 0.06	0.15	4
Boron	2/6	U - 31.2	U - 33.1	U	NR
Calcium	6/6	1800 - 1910	15000 - 16500	1450 - 1490	NR
Chromium	4/6	2.82 - 6.16	5.99 - 19.3	U	100
Cobalt	4/6	0.85 - 1.61	U	0.64 - 0.87	NR
Copper	6/6	1.11 - 1.48	3.42 - 9.49	1.72 - 11.8	1300
Iron	4/6	34.2 - 1650	80.2 - 523	U	NR
Lead	6/6	2.26 - 2.31	2.47 - 4	1.78 - 3.01	15*
Magnesium	6/6	293 - 434	631 - 931	593 - 613	NR
Manganese	6/6	26.4 - 38.6	3.29 - 5.02	8.82 - 11	NR
Nickel	5/6	2.05 - 4.25	9.19 - 33.9	U - 2.08	100
Potassium	6/6	380 - 514	1270 - 1600	229 - 258	NR
Sodium	6/6	7050 - 7900	24700 - 30500	1940 - 2070	NR
Vanadium	4/6	0.37 - 3.65	9.49 - 16.3	U	NR
Zinc	6/6	21.4 - 34.2	3.64 - 23.4	4.6 - 7.83	NR
Cyanide	4/6	U - 1.7	1.7 - 2.2	U - 1.7	200
RADIONUCLIDES and RADIONUCLIDE INDICATORS (pCi/L)					
Actinium-228	1/6	U - 6.06	U	U	NR
Gross alpha	3/3	2.44	2.68	1.04	15
Antimony-125	1/6	U	U	U - 4.9	NR
Barium-133	1/6	U	U - 11.8	U	NR
Nonvolatile beta	2/3	61	2.51	U	NR
Cerium-144	1/6	U - 17.5	U	U	NR

*The SDWA standard for lead is a nonenforceable "at the tap" action level.
U = Not detected

NR = No regulatory level (MCL)

Table 5-34 Analyte Concentration Summary for the UP-LAZ Monitoring Wells (continued)

ANALYTE	FREQUENCY DETECTED	BRR 6C RANGE	BRR 7C RANGE	BRR 8C RANGE	MCL
RADIONUCLIDES and RADIONUCLIDE INDICATORS (pCi/L)					
Europium-154	1/6	U - 5.35	U	U	NR
Lead-212	4/6	U - 10.5	5.69 - 9.59	U - 6.8	NR
Potassium-40	3/6	U - 37.5	U - 32.4	U - 31.3	NR
Promethium-144	1/6	U	U	U - 2.8	NR
Ruthenium-106	1/6	U	U	U - 70	NR
Thorium-234	5/6	186 - 212	U - 151	97.6 - 102	NR
Tritium (pCi/mL)	3/3	4.27	168	10.2	20
Yttrium-88	1/6	U	U	U - 2.36	NR
Zinc-65	2/6	U	U - 3.2	U-5.43	NR
Zirconium-95	2/6	U - 9.55	U	U - 10.9	NR
GENERAL CHEMISTRIES (ug/L)					
Chloride	6/6	2890 - 2920	2850 - 3380	2450 - 2620	NR
Fluoride	2/6	U	167 - 240	U	4000
Nitrite-nitrate as nitrogen	6/6	840 - 900	910 - 930	1270 - 1280	10000
pH (in pH units)	NA	5.9 - 5.94	9.16 - 9.94	5.3 - 5.49	NR
Silica	6/6	12200 - 12300	15300 - 15600	7320 - 7460	NR
Specific conductance (uS/c)	NA	52.5 - 53.8	217 - 225	30.1 - 30.9	NR
Sulfate	4/6	3270 - 4010	20700 - 28300	U	NR

U = Not detected

NA = Not applicable

NR = No regulatory level (MCL)

Table 5-34 Analyte Concentration Summary for the UP-LAZ Monitoring Wells (continued)

ANALYTE	FREQUENCY DETECTED	BRR 6C RANGE	BRR 7C RANGE	BRR 8C RANGE	MCL
GENERAL CHEMISTRIES (ug/L)					
Total dissolved solids	6/6	44000 - 54000	142000 - 144000	24000 - 32000	NR
Total organic carbon	2/6	U	1290 - 1450	U	NR
Total organic halogens	2/6	U	U - 9.1	U - 7.3	NR
Total phosphates	1/6	U	U- 110	U	NR

U = Not detected

NR = No regulatory level (MCL)

5.4.2.1 TAL Constituents

Nineteen TAL constituents were detected within groundwater samples collected from the UP-LAZ wells. Aluminum and iron were present at concentrations that exceeded 2° MCLs and sodium was detected at a level that exceeded the Drinking Water Equivalent Level (DWEL) health advisory.

Aluminum was present in each of the six groundwater samples collected during the investigative program (three wells sampled during two quarters). Concentrations ranged from 33.9 ug/L to 1590 ug/L. Samples collected during the first quarter of 1994 from BRR 6C (1590 ug/L) and BRR 7C (473 ug/L) exceeded the 2° MCL. Iron was detected in samples collected from BRR 6Cand BRR 7C, with levels ranging from 34.2 ug/L to 1650 ug/L. The 2° MCL of 300 ug/L was exceeded by the BRR 6C (1650 ug/L) and BRR 7C (523 ug/L) samples obtained during the first quarter of 1994. Sodium was present in each of the samples collected during the two quarters. Sodium concentration varied from 1940 ug/L (BRR 8C) to 30500 ug/L (BRR 7C). The concentration in samples collected from BRR 7C during both quarters exceeded the DWEL for sodium (20,000 ug/L). The levels obtained for the BRR 7C samples were 30,500 ug/L and 24,700 ug/L.

Among the other TAL constituents detected during the sampling, but with concentrations less than the SDWA standards, were chromium, lead, nickel, and cyanide. Chromium was present in samples collected from wells BRR 6C and BRR 7C where the concentration ranged from 2.82 ug/L (BRR 6C) to 19.3 ug/L (BRR 7C). Lead was detected in each of the samples in a concentration range of 1.78 ug/L (BRR 8C) to 4 ug/L (BRR 7C). Nickel was not detected in the BRR 8C sample collected during the first quarter of 1994, but was present in the remaining five samples collected. Nickel concentrations ranged from 2.08 ug/L (BRR 8C) to 3.9 ug/L (BRR 7C). Cyanide was present in both samples collected from BRR 7C and in the second quarter samples collected from BRR 6C and BRR 8C. Detected levels ranged from 1.7 ug/L (BRR 6C, BRR 7C, and BRR 8C) to 2.2 ug/L (BRR 7C).

5.4.2.2 BNAs

Five BNAs were detected in groundwater samples collected from the upper zone wells. None of the analytes exceeded MCLs. Bis (2-ethylhexyl) phthalate was detected in the samples collected from BRR 7C with concentrations of 13 ug/L (first quarter 1994) and 0.65 ug/L. The BNA compound 2-chlorophenol was only detected in the BRR-7C sample collected during the first quarter of 1994 at a concentration of 0.17 ug/L. Di-n-butyl phthalate was detected in the first quarter sample collected from BRR 7C (at a concentration of 1.39 ug/L). Isophorone had a level of 1.52 ug?L in the BRR 7C second quarter sample. Pyrene was detected once, in the BRR 8C second quarter sample, at a concentration of 0.18 ug/L.

5.4.2.3 Volatile Organics

Nine organic compounds were detected during the graoundwater sampling program, but none exceeded SDWA standards. Among the compounds detected were benzene, carbon tetrachloride, chloroform, dichloromethane, and trichloroethylene. Benzene was only detected in the BRR 7C samples with concentrations of 0.07 ug/L (first quarter) and 0.06 ug/L. Carbon tetrachloride was present in samples collected from BRR 6C and BRR 8C during both sampling quarters. The detected levels ranged from 0.06 ug/L to 0.14 ug/L. Chloroform was present in each collected sample with concentrations ranging from 0.05 ug/L to 0.22 ug/L in BRR 6C. Dichloromethane was detected in each well, but not in all of the samples. Detected levels of dichloromethane ranged from 0.3 ug/L (BRR 7C) to 0.48 ug/L (BRR 7C and BRR 8C). Trichloroethylene was detected in each of the six collected samples with concentrations ranginf from 0.53 ug/L (BRR 8C) to 3.12 ug/L (BRR 6C).

5.4.2.4 Pesticides/PCBs

Only one pesticide (2,4,5-T) was detected in the UP-LAZ groundwater sampling. The concentration did not exceed SDWA standards. The pesticide was present in first samples collected from BRR 6C and BRR 7C with concentrations of 0.2 ug/L and 0.39 ug/L, respectively. Analysis for the presence of 2,4,5-T was not performed on the groundwater samples collected during the second quarter. No PCBs were detected during the upper portion monitoring well sampling.

5.4.2.5 Radionuclides and Radionuclide Indicators

Fourteen radionuclides and two radionuclide indicators were detected in the UP-LAZ monitoring wells. Among those detected were actinium-228, lead-212, thorium-234, tritium, the gross alpha particle activity indicator, and the nonvolatile beta particle activity indicator. Actinium-228 was only detected in BRR 6C at a level of 6.06 pCi/L. Lead-212 was present in each of the wells with its detected activities ranging from 5.69 pCi/L (BRR 7C) to 10.5 pCi/L (BRR 6C). Thorium-234 was detected in five of the six collected samples with detected activities ranging from 97.6 pCi/L (BRR 8C) to 212 pCi/L (BRR 6C). Each groundwater sample that was analyzed for the presence of tritium contained detectable concentrations. Tritium levels ranged from 4.27 pCi/mL (BRR 6C) to 168 pCi/mL (BRR 7C). **BRR 7C concentrations exceeded the primary SDWA standards.** Analysis for the indicator parameters was only performed on the samples collected during the first quarter of 1994. The gross alpha particle indicator was detected in each of the well samples witn activities ranging from 1.04 pCi/L (BRR 8C) to 2.68 pCi/L (BRR 7C). The nonvolatile beta particle indicator was detected in wells BRR 6C (61 pCi/L) and BRR 7C (2.51 pCi/L).

5.4.2.6 General Chemistries

Numerous general chemistry parameters were measured for the UP-LAZ groundwater samples. Only one parameter, pH, was outside of the SDWA standards. The 2° MCL for pH ranges from 6.5 to 8.5, but each of the six samples collected during the two quarters was outside of this range. The pH values for wells BRR 6C and BRR 8C were less than the lower pH limit with the lowest value measured in BRR 8C (pH of 5.3). BRR 7C had pH values exceeding the upper limit of the range with a high pH value of 9.94.

5.4.2.7 Summary

None of the samples collected from the monitoring wells penetrating the UP-LAZ of the Upper Three Runs Aquifer has analyte concentrations which exceeded the primary MCLs, **except tritium in the BRR 7C well with concentrations of 170,000 pCi/L (1Q94) and 160,000 pCi/L (2Q94). Table 5-33 lists the concentrations for tritium and Figure 5-15 depicts the trtium analyte concentration.**

5.4.3 *Lower Aquifer Zone Monitoring Well Analytical Results - Lower Portion*

Monitoring wells BRR 6B, BRR 7B, and BRR 8B are screened within the lower portion of the Lower Aquifer Zone (LP-LAZ) of the Upper Three Runs Aquifer. Groundwater sampling has been conducted for these wells during the first and second quarters of 1994. **Table 5-35** is a summary of the analytes detected in the LP-LAZ monitoring wells.

5.4.3.1 TAL Constituents

Twenty TAL constituents were detected in the lower portion monitoring wells. Three analytes (aluminum, iron, and manganese) exceeded 2° MCLs, and the analyte thallium exceeded a Lifetime health advisory. Aluminum was detected in each of the six collected samples at concentrations ranging from 13,7 ug/L (BRR 8B) to 481 ug/L (BRR 6B). The 2° MCL of 200 ug/L was only exceeded in BRR 6B. Iron was detected in the samples collected from BRR 6B and BRR 7B. The 2° MCL of 300 ug/L was exceeded in a sample collected from BRR 6B, which had a concentration of 1020 ug/L. Detected

Table 5-35 Analyte Concentration Summary for the LP-LAZ Monitoring Wells

ANALYTE	FREQUENCY DETECTED	BRR 6B RANGE	BRR 7B RANGE	BRR 8B RANGE	MCL
VOLATILE ORGANICS (ug/L)					
Bromodichloro-methane	1/6	U - 0.06	U	U	NR
Carbon Tetrachloride	2/6	U	U	0.18 - 0.19	5
Chloroform	6/6	0.21 - 0.33	0.15 - 0.22	0.11 - 0.14	100
Dichloro-methane	3/6	U - 0.39	U - 0.37	U - 0.55	5
Tetrachloro-ethylene	2/6	U	U	0.25	5
Toluene	6/6	0.06 - 0.18	0.07 - 0.13	0.15 - 0.17	1000
Trichloro-ethylene	6/6	0.2 - 0.28	0.08 - 0.09	2.29 - 3.02	5
SEMI-VOLATILE ORGANICS (ug/L)					
Bis(2-ethyl-hexyl)phthalate	2/6	U - 0.29	U	U - 0.28	NR
2-Chlorophenol	1/6	U - 0.17	U	U	NR
Di-n-butyl phthalate	1/6	U	U - 0.46	U	NR
Fluorene	1/6	U	U	U - 0.2	NR
PESTICIDES/PCBs (ug/L)					
2,4,5-T	2/3	0.35	0.44	U	NR
TARGET ANALYTE LIST (ug/L)					
Aluminum	6/6	40.3 - 481	41.9 - 44.7	13.7 - 30.9	NR
Barium	6/6	14.8 - 20.1	35.6 - 36	38.1 - 40.9	2000
Beryllium	3/6	0.05 - 0.26	U - 0.005	U	4
Calcium	6/6	8730 - 9950	15800	40800 - 41300	NR
Chromium	4/6	2.92 - 12.3	4.37 - 4.42	U	100
Cobalt	1/6	U - 1.12	U	U	NR

U = Not detected
NR = No regulatory level (MCL)

Table 5-35 Analyte Concentration Summary for the LP-LAZ Monitoring Wells (continued)

ANALYTE	FREQUENCY DETECTED	BRR 6B RANGE	BRR 7B RANGE	BRR 8B RANGE	MCL
TARGET ANALYTE LIST (ug/L)					
Copper	6/6	2.1 - 5.71	0.93 - 4.47	0.96 - 2.16	1300
Iron	4/6	35.4 - 1020	50.6 - 56.5	U	NR
Lead	6/6	1.07 - 2.15	1.21 - 1.46	1.14 - 1.56	15*
Magnesium	6/6	692 - 778	772 - 783	464 - 497	NR
Manganese	5/6	40.5 - 56.4	11 - 11.1	U - 0.41	NR
Mercury	3/6	U	0.05 - 0.11	U - 0.04	2
Nickel	5/6	2.75 - 3.58	2.73 - 3.58	U - 2.25	100
Potassium	6/6	555 - 575	884 - 932	366 - 374	NR
Selenium	1/6	U	U - 1.52	U	50
Sodium	6/6	11600 - 14700	12000 - 12200	3020 - 3200	NR
Thallium	1/6	U - 0.86	U	U	2
Vanadium	5/6	1.03 - 2.95	1.24 - 1.63	U - 0.58	NR
Zinc	5/6	14.9 - 19.4	3.15 - 5.58	U - 12.4	NR
Cyanide	3/6	U - 1.7	U - 1.7	U - 1.7	200
RADIONUCLIDES and RADIONUCLIDE INDICATORS (pCi/L)					
Actinium-228	2/6	U	U	9.78 - 10.6	NR
Gross alpha	1/3	U	0.75	U	15
Antimony-125	1/6	U - 6.06	U	U	NR
Nonvolatile beta	2/3	0.82	1.36	U	NR
Cesium-134	1/6	U - 1.57	U	U	NR
Cesium-137	2/6	U	U - 3.98	U - 1.57	NR
Europium-154	1/6	U	U	U - 3.87	NR
Lead-212	2/6	U	U	8.75 - 16.4	NR
Potassium-40	3/6	U - 37.5	U - 28.2	U - 20.3	NR

*The SDWA standard for lead is a nonenforceable "at the tap" action level.
U = Not detected

NR = No regulatory level (MCL)

Table 5-35 Analyte Concentration Summary for the LP-LAZ Monitoring Wells (continued)

ANALYTE	FREQUENCY DETECTED	BRR 6B RANGE	BRR 7B RANGE	BRR 8B RANGE	MCL
RADIONUCLIDES and RADIONUCLIDE INDICATORS (pCi/L)					
Radium, total alpha emitting	1/3	U	0.5	U	NR
Ruthenium-106	2/6	17 - 17.6	U	U	NR
Sodium-22	1/6	U	U	U - 1.57	NR
Thorium-234	2/6	U	U - 105	U - 235	NR
Tin-113	1/6	U	U	U - 3.23	NR
Tritium (pCi/mL)	2/3	U	4.97	99.6	20
Yttrium-88	1/6	U - 2.42	U	U	NR
Zinc-65	1/6	U	U	U-3.71	NR
GENERAL CHEMISTRIES (ug/L)					
Chloride	6/6	2660 - 2740	2240 - 2410	3140 - 3240	NR
Fluoride	4/6	197 - 199	142- 146	U	4000
Nitrite-nitrate as nitrogen	6/6	520 - 540	480 - 600	3760 - 4080	10000
pH (in pH units)	NA	6.61 - 6.64	6.7 - 6.84	7.78 - 7.92	NR
Silica	6/6	11400 - 12200	12500	12300 - 12400	NR
Specific conductance (uS/c)	NA	110 - 125	130 - 141	222 - 226	NR
Sulfate	4/6	7800 - 10300	5570 - 5620	U	NR

U = Not detected

NA = Not applicable

NR = No regulatory level (MCL)

Table 5-35 Analyte Concentration Summary for the LP-LAZ Monitoring Wells (continued)

ANALYTE	FREQUENCY DETECTED	BRR 6B RANGE	BRR 7B RANGE	BRR 8B RANGE	MCL
GENERAL CHEMISTRIES (ug/L)					
Total dissolved solids	6/6	11400 - 12200	83000 - 93000	148000 - 152000	NR
Total organic carbon	2/6	U	U - 1250	U - 1180	NR
Total organic halogens	1/6	U	U	U - 5.3	NR
Total phosphates	4/6	240 - 530	110	U	NR

U = Not detected

NR = No regulatory level (MCL)

concentrations ranged from 35.4 ug/L (BRR 6B) to 1020 ug/L (also BRR 6B). Manganese was found in each of the wells, although it was not detected in the second quarter sample collected from BRR 8B. Detected manganese concentrations ranged from 0.41 ug/L (BRR 8B) to 56.4 ug/L (BRR 6B). Only the second quarter BRR 6B sample exceeded the manganese 2° MCL of 50 ug/L. Thallium was only detected in the first quarter sample collected from BRR 6B. It was present at a concentration of 0.86 ug/L, which exceeds the Lifetime health advisory of 0.4 ug/L.

Among the other TAL constituents present in the lower portion groundwater samples were lead, mercury, and cyanide. Lead was present in each of the collected samples with concentrations ranging from 1.07 ug/L (BRR 6B) to 2.15 ug/L (BRR 6B). Mercury was detected in the BRR 7B samples and the second quarter sample obtained from BRR 8B. The detected levels ranged from 0.04 ug/L (BRR 8B) to 0.11 ug/L (BRR 7B). Cyanide was detected in each of the second quarter well samples. Each of the three samples (BRR 6B, BRR 7B, and BRR 8B) had a concentration of 1.7 ug/L.

5.4.3.2 BNAs

Four BNA compounds were detected during the lower portion monitoring well sampling. None exceeded SDWA standards. Bis(2-ethylhexyl) phthalate was present in second quarter samples from BRR 6B and BRR 8B with concentrations of 0.29 ug/L and 0.28 ug/L, respectively. The compound 2-chlorophenol was detected in the first quarter sample from BRR 7B at a concentration of 0.46 ug/L. Fluorene was detected in the second quarter sample from BRR 8B at a concentration of 0.2 ug/L.

5.4.3.3 Volatile Organics

Eight volatile organic compounds were detected in the lower portion groundwater samples. None of the compounds were present at a concentration that exceeded SDWA standards. Among the compounds present were carbon tetrachloride, chloroform, dichloromethane, toluene, and trichloroethylene. Carbon tetrachloride was present in the samples collected from BRR 8B with concentrations of 0.19 ug/L in the first quarter sample and 0.18 ug/L in the second quarter sample. Chloroform was present in each of the groundwater samples. The concentrations ranged from 0.11 ug/L (BRR 8B) to 0.33 ug/L (BRR 6B). Dichloromethane was detected in the samples collected during the first quarter of 1994. Detected concentrations ranged from 0.37 ug/L (BRR 7B) to 0.55 ug/L (BRR 8B). Toluene and trichloroethylene were detected in each of the samples. Toluene concentrations ranged from 0.06 ug/L (BRR 6B) to 0.18 ug/L (BRR 6B), and trichloroethylene concentrations ranged from 0.08 ug/L (BRR 7B) to 3.02 ug/L (BRR 8B).

5.4.3.4 Pesticides/PCBs

The pesticide 2,4,5-T was detected in first quarter samples obtained from wells BRR 6B and BRR 7B with concentrations of 0.35 ug/L and 0.44 ug/L, respectively. The samples were not analyzed for the presence of 2,4,5-T during the second quarter. PCBs were not detected in any of the LP-LAZ groundwater samples.

5.4.3.5 Radionuclides and Radionuclide Indicators

A total of sixteen radionuclides and two radionuclide indicators were detected in the LP-LAZ monitoring well samples. Among those detected were actinium-228, lead-212, radium (total alpha-emitting), thorium-234, tritium, the gross alpha particle activity indicator, and the nonvolatile beta particle activity indicator. Actinium-228 and lead-212 were present in the BRR 8B groundwater samples. Actinium activities of 10.8 pCi/L and 9.78 pCi/L were found in the first and second quarter samples, respectively. Lead-212 sample activities were 16.4 pCi/L and 8.75 pCi/L in the first and second quarters, respectively. A total alpha-emitting radium activity of 0.5 pCi/L was detected in the BRR 7B sample collected during the first quarter. Radium was not detected in the other first quarter samples and was not an analyte for the second quarter. Thorium-234 was present in samples collected from BRR 7B and BRR 8B. Detected activities of thorium-234 were 105 pCi/L (BRR 7B) and 235 pCi/L (BRR 8B). Tritium was an analyte for the first quarter samples and it was detected in the BRR 7B and BRR 8B groundwater samples. Tritium activities were 4.97 pCi/mL in BRR 7B and 99.6 pCi/mL in BRR 8B. **Tritium activities for second quarter samples at well BRR 8B was 110 pCi/mL. Tritium activities in well BRR 8B exceeded SDWA standards.** The two activity indicators, gross alpha and nonvolatile beta, were analyzed for in the first quarter groundwater samples. Nonvolatile beta particle activity was present in BRR 6B and both indicators were present in the BRR 7B sample. BRR 6B had a nonvolatile beta particle activity of 0.82 pCi/L while the BRR 7B sample had a gross alpha particle activity of 0.75 pCi/L and nonvolatile beta particle activity of 1.36 pCi/L.

5.4.3.6 General Chemistries

Several general chemistries were conducted on the lower portion groundwater samples. None of the testing showed analyte concentrations that exceeded or were outside of MCL, 2° MCL, or health advisory standards.

5.4.3.7 Summary

Groundwater samples collected from the monitoring wells set into the LP-LAZ of the Upper Three Runs Aquifer did not exhibit analyte concentrations that exceeded primary MCLs, **except tritium in well BRR 8B. The tritium concentrations which exceeded the primary MCL was 100,000 pCi/L (1Q94) and 110,000 pCi/L (2Q94). Table 5-33 and Figure 5-15 provide the information on the tritium concentrations.**

5.4.4 *Hydrocone Groundwater Sampling*

Groundwater samples were collected from five Hydrocone soil boring locations (see Figure **4-19** for Hydrocone sampling locations). Of the five locations, two are considered upgradient locations (HC-5/BR-13-01 and HC-8/BR-09-01) while the other three are considered downgradient (HC-6/BR-11-01, HC-7/BR-10-01, and HC-9/BR-12-01). However, all of the Hydrocone sampling locations are downgradient of the SRS F-Area site. Table **5-36** gives a summary of analytes detected in the Hydrocone sampling.

5.4.4.1 TAL Constituents

Nine TAL constituents were detected during the Hydrocone groundwater sampling program. Only mercury was detected at a concentration that exceeded a MCL, 2° MCL, or SDWA health advisory. In the HC-7/BR-10-01 sample, the mercury concentration was 3.12 ug/L which exceeds the MCL of 2 ug/L. Mercury was only detected in one other sample (HC-8/BR-09-01) at a concentration of 0.26 ug/L. However, HC-8/BR-09-01 was upgradient of HC-7/BR-10-01 and was the upgradient Hydrocone sampling location for the BRRP site. This suggests that the site may have contributed to the contamination of the groundwater at the HC-7/BR-10-01 location, but this may also be the result of the migration of a contaminated groundwater plume.

Among the other constituents detected were chromium, copper, and lead. Chromium was detected in every sample but HC-5/BR-13-01. Detected chromium concentrations ranged from 8.89 ug/L (HC-9/BR-12-01) to 24.1 ug/L (HC-6/BR-11-01). Copper was detected in each of the five Hydrocone samples. Concentrations ranged from 10.5 ug/L in HC-5/BR-13-01 to 54.9 ug/L in HC-6/BR-11-01. Lead was detected in every sample but HC-8/BR-09-01. Detectable levels ranged from 5.37 ug/L (HC-9/BR-12-01) to 10.1 ug/L (HC-6/BR-11-01).

Table 5-36 Hydrocone Sampling Analyte Concentration Summary

ANALYTE	FREQUENCY DETECTED	RANGE	MCL
VOLATILE ORGANICS (ug/L)			
Carbon Tetrachloride	1/5	U - 15	5
Chloroform	1/5	U - 1.3	100
Dichloromethane	2/5	U - 3	NR
Trichlorofluoromethane	1/5	U - 3.9	5
SEMI-VOLATILE ORGANICS (ug/L)			
Bis(2-ethylhexyl)phthalate	1/5	U - 8.1	NR
TARGET ANALYTE LIST (ug/L)			
Barium	5/5	13.9 - 137	2000
Chromium	4/5	U - 24.1	100
Cobalt	4/5	U - 8.71	NR
Copper	5/5	10.5 - 54.9	1300
Lead	4/5	U - 10.1	15*
Mercury	2/5	U - 3.12	2
Nickel	5/5	6.4 - 23.4	100
Vanadium	4/5	U - 33.9	NR
Zinc	5/5	59.8 - 152	NR
RADIONUCLIDES and RADIONULCIDE INDICATORS (pCi/L)			
Gross alpha	5/5	5.99 - 203	15
Nonvolatile beta	5/5	4.53 - 86.7	NR
Tritium (pCi/mL)	4/5	U - 7.71	20
GENERAL CHEMISTRIES (ug/L)			
Ammonia	2/5	U - 270	NR
Chloride	5/5	1480 - 4240	NR
Nitrate as nitrogen	5/5	539 - 2610	10000
pH (in pH units)	NA	4.5 - 6.09	NR
Sulfate	4/5	U - 3820	NR
Total dissolved solids	5/5	14000 - 3260000	NR
Total organic carbon	3/5	U - 3360	NR
Total organic halogens	4/5	U - 13.9	NR

* The SDWA standard for lead is a nonenforceable "at the tap" action level.

NR = No regulatory level (MCL)　　U = Not detected　　NA = Not applicable

5.4.4.2 BNAs

Only one BNA compound, bis(2-ethylhexyl) phthalate) was detected during the Hydrocone sampling. It was only present in HC-8/BR-09-01 at a concentration of 8.1 ug/L. This does not exceed any MCLs, 2° MCLs, or SDWA health advisories.

5.4.4.3 Volatile Organics

Four volatile organic compounds were detected in the Hydrocone sample analyses and one (carbon tetrachloride) was present at a level that exceeded the MCL. Carbon tetrachloride was detected in only one sample (HC-8/BR-09-01) at a concentration of 15 ug/L, which exceeds the MCL of 5 ug/L. Since HC-8/BR-09-01 is the upgradient Hydrocone sample for the BRRP site, it is suggested that the carbon tetrachloride is the result of contaminant plume migration from an upgradient groundwater area (such as the F-Area Separations Facility).

Other volatile organics detected were chloroform, dichloromethane, and trichlorofluoromethane. Chloroform and trichlorofluoromethane were only detected in the HC-8/BR-09-01 groundwater sample. Chloroform had a concentration of 1.3 ug/L and trichloroflurometháne had a concentration of 3.9 ug/L. Dichloromethane was present in two samples at concentrations of 1.6 ug/L (HC-6/BR-11-01) and 3 ug/L (HC-9/BR-12-01).

5.4.4.4 Pesticides/PCBs

No pesticides or PCBs were detected in the Hydrocone groundwater samples collected at the site.

5.4.4.5 Radionuclides and Radionuclide Indicators

The indicator gross alpha particle activity was detected in the Hydrocone samples at levels that exceeded its MCL. The MCL of 15 pCi/L was exceeded in samples collected from HC-6/BR-11-01 and HC-9/BR-12-01 with activities of 38.4 pCi/L and 203 pCi/L, respectively. It was also detected in the three other Hydrocone samples with concentrations ranging from 5.99 pCi/L to 11 pCi/L.

One other radionuclide activity indicator and one radionuclide were detected during the Hydrocone sampling. Neither exceeded any SDWA standards. The other indicator, nonvolatile beta particle activity, was detected in each of the five Hydrocone samples. The activities ranged from 4.53 pCi/L (HC-5/BR-

13-01) to 86.7 pCi/L (HC-9/BR-12-01). The radionuclide tritium was detected in four of the five samples. It was not detected in the HC-6/BR-11-01 groundwater sample. Detected activities of tritium ranged from 5.21 pCi/mL (HC-7/BR-10-01) to 7.71 pCi/mL (HC-6/BR-11-01).

5.4.4.6 General Chemistries

Several general chemistry analyses were performed on the Hydrocone groundwater samples. Of these, two showed sample results that exceeded or were outside of 2° MCLs. The pH value of each of the five groundwater samples was below the lower limit of the pH 2° MCL range (pH of 6.5). The pH values ranged from 4.5 (HC-9/BR-12-01 sample) to 6.09 (HC-6/BR-11-01 sample). The other 2° MCL that was exceeded was the total dissolved solids (TDS) concentration in the HC-9/BR-12-01 sample. The 2° MCL for TDS is 500,000 ug/L and the sample had a TDS concentration of 3,260,000 ug/L.

5.4.4.7 Summary

Hydrocone sampling showed four samples with analyte levels that exceeded primary MCLs. The MCL for gross alpha particle activity (15 pCi/L) was exceeded in the samples collected from HC-6/BR-11-01 (with a concentration of 38.4 pCi/L) and HC-9/BR-12-01 (203 pCi/L). The MCL for mercury (2 ug/L) was exceeded in HC-7/BR-10-01 with a concentration of 3.12 ug/L. The carbon tetrachloride MCL of 5 ug/L was exceeded in HC-8/BR-09-01 with a concentration of 15 ug/L. **Table 5-37 summarizes this information and Figures 5-15 and 5-16 are maps with this information on them.**

5.4.5 *Groundwater Summary*

A variety of metals, volatile organic compounds, semi-volatile organic compounds, radionuclides, and one pesticide were detected in groundwater samples. Those compounds that were detected in concentrations greater than a primary MCL are: nitrate/nitrite (as N), mercury, carbon tetrachloride, and gross alpha activity, **thorium-234**, and tritium **(Figures 5-15 and 5-16). Tables 5-33 and 5-37 lists the constituents that were exceeded in the groundwater samples and hydrocone samples.**

Table 5-37 Hydrocone Contamination Concentration Data

ANALYTE	LEAD* (ug/L)	MERCURY (ug/L)	NITRATE/ NITRITE (as NITROGEN) (ug/L)	CARBON TETRACHLORIDE (ug/L)	GROSS ALPHA (pCi/L)	TRITIUM (pCi/mL)	THORIUM-234 (pCi/L)
MCL	15	2	10000	5	15	20	400
HYDROCONE NUMBER							
HC-5 (BR-13-01)	5.6	U (<0.2)	818	U (<1)	6.78	5.7	NA
HC-6 (BR-11-01)	10.1	U (<0.2)	2610	U (<1)	**38.4**	7.71	NA
HC-7 (BR-10-01)	5.44	**3.12**	539	U (<1)	5.99	5.2	NA
HC-8 (BR-09-01)	<3	0.26	1930	**15**	11	U (<0.7)	NA
HC-9 (BR-09-01	5.37	U (<0.2)	1920	U (<1)	**203**	5.7	NA

Samples dates: HC-5 (12/01/93 to 12/02/93); HC-6 (12/05/93); HC-7 (11/23/93 to 11/24/93); HC-8 (11/22/93 to 11/23/93); and HC-9 (11/21/93).
Bolded concentrations represent those which exceeded the MCL, or in the case of lead, the "at the tap" action level.
* The SDWA standard for lead is a nonenforceable "at the tap" action level.
NA = No analysis
U = Below the detection limit

5.5 Sediment and Surface Water

Sediment and surface water samples were collected from the water-filled borrow pit located adjacent to the BRRP. One sediment sample (BRRP 101) and two surface samples (BRRP 102 and BRRP 103) were collected. Additionally, two runoff-impacted sediment samples (BR-05-01 and BR-06-01), and a corresponding duplicate sample (BR-05-01) were collected from the area adjacent to the site. Appendix J contains a summary of the contaminants which were detected in the sediment and surface water samples.

Contaminant concentrations in the sediment samples will be compared against background soil sample contaminant concentrations. Since upstream surface water samples were not collected at the site, contaminant impact upon the surface water at the site will be related to MCLs.

Background surface water samples were not collected because there is no upgradient body of surface water within the immediate vicinity of the BRRP site from which to obtain a unit-specific background sample.

5.5.1 *Borrow Pit Surface Water and Sediment Samples*

Table 5-38 summarizes the analytes detected in the surface water samples and Table 5-39 summarizes the analytes detected in the borrow pit sediment sample.

5.5.1.1 TAL Constituents

Numerous TAL constituents were detected in the sediment sample collected from the borrow pit (BRRP 101). **Chromium (26.7 mg/kg), iron (22,700 mg/kg), and vanadium (62 mg/kg) were at concentrations exceeding the CBC. However, chromium and vanadium were below their respective RBC levels of 10000 mg/kg and 14000 mg/kg. Iron was evaluated in the BRA and it was noted that the iron concentrations detected would not exceed the RDAs or ESADDIs if site-speific soil concentrations were ingested.**

Antimony and selenium had no CBC with which to screen them. Therefore, these contaminants were compared to their respective RBC levels. Antimony, with a concentration of 4.56 mg/kg, did not exceed its RBC value of 820 mg/kg. Selenium, with a concentration of 4.37 mg/kg, did not exceed its RBC level of 10000 mg/kg.

Table 5-38 Borrow Pit Surface Water Sample Results

LOCATION	BRRP 102	BRRP 103	MCL
SAMPLE DATE	02/22/94	02/22/94	
ANALYTE (ug/L)			
Aluminum	1500	319	NR
Antimony	2.41	U	6
Barium	11.2	10.1	2000
Calcium	833	905	NR
Chromium	3.06	U	100
Iron	1310	290	NR
Magnesium	386	377	NR
Manganese	25.2	23.5	NR
Nickel	3.01	U	100
Sodium	517	518	NR
Vanadium	5.12	U	NR
Zinc	21	23.2	NR

U = Not detected

NR = No regulatory level (MCL)

Table 5-39 Summary of Analytes Detected in Borrow Pit Sediment Samples

LOCATION	BRRP 101
SAMPLE DATE	02/22/94
VOLATILE ORGANICS (ug/kg)	
Acetone	6.71
Benzene	0.0735
SEMI-VOLATILE ORGANICS (ug/kg)	
Bis(2-ethylhexyl)phthalate	25.4
Di-n-butyl phthalate	21
Fluoranthene	5.87
TARGET ANALYTE LIST (mg/kg)	
Aluminum	13400
Antimony	4.56
Arsenic	10.4
Barium	14.5
Beryllium	0.212
Calcium	213
Chromium	26.7
Cobalt	0.795
Copper	4.46
Iron	22700
Lead	10.9
Magnesium	151
Manganese	26.7
Mercury (ug/kg)	46.1
Nickel	1.69
Potassium	121
Selenium	4.37
Vanadium	62
Zinc	4.86
Cyanide (ug/kg)	343

All other TAL constituents detected in the sediment sample collected from the borrow pit were below their CBC level.

The two surface water samples (BRRP 102 and BRRP 103) collected from the borrow pit had detectable levels of various contaminants. Two of the contaminants, aluminum and iron, had concentrations that exceeded the 2° MCLs for these constituents. Aluminum was found in both of the surface water samples with concentrations of 1500 and **319** ug/L. These concentrations exceed the 2° MCL of 200 ug/L. **Iron was detected in both of the surface water samples with concentrations of 1310 ug/L and 290 ug/L. Only one sample (BRRP 102)** exceeded 2° MCL standards with a concentration of 1310 ug/L (the standard is 300 ug/L). **None of the contaminants exceeded primary SDWA-MCLs.**

5.5.1.2 BNAs

Three BNAs were detected in sediment sample BRRP 101. **Bis(2-ethylhexyl)phthalate was detected at a concentration of 25.4 ug/kg. Di-n-butyl phthalate was detected at a concentration of 21.0 ug/kg. Neither of these constituents have CBC levels that can be used as a screening tool. The bis(2-ethylhexyl)phthalate concentration was below its RBC level (46 mg/kg or 46000 ug/kg). A RBC level does not exist for di-n-butyl phthalate.** Fluoranthene was also among the compounds detected, with a concentration of 5.87 ug/kg **(0.00587 mg/kg), which is below the CBC level of 5.92 ug/kg. Fluoranthene's concentration was also below the RBC level of 3100 mg/kg.**

No BNA compounds were detected in the surface water samples.

5.5.1.3 Volatile Organics

Acetone (at a concentration of 6.71 ug/kg) and benzene (at a concentration of 0.0735 ug/kg) were the only volatile organic compounds detected in sediment sample BRRP-101. Neither of the detected compounds **exceeded their RBC levels. Volatile organic compounds are not screened against background concentrations, per regulatory guidance.**

No volatile organic compounds were detected in the two surface water samples collected from the borrow pit.

5.5.1.4 Pesticides, PCBs

No pesticides or PCBs were detected in any of the borrow pit sediment samples or surface water samples.

5.5.1.5 Radionuclides and Radionuclide Indicators

No radionuclides or indicators were detected in the borrow pit sediment or surface water sediment samples collected at the site.

5.5.1.6 Summary

Chromium, iron, and vanadium were detected at concentrations exceeding their CBC levels. However, based on RBC levels and information obtained from the BRA, these constituents should not be considered as contaminants of concern at the BRRP. Antimony and lead did not exceed their respective RBC levels. Bis(2-ethylhexyl)phthalate and fluoranthene were not considered as potential contaminants since their concentrations were below the screening criteria. Di-n-butyl phthalate had no CBC or RBC levels that could be used as a screening criteria. The two volatile organic compounds (acetone and benzene) detected were below their respective RBC levels.

Analyses of the surface water samples collected from the borrow pit showed that no primary MCLs were exceeded in the borrow pit surface water.

5.5.2 *Runoff Sediment Samples*

Table 5-40 summarizes the analytes detected in the runoff sediment samples collected at the site.

5.5.2.1 TAL Constituents

Eighteen TAL constituents were found in the surface runoff sediments. Fourteen of the constituents were found at levels below the unit-specific CBC. Three constituents, chromium, iron, and vanadium, were found at levels exceeding the unit-specific CBC. However, chromium and vanadium were found at levels below their respective residential RBC levels. According to the BRA, iron was not found at concentrations exceeding the RDA or ESADDI level for iron. Arsenic (surface) does not have a CBC since the concentrations detected in the background samples was

Table 5-40 Summary of Analytes Detected in the Runoff Sediments

ANALYTE	FREQUENCY DETECTED	CONCENTRATION RANGE
VOLATILE ORGANICS (ug/kg)		
1,4-Dichlorobenzene	1/3	U - 36.2
SEMI-VOLATILE ORGANICS (ug/kg)		
Pyrene	1/3	U - 11.4
TARGET ANALYTE LIST (mg/kg)		
Aluminum	3/3	2940 - 55620
Arsenic	1/3	U - 5.38
Barium	3/3	2.58 - 17
Beryllium	3/3	0.1 - 0.157
Calcium	3/3	35.8 - 110
Chromium	3/3	4.36 - 26.5
Cobalt	3/3	0.413 - 0.809
Copper	3/3	1.48 - 3.29
Iron	3/3	3670 - 22700
Lead	2/3	U - 3.86
Magnesium	3/3	30.7 - 202
Manganese	3/3	13.5 - 122
Mercury (ug/kg)	3/3	27.1 - 40.1
Nickel	2/3	U - 0.934
Potassium	2/3	U - 157
Vanadium	3/3	9.2 - 56.2
Zinc	3/3	2.22 - 5.09
Cyanide (ug/kg)	3/3	42.8 - 53

U = Not detected

Table 5-40 Summary of Analytes Detected in the Runoff Sediments (continued)

ANALYTE	FREQUENCT DETECTED	CONCENTRATION RANGE
RADIONUCLIDES and RADIONUCLIDE INDICATORS (pCi/g)		
Actinium-228	3/3	0.929 - 1.33
Gross alpha	3/3	3.7 - 8.7
Nonvolatile bets	2/3	U - 5.5
Cesium-137	3/3	0.00516 - 0.0653
Europium-155	3/3	0.236 - 0.321
Lead-212	3/3	0.722 - 1.06
Manganese-54	3/3	0.0081 - 0.0127
Neptunium-239	2/3	U - 0.0638
Potassium-40	3/3	0.615 - 1.05
Promethium-144	1/3	U - 0.00736
Promethium-146	3/3	0.00838 - 0.0167
Thorium-234	3/3	0.743 - 0.894
Yttrium-88	1/3	U - 0.000687
Zinc-65	1/3	U - 0.00301
Zirconium-95	3/3	0.000512 - 0.000611

U = Not detected

below the quantification limits. Therefore, arsenic was compared to the RBC level. Arsenic, which was detected in one out of three samples at a concentration of 5.38 mg/kg, did not exceed the noncarcinogenic RBC level (23 mg/kg); it did, however, exceed the carcinogenic RBC level (0.37 mg/kg).

5.5.2.2 BNAs

The BNA compound pyrene was detected in one of the runoff sediment samples. Pyrene was present in sample BR-06-01 at a concentration of 11.4 ug/kg, **which doe s not exceed the CBC of 13.82 ug/kg.**

5.5.2.3 Volatile Organics

1,4-Dichlorobenzene was detected in runoff sediment sample BR-05-01, with a concentration of 36.2 ug/kg. 1,4-Dichlorobenzene was not present at a concentration that exceeded **the RBC level of 27 mg/kg (27000 ug/kg).** No other volatile organic compounds were detected in BR-05-01 or the remaining two runoff sediment samples.

5.5.2.4 Pesticides, PCBs

No pesticides or PCBs were detected at concentrations exceeding the method detection limits in any of the runoff sediment samples.

5.5.2.5 Radionuclides and Radionuclide Indicators

Thirteen radionuclides and two radionuclide activity indicators were detected in the runoff sediment samples. **Of the analytes detected, only promethium-144 and yttrium-88 had no CBC or RBC levels to use as screening tools. However, they were only detected in one out of three samples at low concentrations. Promethium-144 was detected at 0.00736 pCi/g in BR-06-01 and yttrium-88 was detected at 0.00068 pCi/g in BR-06-01. Due to their half-lives and the concentrations at which they were detected, these two compounds are present at concentrations that will pose a hazard. All other analytes detected in the runoff sediment samples were below their respective CBC concentration.**

5.5.2.6 Summary

Of the analytes detected in the runoff sediment samples, only arsenic exceeded the screening criterion. Arsenic, which was detected at a concentration of 5.38 mg/kg, exceeded the carcinogenic RBC level of 0.37 mg/kg.

5.6 Summary

Table 5-41 displays the contaminants on site, by media, that were detected at concentrations that exceed the applicable regulatory guidelines.

Table 5-41 Summary of Contaminants by Media

Media	Compound
Soil	Arsenic, Beryllium, Actinium-228*, Cobalt-60, Europium-154, Europium-155, Lead-212*, Manganese-54, Neptunium-239, Zinc-65, and Zirconium-95
Groundwater	Nitrite/Nitrate (as N), Mercury, Carbon Tetrachloride, Gross Alpha Particle Activity, Tritium, and Thorium-234
Surface Water and Sediment	None applicable
Runoff Sediment	Arsenic

* naturally occurring radionuclides

6.0 CONTAMINANT PERSISTENCE AND TRANSPORT

This chapter discusses the fate of selected contaminants found at the BRRP. Chapter 5 identified those contaminants that are present on site in concentrations greater than the regulatory guidance levels. Those contaminants: mercury, carbon tetrachloride, nitrite/nitrate (as N), and gross alpha, are discussed with respect to their persistence on site and migration. This chapter is divided into two major sections. Section 6.1 discusses the physical and chemical characteristics of the contaminants and the processes in the environment that control their persistence (or residence time) on site. Section 6.2 discusses the principal routes of contaminant migration on site. Table 6-1 summarizes the contaminants that were detected in the various media in concentrations that exceed regulatory guidance levels.

Table 6-1 Summary of Contaminants by Media

Media	Compound
Soil	Arsenic, Beryllium, Actinium-228*, Cobalt-60, Europium-154, Europium-155, Lead-212*, Manganese-54, Neptunium-239, Zinc-65, and Zirconium-95
Groundwater	Nitrite/Nitrate (as N), Mercury, Carbon Tetrachloride, Gross Alpha Particle Activity, Tritium, and Thorium-234
Surface Water and Sediment	None applicable
Runoff Sediment	Arsenic

* naturally occurring radionuclides

6.1 Contaminant Persistence

6.1.1 *Carbon Tetrachloride*

Carbon tetrachloride was found in groundwater at concentrations that exceed the MCL. The persistence of an organic compound in the environment is primarily a function of its ability to degrade, volatilize, adsorb, and solubilize.

Degradation is the breakdown of the chemical structure of a compound. Degradation may be abiotic (e.g. hydrolysis or photolysis) or biological. Abiotic degradation is influenced by the presence of other compounds (both waste related and natural) or exposure to physical phenomena, such as sunlight. Carbon tetrachloride can be hydrolysed (Dragun, 1988). The rate of hydrolysis depends on the concentration and other site specific factors such as pH. Biodegradation of organic compounds is controlled by a variety of factors including: the chemical structure of the compound and its susceptibility to biological breakdown, the presence and population size of microorganisms capable of metabolizing the chemical, nutrient availability (e.g. oxygen, water, mineral ions) and the presence or absence of inhibitory substances. Carbon tetrachloride is susceptible to biodegradation (Tabak et al, 1981). The rate of biodegradation is dependent on the aforementioned site specific factors.

Volatilization from soil and water can be an important process influencing the persistence of a organic compound in a particular environmental media. Highly volatile compounds, as dictated by the vapor pressure and Henry's Law constant, have a strong tendency to volatilize from soil or water to the atmosphere. The vapor pressure of carbon tetrachloride is high, 114 mm Hg at 20°, as is the Henry's constant, 3.04×10^{-2} atm-m^3/mol. Therefore carbon tetrachloride volatilizes rapidly from water to the atmosphere.

Adsorption refers to the tendency of a chemical compound to adhere or partition onto soil and sediment particles. Compounds with high partitioning coefficients tend adhere to soils and sediments whereas compounds with low partitioning coefficients tend to leach from soils and sediments into surface or ground water. The octanol/water partition coefficient (K_{ow}) represents the distribution of a chemical between octanol and water phases under equilibrium conditions. Octanol water partition coefficients are usually reported in logarithmic form and represent the tendency of a chemical to move between an organic phase and water. The log K_{ow} of carbon tetrachloride is 2.83, an intermediate value indicating that carbon tetrachloride is neither strongly hydrophobic or hydrophilic. The organic carbon partition coefficient (K_{oc}) indicates the tendency of an organic chemical to be adsorbed to organic materials in soils or sediments. The capacity for a chemical to be adsorbed is a function of K_{oc} and the percentage of organic carbon in the soil. The K_{oc} of carbon tetrachloride is 110 ml/g, again an intermediate value.

The solubility of an organic compound refers to its ability to dissolve in a solvent (usually water). Precipitation occurs when the solvent is saturated with respect to a given chemical. The water solubility of carbon tetrachloride is 805 mg/l. Table 6-2 summarizes the physical and chemical characteristics of carbon tetrachloride that impact its persistence. **Carbon tetrachloride as with the majority of other groundwater contaminants is believed to have an upgradient source (Rabin, 1995) (Appendix L).**

Table 6-2 Physical Characteristics of Carbon Tetrachloride

Analyte	log K_{ow}	K_{oc}	Vapor Pressure	Henry's Constant	Solubility
Carbon tetrachloride	2.83	110 ml/g	114 mm Hg	3.04 x 10^{-2} atm-m^3/mol	805 mg/l

6.1.2 *Metal and Metal Compounds*

The physical characteristics of antimony, **arsenic, beryllium,** lead and mercury, the **five** metals found on site in concentrations exceeding regulatory thresholds, are displayed in Table 6-3.

Table 6-3 Physical Characteristics of Metals

Metal	Molecular Weight	Physical State	Water Solubility	Organic Solubility	Acid Solubility	Specific Gravity
Antimony	122	solid	insoluble	NDA	variable	6.684
Arsenic	**75**	**solid**	**insoluble**	**NDA**	**variable**	**5.727**
Beryllium	**9.0**	**solid**	**variable**	**NDA**	**variable**	**1.85**
Lead	207	solid	insoluble	insoluble	soluble	11.344
Mercury	201	liquid	insoluble	soluble	variable	15.594

NDA = No Data Available

Metals occur naturally at different concentrations in the environment. The presence, physical state and concentrations of metals in various media at the BRRP are determined by several processes. The more important of these processes are solubility, hydrolysis, sorption, oxidation-reduction, and complexation. A brief discussion of these processes follows.

Precipitation was discussed previously. Precipitation of inorganic compounds usually results in a solid precipitate. Factors which influence the solubility of inorganic compounds include pH, ionic speciation, and temperature.

Hydrolysis is the decomposition of a compound through a reaction with water. Acid-base hydrolysis controls the hydrogen ion concentration and affects the pH of the media. Solubility, sorption capacity, and oxidation-reduction potential are influenced by pH: therefore hydrolysis reactions contribute to the ability of metals to be leached from soils.

Sorption is the process of binding the constituent to a solid (soil particles) or in a separate liquid phase. Adsorption occurs by the interphase accumulation of substances at a surface or interface. The sorption process depends on the type of metal and the chemical properties of the solution and subsurface materials.

In an oxidation reaction, the reacting species is converted to a higher oxidation state. The electron transfer adjusts the valence state of atoms, which may influence the adsorption potential, solubility, toxicity and other characteristics or the constituent.

Metals ions may react with a ligand to form complexes. Transition metals form the most stable metal complexes and are less likely to be transported through the site media.

Antimony is found in the environment as stibnite, the native metal, antimonides of heavy oxides and as antimony oxides. Antimony is insoluble in water, however, some compounds of antimony are soluble. Antimony is present on most natural waters as a soluble oxide. Although it is unknown to what extent sorption reduces the transport of antimony in waters, sorption to clays is normally the most important mechanism that removes antimony from solution.

Lead occurs in the environment in one of three oxidation states (0, +2, +4). Lead is extremely persistent in soil and water. Its speciation varies widely with pH, temperature, and the nearby concentration of humic materials. The chemistry of lead in solution is influenced by the speciation of the ion. Sorption is the dominant process affecting lead distribution in the environment. The mobility of lead is usually controlled by adsorption onto inorganic solids, organic materials, and hydrous iron and manganese oxides. As a result, lead is strongly adsorbed to sediments in aquatic systems. Lead is strongly adsorbed to soil with minimal transportation into surface and ground water.

Mercury occurs in the environment in several forms: insoluble elemental mercury, inorganic species and organic species. Mercuric (+2) salts are less soluble and more common then the mercurous (+1) salts. Mercury also forms stable organic complexes. The nature and solubility of the chemical species depend on the redox potential and pH of the environment. Mercury and some mercury containing compounds volatilize from water and soils to the atmosphere. Volatilization is decreased by the conversion of metallic mercury to complexed species. Adsorption is the most important process determining the fate of mercury in an aquatic environment.

6.1.3 *Nitrate/Nitrite (as N)*

Nitrate and nitrite are naturally occurring compounds. Nitrogen may enter soils and water from fertilizer, animal wastes, sewage, and wastewaters or leachate from wastes. Nitrite may be formed from nitrate or ammonia. In an aerobic environment nitrite is oxidized to nitrate. Conversely, under anaerobic conditions, nitrate containing soils or water may be converted to nitrite, molecular nitrogen or nitrous oxide. Since the BRRP was at one time a farm, it is possible that the high nitrate/nitrite (as nitrogen) concentrations are due to animal wastes or fertilizer used on site.

6.1.4 *Radionuclides*

Chemical elements are classified by the atomic number (the number of protons in the nucleus). However, many elements may have different forms (based on their atomic weight, which is approximately equal to the number of protons and neutrons present in the nucleus). These differing forms of the element are called isotopes. Although the isotopes are the same element, they are not present in the elemental compounds at the same proportion. The proportions in which the isotopes occur are based on the relative stability of the atomic nucleus. The nucleus is held together (and thrown apart) by the interaction of nuclear forces and the nuclear particles. Elements have one relatively stable isotope and may have one or several unstable isotopes. Unstable isotopes (called radioisotopes or radionuclides) have nuclei that disintegrate due to the action of nuclear forces on the particles of the nuclei.

Although radionuclides are relatively unstable, most are naturally-occurring and are present in small quantities in elemental compounds. Most radionuclides are isotopes of metallic elements, although tritium (a hydrogen isotope) is also encountered in environmental investigations. For the metallic elements, the environmental fate of these radionuclides is based on the physicochemical processes affecting the metals and on the radioactive decay that the radionuclide undergoes. The radioactive decay processes are detailed within this section.

As the nuclei disintegrate, radioactivity is released from the nucleus. This is called radioactive decay.

There are three types of radioactive decay. These are alpha particles, beta particles, and gamma rays. Alpha particles are comprised of two neutrons and two protons. Decay by emission of an alpha particle causes the number of protons and neutrons in the atomic nucleus to change, thus creating a different daughter element from the parent element (called transmutation). A beta particle is comprised of an electron formed during the disintegration of a neutron. During the neutron disintegration, a beta particle and a proton are in the atomic nucleus. The electron (the beta particle) is expelled from the nucleus. Transmutation occurs during beta particle emission because an additional proton is created during the disintegration. Gamma rays are photons emitted by the nucleus as the energy state of the element is decreased. This typically occurs after transmutation or nuclear collisions.

Gross alpha emissions, **thorium, and tritium** were detected on site in groundwater at the BRRP at concentrations greater than the regulatory threshold. One of the radionuclides for which the soil samples were tested decays by alpha emission, lead-212. Alpha emission does not travel far (only a few centimeters in air). Generally the persistence of alpha emission on site depends on the half-lives of alpha emitting radionuclides, the amount of radionuclides present and the physical characteristics of the isotopes. Lead-212 has a half-life of 10.6 hours. The physical characteristics of lead are discussed in section 6.1.2. Lead-212 was detected onsite at most sampling locations (61/68).

Most radionuclides, because of their large atomic sizes and the chemical reactions they undergo as metals, are relatively immobile in soil/water systems. They are typically present as oxide or hydroxide compounds with relatively low solubilities or as cations fixated within the soil matrix. The amount of clay in the soil greatly affects the amount of metal sorption and, thus, the sorption and movement of most radionuclides. Clays and organic soils strongly adsorb cations and fix metals at a much greater rate than silts and sands.

Two factors which may increase the mobility of metals (and radionuclides) are the pH of the soil/water solution and the amount of suspended particulate matter in the water system. An strongly acidic pH value (typically 4.0 or less) increases the presence of cations in the solution and reduces the amount of sorption of most metals. Suspended colloidal materials in the water system will adsorb metals on to their structures and fixate the metals. However, the relatively small size of the colloids allows the entire particle to be readily transported through the system. Thus, the metal remains fixed in the soil matrix, but the matrix is transported through the aquifer.

6.2 Contaminant Migration

The migration routes for contaminants identified at the BRRP are: surface runoff, migration of soil contaminants into groundwater, groundwater flow, and airborne migration. These migration routes are discussed in the context of the contaminants found in the various media on site.

Mercury was detected in upper aquifer at a concentration that exceeded the MCL. Mercury and some mercury containing complexes volatilize from water and soils to the atmosphere. Mercury may be adsorbed to organic particles. The primary routes of migration that apply to mercury are volatilization and groundwater flow.

Carbon tetrachloride was detected in one sample from the upper aquifer zone at a concentration that exceeds the MCL. Carbon tetrachloride has a strong tendency to volatilize from water to the atmosphere. Carbon tetrachloride may be adsorbed to organic materials. Its K_{OC} and K_{OW} indicate an intermediate tendency to move from water to an organic phase. The primary routes of migration that apply to carbon tetrachloride are migration to the atmosphere, groundwater flow and sorption to soils.

The fate of nitrite/nitrate is dependent in part on the populations of microorganisms and presence of oxygen. Nitrites and nitrate are both soluble in water and may flow with the upper aquifer to the west.

Radionuclides and indicators were measured in groundwater, soils, and surface water and sediments. With the exception of tritium, radionuclides are large molecules and therefore not very mobile in the environment. Lead 212, which emits alpha particles, decays with a half-life of 10.6 hours. Lead is strongly adsorbed to soils. **Tritium is very mobile in groundwater. As dicussed previously, tritium is believed to have an upgradient source, the F-Area Inactive Process Sewer Lines.**

Arsenic and beryllium were found in soils at concentrations exceeding the regulatory guidelines.

7.0 BASELINE RISK ASSESSMENT

A Baseline Risk Assessment (BRA) was conducted as part of this investigation of the BRRP. This assessment included an evaluation of risks to both human health and the environment that may result from contamination at the BRRP. The entire BRA is included as Volume II of this report. This chapter summarizes the major conclusions of the BRA. Table 7-1 presents the contaminants considered as constituents of potential concern.

The human health portion of the risk assessment evaluates whether the chemical and radionuclide concentrations detected in soil and groundwater at the BRRP constituted an unacceptable threat to human health. The ecological risk assessment assessed potential impacts to biota caused by exposure to chemical and radionuclide stressors from the BRRP.

The ecological risk assessment determined exposure pathways and established a conceptual model on the basis of site reconnaissance and sampling results. Chemicals of ecological concern were established by comparing chemical concentrations (from sampling results) to benchmarks, such as background, ARARs (applicable or relevant and appropriate requirements), and guidance values. Chemicals of ecological concern were compared to literature toxicological concentrations and dosages to determine if chemical stressors at the BRRP were likely to cause ecological risks. No contaminants in surface soil were shown to present an ecological risk. In addition, no chemicals in sediments and surface water at the nearby borrow pit were found to present an ecological risk. For this reason and the intermittent nature of surface water at the borrow pit, the sediments and surface water were judged unlikely to impact aquatic receptors. No wetlands or Threatened and Endangered species were observed at the BRRP. Hence, no ecological risk is expected at the BRRP and the vicinity.

The human health portion of the BRA was based on the frequency of detection, relative toxic potential, chemical nutrient status, and background concentrations of chemicals detected on site. An exposure assessment was performed to provide an indication of potential exposures which could occur based on the chemical concentrations detected in the environmental media. Constituents of potential concern included volatile organic compounds, semi-volatile organic compounds, metals and other inorganic analytes, and radionuclides.

An exposure assessment was performed to provide an indication of the potential exposures which could occur based on the chemical concentrations detected in the environmental media during

TABLE 7-1 SUMMARY OF CONSTITUTENTS OF POTENTIAL CONCERN AT THE BRRP BY MEDIA

Chemical	Is the analyte considered a constituent of potential concern?		
	Surface Soil	Full Soil Column	Groundwater
Xylenes	Yes	Yes	Yes
Actinium-228	Yes	Yes	Yes
Antimony-124	*	Yes	*
Antimony-125	Yes	Yes	Yes
Barium-133	*	Yes	Yes
Cerium-144	Yes	Yes	Yes
Cesium-134	*	Yes	Yes
Cesium-137	Yes	Yes	Yes
Cobalt-57	*	*	Yes
Cobalt-58	Yes	Yes	Yes
Cobalt-60	*	Yes	Yes
Europium-152	*	Yes	Yes
Europium-154	*	*	Yes
Europium-155	Yes	Yes	Yes
Lead-212	Yes	Yes	Yes
Manganese-54	Yes	Yes	*
Neptunium-239	Yes	Yes	Yes
Potassium-40	Yes	Yes	Yes
Promethium-144	Yes	Yes	Yes
Promethium-146	Yes	Yes	*
Radium-total alpha	*	*	Yes
Ruthenium-106	Yes	Yes	Yes
Sodium-22	*	Yes	Yes
Thorium-234	Yes	Yes	Yes
Tin-113	*	Yes	Yes
Tritium	Yes	Yes	Yes

* - Not Detected Above Detection Limits
BB - Below Background

TABLE 7-1 SUMMARY OF CONSTITUTENTS OF POTENTIAL CONCERN AT THE BRRP BY MEDIA (continued)

Chemical	Is the analyte considered a constituent of concern?		
	Surface Soil	Full Soil Column	Groundwater
Yttrium-88	Yes	Yes	Yes
Zinc-65	Yes	Yes	Yes
Zirconium-95	Yes	Yes	Yes
Nonvolatile beta	Yes	Yes	*
Gross Alpha	*	*	Yes
Aluminum	Yes	BB	Yes
Antimony	Yes	Yes	Yes
Arsenic	BB	BB	Yes
Barium	BB	BB	Yes
Beryllium	BB	BB	Yes
Boron	*	*	Yes
Cadmium	*	Yes	Yes
Chromium (total)	Yes	BB	Yes
Cobalt	BB	BB	Yes
Lead	BB	BB	Yes
Manganese	BB	BB	Yes
Mercury	Yes	BB	Yes
Nickel	Yes	BB	Yes
Selenium	*	Yes	Yes
Silver	*	Yes	*
Thallium	*	*	Yes
Vanadium	BB	BB	Yes
Zinc	BB	BB	Yes
Cyanide	Yes	BB	Yes

* - Not Detected Above Detection Limits
BB - Below Background

sampling activities. The site was historically utilized as a disposal area for solid inert waste over the period of 1973 through 1983. The only existing exposure scenarios identifiable for the BRRP were for environmental researchers who may work or traverse the site vicinity on an intermittent/limited basis. The environmental researcher receptor scenarios were also evaluated on a future scenario basis. In addition, conservative future residential and occupational land use scenarios were examined to characterize the worst case exposures for a hypothetical future receptor. Although such future residential and occupational on-site scenarios are unlikely, it was assumed that the site would be developed for residential or occupational/commercial purposes in the future and that an adult and a child resident would live in a house built on the site or a worker would be employed on-site. The soils were assumed to be devoid of cover (i.e., vegetation, concrete, gravel, etc.). The ambient air concentrations of the constituents of potential concern which would be expected to be associated with the maximum chemical concentrations in soil were derived from conservative predictive modeling techniques.

Existing and hypothetical future pathways were evaluated quantitatively for exposure to soils and groundwater: ingestion of soil, inhalation of vapors and/or particulates from soil, dermal contact with soil, external radiation exposure to soil, external radiation/air immersion, ingestion of homegrown produce, ingestion of groundwater, dermal contact with groundwater and inhalation of vapors from groundwater.

A toxicity assessment was performed to determine appropriate toxicity values for the constituents of potential concern. The toxicity values represent the exposure levels which are expected to be without adverse non-cancer health consequences, or which would be protective against excess cancer risk. In addition, the toxicity assessment identifies the critical toxic effects associated with the chemicals of concern, as well as any ARARs for the constituents of potential concern.

A risk characterization was conducted for the constituents of potential concern in which the exposure levels calculated in the exposure assessment were compared to the toxicity values identified in the toxicity assessment. U.S. EPA risk assessment requirements stipulate that a noncancer hazard index of 1.0 and a cancer risk estimate of 1.0E-06 must not be exceeded to demonstrate that site conditions are not associated with unacceptable human health effects. Cancer risk criteria of 1E-04 to 1E-06 represent a risk range of concern.

Total site hazard indices and risk estimates were calculated for both the adult and child receptor. The hazard indices and risk estimates represent the summation of the hazards and risks for the constituents of potential concern across the relevant exposure pathways. The total site noncancer hazard indices were below unity and cancer risk levels were below 1.0E-06 for the existing and future case environmental researcher scenarios.

The future case residential and occupational scenarios showed total hazard and risk levels which exceeded U.S. EPA criterion values. Exposure to chemicals in groundwater provided the primary contribution to the total noncancer hazard levels for the future residential and occupational scenarios. The total carcinogenic risks (i.e., chemical-/radionuclide-specific risk >1E-06) for the future residential and occupational scenario were primarily associated with groundwater ingestion and /or inhalation for chemicals and radionuclides.

8.0 SUMMARY AND CONCLUSIONS

The primary objective of this investigation was to determine the extent of contamination on site, specifically determining sources of contamination, delineating possible hazardous releases to soils, delineating possible hazardous releases to groundwater, and delineating possible hazardous releases to sediments and surface water. To this end, a geophysical investigation, soil sampling investigation, groundwater sampling investigation, and surface water and sediment investigation were conducted.

8.1 Sources of Contamination

The GPR survey, magnetic survey and EM survey identified two trenches on site, potential sources of contamination. The EM survey and the magnetic survey determined that metallic debris were located in these pits. The EM survey suggested that the highest concentrations of metallic debris were in the east corner of the north trench. The EM survey and magnetic survey were not able to identify the type of objects (such as drums) within the trenches due to the high concentrations of metal objects within the trenches. Debris and rubble were encountered while drilling soil borings along the perimeter of the trenches. During the in-pit boring investigation, the OVA detected high concentrations of volatile organic substances at three locations along the trenches: BRRP 4 (along the northern edge of the northern trench), BRRP 12, and BRRP 15 (along the southern edge of the southern trench).

The EM and magnetic survey also detected an unidentified buried metal object in the northwest corner of the BRRP unit in an area of disturbed soil.

8.2 Soil Contamination

Surface and subsurface soil samples were collected from seventeen locations on site. Soil borings indicate that the soil in the vicinity of the BRRP is of a sandy constituency. Metals, semi-volatile organic compounds, volatile organic compounds, radionuclides and one pesticide (Aldrin) were detected in soil samples. Volatile organic compounds were detected on site at low concentrations, several orders of magnitude less than the regulatory thresholds. There were no semi-volatiles detected on site that exceeded CBC or RBC levels. The metals detected at the BRRP included arsenic and beryllium. Radionuclides were detected in the soils samples at concentrations that exceeded either their CBC and/or PRG. The radionuclides included actinium-228, cobalt-60, europium-154, europium-155, lead-212, manganese-54, neptunium-239, zinc-65, and zirconium-95. It should be noted that actinium-228 and lead-212 are naturally occurring radionuclides. Aldrin did not exceed its RBC level. It should also be noted that since arsenic was used as a component of agricultural chemicals in the period before the SRS existed, the detected arsenic values may be a result of farming activities in the 1930's through 1950.

8.3 Groundwater Contamination

Metals, volatile organic compounds, semi-volatile organic compounds, radionuclides and one pesticide were detected in groundwater samples. Nitrate/nitrite (as nitrogen), mercury, carbon tetrachloride, gross alpha particle activity, tritium, and thorium-234 were all detected in groundwater samples at concentrations that exceeded primary SDWA standards. According to a report (Rabin, 1995) which compared BRRP groundwater contamination to upgradient sources, nitrate/nitrite (as nitrogen), carbon tetrachloride, and tritium concentrations detected in the BRRP groundwater are the result of upgradient migration. The other compounds may also be the result of upgradient migration, or have concentrations less than the F & H remediation goals.

It should be noted that thorium-234, as identified by gamma pulse height analysis, has a 24-day half-life. Uranium-238, the parent of thorium-234 and an alpha emitter, would have to present along with the thorium-234 if groundwater contamination is the case. Gross alpha analysis does not support groundwater contamination conditions in the BRR wells. Thus, the thorium-234 values in the BRR wells are suspect due to the presence of the "J" qualifiers (which represent estimated values) reported with the results and the potential for counting errors in the analyses.

8.4 Contamination in Surface Water and Sediments

No compounds were detected in surface water and sediment samples at concentrations that exceeded the CBC, RBC, PRG or SDWA-MCL levels. Arsenic was detected in runoff sediment samples at concentrations that exceeded the carcinogenic RBC level. As previously discussed, arsenic was used as a component of agricultural chemicals in the period before the SRS existed, the detected arsenic values may be a result of farming activities in the 1930's through 1950.

8.5 Proposed Path Forward

Based on the review of the analytical data and the screening techniques used to determine the chemicals of concern, it is being proposed that no action be performed at the BRRP unit. Per the

BRA, analytical data from surface soils, sediments, and surface water as well as subsurface soils have been demonstrated to pose no risk. Source characterization has shown that historical documents are correct in stating that only inert material has been disposed of at the BRRP; therefore, the BRRP is not expected to be a future source of contamination.

Although there is groundwater contamination beneath the BRRP, the groundwater contamination is due to migration from upgradient sources in the General Separations Area (i.e., F-Area Inactive Process Sewer Lines and the F-Area Seepage Basins). Appendix L contains a report that compares the groundwater contamination beneath the BRRP to the upgradient sources. **Groundwater contamination, both horizontal and vertical extent, will be characterized prior to Phase II of the RCRA Corrective Action Plan for the F-Area Groundwater Operable Unit. A Phase III Assessment Plan to describe the F- and H- Inactive Process Sewer Lines characterization will be submitted within 60 days of the effective date (October 5, 1995) of the Hazardous Waste Management Facility RCRA Part B Permit.**

9.0 REFERENCES

Aadland, R. K., A. D. Smits, and P. A. Thayer, 1992, *Geology and Hydrostratigraphy of the A/M Area,* Savannah River Site (SRS), South Carolina (U).

Aadland, R. K. and H. W. Bledsoe, 1990a, *Classification of Hydrostratigraphic Units at the Savannah River Site, South Carolina.* US DOE Report, WSRC-RP-90-987, Westinghouse Savannah River Company, Westinghouse Savannah River Laboratory, Aiken, South Carolina.

Bouwer, H. and R. C. Rice, 1976, *A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells.* Water Resources Research, Vol. 12, No. 3: 423-428.

Bouwer, H., 1989, Discussion of *The Bouwer and Rice Slug Test - An Update.* Groundwater, Vol. 27, No. 25.

Clement Associates, Inc., 1985, *Chemical, Physical and Biological Properties of Compounds Present at Hazardous Waste Sites,* prepared for the U.S. Environmental Protection Agency.

Cumbest, R. J., D. Marcy, J. Hango, T. Gaughan, D. Wyatt, D. Mohon, B. Cain, 1994, *Magnetic Survey of the Burma Road Rubble Pit,* Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

Dragun, James, 1988, *The Soil Chemistry of Hazardous Materials,* Hazardous Materials Control Research Institute, Silver Spring, Maryland.

EPA (Office of Solid Waste), 1989a, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance,* PB89-151047, Washington, DC.

EPA (Office of Emergency and Remedial Response), 1989b, *Risk Assessment Guidance for Superfund, Volume 1-Human Health Evaluation Manual,* EPA/540/1-89/002, Washington, DC.

EPA (Office of Emergency and Remedial Response), 1989c, *Risk Assessment Guidance for Superfund, Volume 2-Environmental Evaluation Manual,* EPA/540/1-89/001, Washington, DC.

EPA (Office of Policy, Planning, and Evaluation), 1992a, *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media,* PB89-23459, Washington, DC.

EPA (Office of Policy, Planning, and Evaluation), 1992b, *Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Ground Water,* PB94-138815, Washington, DC.

Fallow, W. C. and Van Price, 1994, *Stratigraphy of the Savannah River Site and Vicinity,* Department of Geology, Furman University and Westinghouse Savannah River Company, Aiken, South Carolina.

Fetter, C. W., 1993, *Contaminant Hydrogeology,* Macmillan Publishing Company, New York.

Gilbert, R. O., 1987, *Statistical Methods for Environmental Pollution Monitoring,* Van Nostrand Reinhold, New York.

Gohn, G. S., J. E. Hazel, L. M. Byeball and L. E. Edwards, 1983, The Fishburne Formation (Lower Eocene), a newly defined subsurface unit in the South Carolina Coastal Plain: US *Geological Survey Bulletin* 1537-C.

Huddlestun, P. F. and J. H. Hetrick, 1991, The stratigraphic framework of the Fort Valley Plateau and the central Georgia kaolin district: *Georgia Geologic Society, Guidebook for the 26th Annual Field Trip,* v. 11, no. 1.

Huddlestun, P. F. and J. H. Hetrick, 1986, Upper Eocene stratigraphy of central and eastern Georgia: *Georgia Geological Survey Bulletin* 95, p 56-76.

Huddlestun, P. F., 1982, The development of the stratigraphy terminology of the Claibornian and Jacksonian marine deposits of western South Carolina and eastern Georgia, in Nystrom, P. G. Jr., and R. H. Willoughby, eds., Geological investigations related to the stratigraphy in the kaolin mining district, Aiken County, SC: *Carolina Geological Society Field Trip Guidebook 1982,* South Carolina Geological Survey, Columbia, South Carolina, p 21-33.