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Remedial Investigation Report For the Westinghouse Hematite Site

Rev 1, Volume 1: Text

Prepared for:

Westinghouse Electric Company
Hematite Facility
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Festus, MO 63028

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January 2007

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contributed to the preparation of this document and should not be considered an eligible contractor for its review.

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CONTENTS

FIGURES vii

TABLES xi

ACRONYMS xv

EXECUTIVE SUMMARY xvii

1. INTRODUCTION 1-1
   1.1 GOALS AND OBJECTIVES OF THE REMEDIAL INVESTIGATION 1-1
   1.2 SCOPE AND ORGANIZATION OF THE REPORT 1-2
   1.3 FACILITY LOCATION AND HISTORY OF OPERATIONS 1-3
   1.4 DESCRIPTION OF THE WESTINGHOUSE HEMATITE FACILITY AND SITE 1-4
   1.5 PREVIOUS ENVIRONMENTAL INVESTIGATIONS AND ONGOING MONITORING PROGRAMS 1-7
      1.5.1 Radiological Survey of the Combustion Engineering Burial Site, July 1983 1-7
      1.5.2 Preliminary Assessment Hematite Radioactive Site, Hematite, Jefferson County, Missouri, Ecology and Environment, Inc., April 1990 1-8
      1.5.3 Removal Action: Former Evaporation Ponds 1-8
      1.5.4 Investigation to Determine the Source of Technetium-99 in Groundwater Monitoring Wells WS-17 and WS-17B, September 1996 1-8
      1.5.5 Exploratory Probe-hole Investigation for the Evaporation Ponds at the ABB Combustion Engineering Hematite Facility, April 1997 1-9
      1.5.6 Hydrogeologic Investigation and Groundwater, Soil and Stream Characterization, March 1999 1-9
      1.5.7 Interim Hydrogeologic Investigation to Support the Engineering Evaluation and Cost Analysis for Response Actions for Off-Site Groundwater Quality, November 2002 1-10
      1.5.8 Gamma Walkover Survey, April 2003 1-11
      1.5.9 Determination of Distribution Coefficients for Radionuclides of Concern at the Westinghouse Hematite Facility, July 2003 1-12
      1.5.10 Wetlands and Surface Water Assessment 1-12
      1.5.11 Ongoing Environmental Monitoring Programs 1-12
   1.6 AREAS OF CONCERN AND POTENTIAL CONTAMINANTS OF CONCERN 1-13

2. SITE CHARACTERIZATION ACTIVITIES 2-1
   2.1 SURFACE WATER AND SEDIMENT SAMPLING 2-1
      2.1.1 Surface Water Level Measurements 2-2
      2.1.2 Surface Water Sampling 2-2
      2.1.3 Sediment Sampling 2-2
   2.2 SURFACE SOIL SAMPLING 2-3
   2.3 SUBSURFACE SOIL SAMPLING AND INSTALLATION OF OVERBURDEN MONITORING WELLS 2-4
      2.3.1 Field Screening Using the MIP 2-4
      2.3.2 Subsurface Soil Sampling via Direct-Push Technology 2-5
      2.3.3 Installation of Temporary Groundwater Monitoring Wells in Direct-Push Technology Boreholes 2-5

2.3.4 Subsurface Soil Sampling via Rotary Drilling 2-6
2.3.5 Installation and Development of Permanent Overburden Monitoring Wells in Rotary Drilled Boreholes 2-7
2.4 BEDROCK CORING, DISCRETE INTERVAL GROUNDWATER SAMPLING, AND INSTALLATION OF BEDROCK MONITORING WELLS 2-8
2.4.1 Bedrock Coring, Discrete Interval Sampling, and Diffusion Bag Sampling 2-8
2.4.2 Bedrock Monitoring Well Installation 2-10
2.4.3 Video logging and Discrete Interval Groundwater Sampling in Domestic Wells 2-11
2.4.4 Diffusion Bag Sampling and Analysis in Domestic Wells 2-12
2.4.5 Conversion of Domestic Wells to Dual-Completion Monitoring Wells 2-12
2.5 IN-SITU HYDRAULIC CONDUCTIVITY TESTING 2-12
2.6 SITE-WIDE GROUNDWATER INVESTIGATION 2-13
2.6.1 Monitoring Well Inspection/Assessment 2-13
2.6.2 Monitoring Well Redevelopment 2-14
2.6.3 Groundwater Sampling 2-14
2.7 OFF-SITE/BACKGROUND SAMPLING 2-16
2.8 GEOPHYSICAL SURVEY 2-17
2.9 DATA QUALITY AND DATA VALIDATION 2-17

3. CHARACTERIZATION OF STUDY AREA 3-1
3.1 METEOROLOGY 3-1
3.2 GEOLOGY 3-1
3.2.1 Regional Geology and Physiography 3-1
3.2.2 Bedrock 3-2
3.2.3 Unconsolidated Deposits 3-2
3.2.4 Site-Specific Geology 3-3
3.3 HYDROGEOLOGY AND HYDROLOGY 3-7
3.3.1 Regional Hydrogeology 3-7
3.3.2 Site-Specific Hydrology 3-8
3.3.3 Site-Specific Hydrogeology 3-10

4. CONTAMINANT DISTRIBUTION 4-1
4.1 WATER QUALITY PARAMETERS IN GROUNDWATER 4-2
4.1.1 Turbidity 4-2
4.1.2 Specific Conductance 4-3
4.1.3 pH 4-3
4.1.4 Temperature 4-4
4.1.5 Oxidation Reduction Potential and Dissolved Oxygen 4-4
4.1.6 Iron 4-5
4.1.7 Sulfide 4-5
4.1.8 Alkalinity 4-6
4.2 NON-RADIOACTIVE INORGANICS 4-6
4.2.1 Non-radioactive Inorganics in Surface Water 4-6
4.2.2 Non-radioactive Inorganics in Groundwater 4-8
4.2.3 Non-radioactive Inorganics in Sediments 4-13
4.2.4 Non-radioactive Inorganics in Surface Soil 4-13
4.2.5 Non-radioactive Inorganics in Subsurface Soils 4-16
4.3 RADIONUCLIDES 4-19
4.3.1 Radionuclides in Surface Water 4-19
4.3.2 Radionuclides in Groundwater 4-20

4.3.3 Radionuclides in Sediments 4-23
4.3.4 Radionuclides in Surface Soils 4-24
4.3.5 Radionuclides in Subsurface Soils 4-26
4.4 ORGANICS 4-27
4.4.1 Organics in Surface Water 4-29
4.4.2 Organics in Sediments 4-29
4.4.3 Organics in Surface Soils 4-30
4.4.4 Organics in Subsurface Soils 4-33
4.4.5 Organics in Groundwater 4-34
4.4.6 Comparison of Volatile Organic Compounds in Groundwater as Determined by Mobile and Off-Site Laboratories 4-36
4.4.7 Comparison of MIP Results with Soil and Groundwater Sample Analyses 4-36
4.4.8 Organic Contamination Identified in Previous Investigations at the Hematite Site 4-37
4.5 SUMMARY OF FINDINGS IN AREAS OF CONCERN 4-39
4.5.1 AOC #1 Groundwater 4-39
4.5.2 AOC #2 Surface Water Features 4-39
4.5.3 AOC #3 Burial Pits 4-41
4.5.4 AOC #4 Evaporation Ponds 4-41
4.5.5 AOC #5 Former Leach Field/Sanitary Sewer System 4-42
4.5.6 AOC #6 Soil Beneath Buildings 4-43
4.5.7 AOC #7 Limestone Storage and Limestone Fill Areas 4-44
4.5.8 AOC #8 Outdoor and Shallow Surface Area 4-44
4.5.9 AOC #9 Former Gas Station 4-45
4.5.10 AOC #10 Gas Pipeline 4-46
4.5.11 AOC #11 Red Room Roof Burial Area 4-46
4.5.12 AOC #12 Domestic Well #3 4-47
4.5.13 AOC #13 Deul's Mountain 4-47
4.5.14 AOC #14 Cistern Burn Pit Area 4-47
4.5.15 AOC #15 Joachim Creek Bridge. 4-48

5. CONTAMINANT FATE AND TRANSPORT 5-1
5.1 EVALUATION OF INORGANIC AND RADIONUCLIDE CONTAMINATION 5-1
5.1.1 pH 5-2
5.1.2 Redox Conditions 5-2
5.1.3 Soil Texture 5-2
5.2 EVALUATION OF CHLORINATED VOLATILE ORGANIC COMPOUND CONTAMINANTS IN SUBSURFACE SOILS 5-3
5.3 EVALUATION OF THE DISTRIBUTION OF PCE AND TCE IN GROUNDWATER 5-4
5.3.1 PCE and TCE Distribution in Overburden Groundwater 5-5
5.3.2 PCE and TCE Distribution in Bedrock 5-6
5.4 EVALUATION OF THE POTENTIAL FOR THE OCCURRENCE OF DNAPL AT THE HEMATITE SITE 5-6
5.5 CONCEPTUAL SITE MODEL 5-8
5.6 SUMMARY OF GROUNDWATER AND CONTAMINANT TRANSPORT MODELING 5-14
5.7 FATE OF PCE AND TCE: EVALUATION OF EVIDENCE SUPPORTING DEGRADATION OF PCE AND TCE BY NATURAL PROCESSES 5-17

6. SUMMARY AND CONCLUSIONS 6-1

6.1 SUMMARY OF GEOLOGIC AND HYDROLOGIC CONDITIONS 6-1
6.2 SUMMARY OF CONTAMINATION AT THE SITE 6-2
6.2.1 Inorganics 6-2
6.2.2 Radionuclides 6-3
6.2.3 Organics 6-4
6.3 CONCEPTUAL SITE MODEL 6-5
6.4 NUMERICAL MODELING 6-6

7. REFERENCES 7-1

APPENDIX A GROUNDWATER MODELING REPORT A-1

APPENDIX B MIP CHARTS AND VIDEO LOGGING OF PRIVATE WELLS B-1

APPENDIX C BORING LOGS C-1

APPENDIX D TABLE OF WELL CONSTRUCTION DATA AND WATER LEVEL MEASUREMENTS (DECEMBER 2004) D-1

APPENDIX E WELL COMPLETION DIAGRAMS E-1

APPENDIX F WELL ASSESSMENT REPORT F-1

APPENDIX G SLUG TESTS G-1

APPENDIX H ANALYTICAL RESULTS H-1

APPENDIX I CD-ROM OF LABORATORY DATA AND INTEGRITY TESTING OF DUAL-COMPLETION WELLS. I-1

APPENDIX J BACKGROUND CALCULATION J-1

APPENDIX K RADIUM AND THORIUM ISOTOPES AT THE HEMATITE SITE K-1

APPENDIX L GAMMA LIBRARY L-1

FIGURES

1.1. Location of Hematite Site. 1-17
1.2. Site map. 1-18
1.3. Facility map. 1-19
1.4. Areas of concern at the Hematite Site. 1-20
2.1. Surface water gauging stations. 2-23
2.2. Surface water sampling locations. 2-24
2.3. Sediment sampling locations. 2-25
2.4a. Surface soil sampling locations. 2-26
2.4b. Surface soil sampling locations, Detail A. 2-27
2.5a. Subsurface soil sampling locations. 2-28
2.5b. Subsurface soil sampling locations, Detail A. 2-29
2.6a. Groundwater monitoring wells. 2-30
2.6b. Groundwater monitoring wells, Detail A. 2-31
2.7. Off-site soil sample locations. 2-32
3.1a. Location of Hematite in Salem Plateau, Ozarks Plateaus Physiographic Province. 3-23
3.1b. Geologic map of Hematite Site area. 3-24
3.2. Cross-sections of selected overburden borings. 3-25
3.3. Legend for Figs. 3.4 through 3.6 and 3.9 through 3.11. 3-26
3.4. Cross-section A-A'; overburden wells. 3-27
3.5. Cross-section B-B'; overburden wells. 3-28
3.6. Cross-section C-C'; overburden wells. 3-29
3.7. Isopach map of coarse-grain-based deposits. 3-30
3.8. Cross-sections of bedrock wells. 3-31
3.9. Cross-section D-D'; bedrock wells. 3-32
3.10. Cross-section E-E'; bedrock wells. 3-33
3.11. Cross-section F-F'; bedrock wells. 3-34
3.12. Cross-section G-G'; bedrock wells corrected for geologic dip. 3-35
3.13. Identification of hydrostraticgraphic units. 3-36
3.14. Hydraulic conductivity from slug tests. 3-37
3.15. Injection test data. 3-38
3.16. Hydraulic summary. 3-39
3.17. Potentiometric surface of shallow (fine-grain) overburden wells (December 2004). 3-40
3.18. Potentiometric surface of deeper overburden wells (December 2004). 3-41
3.19. Potentiometric surface of the Jefferson City-Cotter wells (December 2004). 3-42
3.20. Potentiometric surface of the Jefferson City-Roubidoux contact zone wells (December 2004). 3-43
3.21. Potentiometric surface of the Roubidoux wells (December 2004). 3-44
3.22. Hydraulic gradient (-dh/dz) between shallow and deep overburden wells (December 2004). 3-45
3.23. Hydraulic gradient (-dh/dz) between deep overburden and Jefferson City wells (December 2004). 3-46
3.24. Hydraulic gradient (-dh/dz) between Jefferson City and Roubidoux wells (December 2004). 3-47
3.25. Time series plot of water levels in selected overburden and Jefferson City-Cotter wells. 3-48
3.26. Time series plot of water levels in selected Jefferson City-Cotter wells. Note: The data for BR-04-JC are also shown in Fig. 3.25 but on a different scale for the y-axis. 3-49
3.27. Time series plot of water levels in selected Roubidoux wells. 3-50
3.28. Water level versus time data from USGS well 381405090260301 in Festus, MO. 3-51

4.1. Histogram of turbidity....4-51
4.2. Histogram of specific conductance....4-51
4.3. Histogram of groundwater pH....4-52
4.4. Histogram of groundwater oxidation-reduction potential....4-52
4.5. Histogram of groundwater dissolved oxygen....4-53
4.6. Histogram of ferrous iron concentrations in groundwater....4-53
4.7. Histogram of groundwater alkalinity....4-54
4.8a. Comparison of aluminum concentrations in filtered and unfiltered groundwater samples....4-55
4.8b. Comparison of iron concentrations in filtered and unfiltered groundwater samples....4-55
4.8c. Comparison of manganese concentrations in filtered and unfiltered groundwater samples....4-56
4.8d. Comparison of zinc concentrations in filtered and unfiltered groundwater samples....4-56
4.8e. Comparison of total iron and ferrous iron concentrations in unfiltered groundwater samples. (Total and ferrous iron concentrations were measured in the laboratory and field, respectively.)....4-57
4.9. Cumulative frequency plot for arsenic in surface soils....4-58
4.10. Cumulative frequency plot for arsenic in subsurface soils....4-58
4.11. Anomalous trace inorganic data for surface soils....4-59
4.12. Anomalous trace inorganic data for subsurface soils....4-60
4.13. Comparison between ^{234}U activities in filtered (<0.45 mm) and unfiltered groundwater samples. (Error bars correspond to estimated average measurement error reported with analytical results.)....4-61
4.14. Comparison between ^{238}U activities in filtered (<0.45 mm) and unfiltered groundwater samples. (Error bars correspond to estimated average measurement error reported with analytical results.)....4-61
4.15. Technetium-99 activities in groundwater samples....4-62
4.16. Elevated uranium (U-235) activity in surface soils samples and areas with elevated Gamma activity identified during Gamma survey (SAIC 2003)....4-63
4.17. Elevated Tc-99 in surface soil samples....4-64
4.18. Elevated Uranium (U-235) activity in subsurface soils samples and areas with elevated Gamma activityidentified during Gamma survey (SAIC 2003)....4-65
4.19. PAH in sediment and subsurface soil locations....4-66
4.20a. PAH in surface soil....4-67
4.20b. PAH locations: surface soil, detail a....4-68
4.21. Elevated TCE and PCE (> 40 mg/kg reference value) in subsurface soils. Refer to text for discussion of reference values....4-69
4.22. MIP detector response at BD-02....4-70
4.23. MIP detector response at OA-18....4-71
4.24. MIP detector response at NB-50....4-72
5.1. PCE in soil samples collected from 0 to 10 ft BGS....5-23
5.2. PCE in soil samples collected from 10 to 20 ft BGS....5-24
5.3. PCE in soil samples collected from 20 ft BGS to top of bedrock....5-25
5.4. TCE in soil samples collected from 0 to 10 ft BGS....5-26
5.5. TCE in soil samples collected from 10 to 20 ft BGS....5-27
5.6. TCE in soil samples collected from 20 ft BGS to top of bedrock....5-28
5.7. PCE in shallow overburden wells....5-29
5.8. PCE in deep overburden wells....5-30
5.9. PCE in Jefferson City-Cotter HSU wells....5-31
5.10. PCE in Jefferson City-Roubidoux contact zone HSU wells....5-32
5.11. TCE in shallow overburden wells....5-33
5.12. TCE in deep overburden wells....5-34
5.13. TCE in Jefferson City-Cotter HSU wells....5-35

5.14. TCE in Jefferson City-Roubidoux contact zone HSUs wells. 5-36
5.15. Zones of PCE and TCE domination in coarse-layer overburden groundwater wells based on PCE/TCE (moles/L). 5-37
5.16. Potential for PCE and TCE DNAPL at the Hematite Site. 5-38
5.17. Cross-section F-F'; PCE contamination, Jefferson City-Cotter HSU. 5-39
5.18. Cross-section F-F'; TCE contamination, Jefferson City-Cotter HSU. 5-40
5.19a. TCE in PW-16. 5-41
5.19b. TCE in PW-19. 5-42
5.20. Water levels in Roubidoux HSU: August 13, 2002. 5-43
5.21. Cross-section D-D'; PCE and TCE concentrations. 5-44
5.22. Plan view of MODFLOW/RT3D model domain for the Hematite Site, bounded by solid black line. (Model grid also shown, blue dots correspond to bedrock well locations.) 5-45
5.23. Hydrostratigraphic units and corresponding layers represented in MODFLOW model. (Cross-section A-A' in Fig. 5.22, trending northwest-southeast.) 5-46
5.24. MODFLOW grid in plan and elevation view. [Red line in plan view corresponds to Joachim Creek –cells along this line in the top layer are specified head cells – Arc A-D and Arc B-C are also specified head boundaries in the bottom two layers of the model (refer to Fig. 5.22 for model layers) to produce northeasterly regional groundwater flow.] 5-47
5.25. Comparison between modeled and average measured water levels in wells at the Hematite Site. (Deep overburden, Jefferson City-Cotter, and Roubidoux wells.) 5-48
5.26. MODPATH-simulated (forward and backward) particle pathways and travel times. [Blue lines are potentiometric contour lines for layers corresponding to transmissive Jefferson City-Cotter HSU; pumping in private wells at household rates (35 ft^3/day).] 5-49
5.27. MODPATH-simulated (forward and backward) particle pathways and travel times. [Blue lines are potentiometric contour lines for layers corresponding to transmissive Jefferson City-Cotter HSU; specified extraction flow rate in private wells at 2000 ft3/day (~10.4 gpm) drawn from Jefferson City-Cotter HSU layer to simulate vertical borehole flow.] 5-50
5.28. PCE concentration contours (mg/L) in layer corresponding to terrace/alluvial deposits at t = 3000 days (~8 years). (Constant concentration source of 200 mg/L PCE placed in cell corresponding to BD-02; simulated using MODFLOW model with vertical borehole flow and RT3D Sequential Decay chemical reaction package.) 5-51
5.29. PCE concentration contours (mg/L) in layer corresponding to terrace/alluvial deposits at t = 9000 days (~25 years). (Constant concentration source of 200 mg/L PCE placed in cell corresponding to BD-02; simulated using MODFLOW model with vertical borehole flow and RT3D Sequential Decay chemical reaction package.) 5-52
5.30. PCE concentration contours (mg/L) in layer corresponding to terrace/alluvial deposits at t = 15,000 days (~41 years). (Constant concentration source of 200 mg/L PCE placed in cell corresponding to BD-02; simulated using MODFLOW model with vertical borehole flow and RT3D Sequential Decay chemical reaction package.) 5-53
5.31. Simulated PCE concentration contours (mg/L) in layer corresponding to transmissive Jefferson City-Cotter Formation at t = 15,000 days (~41 years).[Constant concentration source of 100 mg/L PCE placed in vicinity of Burial Pits (red square); simulated using MODFLOW modelwith vertical borehole flow and RT3D sequential decay chemical reaction package (PCE > TCE > cis-1,2-DCE > vinyl chloride > ethene).] 5-54
5.32. Simulated TCE concentration contours (mg/L) in layer corresponding to transmissive Jefferson City-Cotter Formation at t = 15,000 days (~41 years). [Constant concentration source of 100 mg/L PCE placed in vicinity of Burial Pits (red square); simulated using MODFLOW model with vertical borehole flow and RT3D sequential decay chemical reaction package (PCE > TCE > cis-1,2-DCE > vinyl chloride > ethene);note that TCE shown in figure is from degradation of PCE in source.] 5-55

5.33. Simulated uranium concentration contours (mg/L) in layer corresponding to deep overburden at t = 74,000 days (~200 years). [Constant concentration source of 0.2 mg/L uranium placed in Burial Pits and Deul's Mountain (red squares); simulated using MODFLOW modelwith vertical borehole flow and RT3D Tracer Transport package (includes sorption coefficient measured in site-specific study (SAIC 2003c).] 5-56
5.34. Degradation pathway for PCE/TCE under anaerobic conditions. 5-57
5.35. Ratio of PCE:TCE+*cis*-1,2-DCE in deep overburden wells. 5-58
5.36. Ratio of PCE:TCE+*cis*-1,2-DCE in bedrock wells. 5-59

TABLES

1.1. Chemicals used at the Hematite Facility (adapted from LBG 2003) 1-23
1.2. Historical and current use of buildings within the Hematite Facility (Adapted from LBG 2003; refer to Fig. 1.3 for locations within the Hematite Facility.) 1-24
2.1. Analysis methods for surface water samples 2-35
2.2. Analysis methods for sediment samples 2-36
2.3. Analysis methods for surface soil samples 2-37
2.4. Analysis methods for subsurface soil samples 2-38
2.5. Analysis methods for baseline groundwater samples 2-39
2.6. Analysis methods of off-site soil samples 2-40
3.1. Surface Water Level Measurements 3-55
3.2. Summary of Slug Tests, December 2004 3-56
4.1. Arsenic concentrations in groundwater samples (All other results less than the reporting limit of 0.01 mg/L; refer to Fig. 2.6a and b for well locations.) 4-75
4.2. Chromium concentrations in groundwater samples (All other concentrations were less than the reporting limit of 0.004 mg/L; refer to Fig. 2.6a and b for well locations.) 4-75
4.3. Copper concentrations in groundwater samples (All other samples less than the reporting limit of 0.01 mg/L; refer to Fig. 2.6a and b for well locations.) 4-75
4.4. Iron concentrations in groundwater samples (All other samples less than 1 mg/L; refer to Fig. 2.6a and b for well locations.) 4-76
4.5. Lead concentrations in groundwater samples (All other samples less than reporting limit of 0.003 mg/L; refer to Fig. 2.6a and b for well locations.) 4-78
4.6. Nickel concentrations in groundwater samples (All other samples less than 0.05 mg/L; refer to Fig. 2.6a and b for well locations.) 4-78
4.7. Nitrate (as-N) concentrations in groundwater (All other samples less than 1 mg/L; refer to Fig. 2.6a and b for well locations.) 4-79
4.8. Selenium concentrations in groundwater (All other samples below reporting limit of 0.005 mg/L; refer to Fig. 2.6a and b for well locations.) 4-79
4.9. Thallium concentrations in groundwater samples (All other samples below reporting limit of 0.01 mg/L; refer to Fig. 2.6a and b for well locations.) 4-80
4.10. Vanadium concentrations in groundwater (All other samples below reporting limit of 0.01 mg/L; refer to Fig. 2.6a and b for well locations.) 4-80
4.11. Zinc concentrations in groundwater (All other samples less than 0.05 mg/L; refer to Fig. 2.6a and b for well locations.) 4-80
4.12 Inorganics in Site Sediment (refer to Fig. 2.3 for sample locations) 4-81
4.13. Ten highest inorganic concentrations (mg/kg) in surface soils 4-83
4.14. Comparison of Hematite Site surface soil results with local, regional, and international compilations (mg/kg) 4-85
4.15. Ten highest inorganic concentrations (mg/kg) in subsurface soils (Last two digits of Station ID-Depth refers to sample depth in ft.) 4-89
4.16. Comparison of Hematite Site subsurface soil results with local, regional, and international compilations (mg/kg) 4-91
4.17. Uranium activities in Hematite Site surface water samples (pCi/L) (Refer to Fig. 2.2 for sampling locations.) 4-95
4.18. Uranium activity in groundwater by alpha spectrometry (Samples with ^{234}U activity > 2 pCi/L; refer to Figs. 2.6a and 2.6b for well locations.) 4-96
4.19. Isotopic thorium in unfiltered groundwater samples (pCi/L) 4-97
4.20. ^{99}Tc activities in groundwater (pCi/L) 4-98
4.21. Isotopic uranium activity in sediments (pCi/g) (Refer to Fig. 2.3 for sample locations.) 4-99

4.22. ^{99}Tc activity in sediments (pCi/g) (Refer to Fig. 2.3 for sample locations.) 4-100
4.23. Isotopic uranium in surface soils (pCi/g) (Samples analyzed using alpha spectroscopy and samples with detectable ^{235}U activities from gamma spectroscopy analysis are shown in the table; shaded sample results are potentially contaminated using ^{235}U = 0.14 pCi/g as a reference value to distinguish contaminated from uncontaminated soils. Refer to text for discussion of reference value.) 4-101
4.24. ^{99}Tc in surface soil (pCi/g) (Refer to Fig. 4.17 for anomalous sample locations and Figs. 2.4a and 2.4b for locations of all samples analyzed for ^{99}Tc; samples with activities above the MDC (1 pCi/g) are shown below.) 4-103
4.25. Isotopic thorium activities in surface soils (pCi/g) [Refer to Figs. 2.4a and 2.4b for sample locations; thorium activities were not detected (MDC of 0.1 pCi/g) in the rest of the samples.] 4-104
4.26. ^{241}Am activity reported in surface soil (pCi/g) [Refer to Figs. 2.4a and 2.4b for sample locations; ^{241}Am not detected in other samples, with a MDC that ranged from 0.3 to 4 pCi/g.] 4-104
4.27. ^{239}Pu /^{240}Pu activity in surface soils (pCi/g) [Refer to Figs. 2.4a and b for sample locations; ^{239}Pu/^{240}Pu activities not detected on other samples (MDC ~0.02 pCi/g).] 4-104
4.28. Isotopic uranium in subsurface soils (pCi/g) [Refer to Fig. 4.18 for sampling locations and Figs. 2.5a and 2.5b for all sampling locations; table includes all samples that were analyzed by alpha spectrometry, and samples with gamma activities that were above the detection limit (0.5 to 2 pCi/g).] 4-105
4.29. ^{99}Tc in subsurface soils (pCi/g) (Refer to Figs. 2.5a and 2.5b for sample locations.) 4-106
4.30. Isotopic thorium in subsurface soils (pCi/g) (Refer to Figs. 2.5a and 2.5b for sampling locations.) 4-107
4.31. ^{239}Pu /^{240}Pu in subsurface soils (pCi/g) 4-108
4.32. Number of sediment and soil samples with organic analyte concentrations above detection limits. Note that sample counts include samples with concentrations below the reporting limit. Maximum concentrations are given in parentheses. Sample results with associated contaminated laboratory blanks were not included in the sample counts. Green shaded cells indicate that none of the samples exceeded detection limits. Grey shaded cells indicate that analytes were not measured. 4-109
4.33. Number of surface water and groundwater samples with organic analyte concentrations above detection limits. Note that sample counts include samples with concentrations below the reporting limit. Maximum concentrations (µg/L) are given in parentheses. Sample results with associated contaminated laboratory blanks were not included in the sample counts. Green shaded cells indicate that none of the samples exceeded detection limits. Grey shaded cells indicate that analytes were not measured. 4-112
4.34. VOC concentrations in surface water (mg/L) (Refer to Fig. 2.2 for sample locations; only VOCs detected above the reference levels are shown.) 4-115
4.35. PAHs in sediment samples (µg/kg) (Refer to Fig. 2.3 for sampling locations; only PAHs detected above the reference levels are shown.) 4-115
4.36. Dioxins in surface soil (pg/g) (Refer to Fig. 2.4b for sample location.) 4-115
4.37. PAHs in surface soils (µg/kg) (Refer to Figs. 2.4a and 2.4b for surface soil sampling locations; only PAHs detected above the MDL are shown.) 4-116
4.38. PCBs in surface soils (µg/kg) (Refer to Fig. 2.4 for sample locations; only samples with PCBs detected above the risk-based screening levels are shown.) 4-117
4.39. Petroleum in surface soils (mg/kg) [Refer to Fig. 2.4a for sample locations; only samples with detectable diesel fuel and gasoline-range organics detected above the detection limit are shown.] 4-117

4.40. Dioxins in subsurface soil (pg/g) (Refer to Fig. 2.5b for sample location.).....4-117
4.41. PAHs in subsurface soil (μg/kg) (Refer to Figs. 2.5a and 2.5b for sample location.) 4-117
4.42. VOCs in subsurface soil samples (μg/kg) (Refer to Fig. 4.21 for sample locations and Figs. 2.5a and 2.5b for all locations samples.).....4-118
4.43. BNAs in groundwater (μg/L) (Refer to Figs. 2.6a and 2.6b for well locations; only samples with detectable BNAs are shown.).....4-118
4.44. VOCs in groundwater (μg/L) (Refer to Figs. 2.6a and 2.6b for well locations; only samples with VOCs above reference levels are shown.) 4-119
4.45. Mobile versus analytical laboratory results 4-121
4.46. Locations where soil, sediment, surface water, and groundwater samples were obtained and analyzed for VOCs in previous investigations.....4-122

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ACRONYMS

ABB	Asea Brown Boveri
AMSL	above mean sea level
AOC	area of concern
^{241}Am	americium-241
BGS	below ground surface
BNA	base-neutral-acid extractable organic
CCOPC	chemical contaminant of potential concern
CE	Combustion Engineering Inc.
COC	chain-of-custody
CSM	conceptual site model
DCE	dichloroethylene
DNAPL	dense, nonaqueous-phase liquid
DO	dissolved oxygen
DOE	U.S. Department of Energy
DPT	direct-push technology
DSCC	deeper silty clay/clay
ECD	electron capture detector
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
F&T	fate and transport
FID	flame ionization detector
FS	feasibility study
GAC	General Atomic Company
Gulf	Gulf Oil Corporation
GM	Geiger-Mueller
gpd	gallons per day
gpm	gallons per minute
HDPE	high-density polyethylene
HSA	hollow-stem auger
HSU	hydrostratigraphic unit
ID	inside diameter
IDW	investigation-derived waste
KOH	potassium hydroxide
LBG	Leggette, Brashears & Graham, Inc.
MDC	minimum detectable concentration
MDL	method detection limit
MDNR	Missouri Department of Natural Resources
MIP	membrane interface probe
mL/min	milliliters per minute
MS	matrix spike
MSD	matrix spike duplicate
NaI	sodium iodide
^{237}Np	neptunium-237
NPDES	National Pollutant Discharge Elimination System
NSSSC	near surface silt/silty clay
NTU	nephelometric turbidity unit
O.D.	outer diameter
ORP	oxidation-reduction potential

PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	perchloroethylene
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
PGDP	Paducah Gaseous Diffusion Plant
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
^{238}Pu	plutonium-238
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QC	quality control
^{226}Ra	radium-226
RI	remedial investigation
RCOPC	radiological contaminant of potential concern
SAIC	Science Applications International Corporation
s.u.	standard unit
SVOC	semivolatile organic compound
^{99}Tc	technetium-99
TCE	trichloroethylene
^{232}Th	thorium-232
TSWP	task-specific work plan
UF_6	uranium hexafluoride
UNC	United Nuclear Corporation
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
UTL	upper threshold limit
VOC	volatile organic compound
WEC	Westinghouse Electric Company, LLC

EXECUTIVE SUMMARY

INTRODUCTION

This Report presents the results of the remedial investigation (RI) conducted at a former fuel cycle facility that is located within 228 acres of property in Hematite, Missouri, and is currently owned by the Westinghouse Electric Company, LLC (WEC). WEC ceased facility operations in June 2001 and is proceeding with Site characterization, remediation, and facility decommissioning. This Report was prepared by Science Applications International Corporation (SAIC) under contract to WEC.

As used throughout this document, the "Hematite Facility" refers to the central portion of the property, encompassing the historic primary operations area, Site Pond and burial pits area (approximately 18 acres) s, while the "Hematite Site" refers to the "Hematite Facility," and other areas which were the focus of this investigation based on potential impacts by previous Facility operations. The term "Property" refers to the entire 228 acres of land owned by Westinghouse.

The objective of this RI is to establish an understanding of the geology, hydrology, and the nature and extent of contamination in surface water, soils, sediment, and groundwater for the Hematite Site. Characterization data collected during the RI are being used in risk assessment studies that will quantify the impact of contamination associated with previous operations on human health and the ecological environment. The results of the baseline risk assessment will be covered under a separate report. Data obtained during this investigation will be used to facilitate development of feasibility studies for selection of appropriate alternatives for remediation. Coupled with process knowledge for the Hematite Facility and known potential source areas for contaminants, this evaluation has led to the development of a conceptual site model (CSM) from which the fate and transport of contaminants in groundwater have been assessed. Finally, the CSM has become the basis from which a groundwater flow and transport model has been constructed and calibrated against empirical data.

The Hematite Facility was originally constructed as the Mallinckrodt Chemical Works in 1955. The Facility became operational in July 1956, producing uranium metals for the nuclear fuel program of the U.S. Navy. Throughout its history, the manufacture of uranium metal and compounds from natural and enriched uranium was the primary activity at the Facility. Operations included the conversion of uranium hexafluoride gas of various ^{235}U enrichments to uranium oxide, uranium carbide, uranium dioxide pellets, and uranium metal. Although uranium material production was the primary function at the Hematite Facility, records indicate secondary activities such as uranium scrap recovery and a limited amount of work with thorium compounds as part of early research into the use of thorium in the fuel cycle. In addition to the nuclear materials processed at the Hematite Facility, there was a variety of non-nuclear chemical products stored on-Site and used in many of the processes. Those with the greatest potential for contaminating surface water, soils, and groundwater at the Hematite Facility because of leaks (from storage tanks or process pipelines) or waste disposal activities (e.g., Evaporation Ponds and the Burial Pits) include strong mineral acids (hydrochloric, hydrofluoric, and nitric) and chlorinated organic solvents [perchloroethylene (PCE) and trichloroethylene (TCE)]. A number of potential "areas of concern" have been identified at the Hematite Site and include those locations where these (and other) potential contaminants were stored, used, and/or disposed.

SUMMARY OF GEOLOGIC AND HYDROLOGIC CONDITIONS

The geologic framework of the Hematite Site is dominated by two key bedrock formations, the Jefferson City-Cotter Dolomite and the Roubidoux Formation (sandy dolostone and sandstone) that underlie the Hematite Site. These formations dip gently toward the northeast. The regional landscape is highly dissected by streams yielding topographic relief in excess of 150 ft locally. The Hematite Facility is built upon terrace/alluvial flood plain sediments overlying bedrock within the valley carved by Joachim Creek, which is located approximately 1000 ft south of the Facility. These sediments include 10 to 20 ft of fine-grain material underlain by 5 to 20 ft of coarser-grain sands and gravels.

In the unconsolidated terrace/alluvial flood plain sediments (herein referred to as the overburden), groundwater flow is chiefly confined to the basal, coarse-grain unit and is in a southeastward direction from the Hematite Facility toward Joachim Creek where it discharges. A groundwater mound is associated with the northeast corner of the Hematite Facility and has a significant impact on the potentiometric surface. Groundwater flow in the upper Jefferson City-Cotter Dolomite appears to be affected by the mounding, and components of flow radiate from the Hematite Facility toward the northeast (along bedding planes) and toward the southeast (in a transmissive zone) within this bedrock unit. Below the Jefferson City-Cotter Dolomite, the current direction of groundwater flow appears to reflect a northeasterly direction, which is consistent with the regional groundwater flow direction in the Roubidoux Formation.

In this RI report, several hydrostratigraphic units (HSUs) in bedrock have been defined. In descending order of depth, these are the Jefferson City-Cotter, Jefferson City-Roubidoux contact zone, and Roubidoux HSUs, respectively.

Vertical head gradients are downward from the shallow to deep overburden. Between the deep overburden, and Jefferson City-Cotter HSU, gradients are downward in the vicinity of the Hematite Facility and generally upward near Joachim Creek. Vertical gradients tend to be upward from the Jefferson City-Cotter HSU and deeper HSUs. However, until approximately mid-2004, this gradient was reversed (i.e., downward) as a result of the significant lowering of heads in the Roubidoux Formation. A possible reason for lower heads in the deeper HSUs was the pumping of groundwater from the Roubidoux Formation by water supply wells in the city of Festus.

SUMMARY OF CONTAMINATION AT THE HEMATITE SITE

Most constituents (radionuclides, metals, and organics) at the Hematite Site are closely associated with the footprint of the Hematite Facility and disposal sites within the Hematite Facility.

Inorganic constituents were elevated in surface soil, soil and groundwater at known waste areas/areas of concern within the Hematite Site. These include: the Evaporation Ponds, Deul's Mountain, soils under the buildings, outdoor areas adjacent to buildings, the Burial Pits and the Site Pond. Because the elevated metals concentrations in the groundwater are localized, this suggests that groundwater migration of inorganics is limited and not as extensive as that of chlorinated solvents. There was no indication of metals contamination in the bedrock groundwater.

Sediment data indicate the presence of some inorganics in the Site Pond, Site Creek and Northeast Site Creek. However, the inorganics were generally not detected in the surface water samples from the Site, suggesting that migration of inorganics through surface water is limited or does not occur.

Technetium-99 (^{99}Tc) and, to a lesser extent, uranium is evident in soils, but contamination is also associated with known waste disposal areas (the Evaporation Ponds, Deul's Mountain, Site Pond, Burial

Pits) and soil underneath process buildings, and even where migration to the subsurface has occurred, there is little or no evidence of lateral migration away from these areas. Comparison of the uranium and ^{99}Tc groundwater data with chlorinated volatile organic compound (VOC) results indicates that the radionuclides have not migrated as extensively as the VOCs.

Several sediment samples from Site Pond were found to contain significant contamination with uranium and ^{99}Tc. However, ^{99}Tc was not detected in any of the surface water samples from the Site. Furthermore, uranium activities in surface water are elevated in the Site Pond but decrease significantly in the Site Creek downstream of the Site Pond dam. These data suggest that there is no to minimal migration of these radionuclides via surface water.

The principal organic contaminants in sediment and soil are PCE and TCE. The distribution of PCE and TCE in the groundwater and soil samples appear to reflect one or more source areas associated with the Hematite Facility and nearby disposal areas, although contaminated soils extend southeastward from the Hematite Facility toward Joachim Creek and probably reflect migration of contaminated groundwater from which sorption to soil organic matter has occurred. Dense, nonaqueous-phase liquid (DNAPL) was confirmed at one location under a building at the Hematite Facility based on elevated concentrations of PCE.

Contamination of groundwater with VOCs is widespread. PCE, TCE, and their degradation products are commonly observed. A number of locations have sufficiently elevated PCE or TCE concentrations to suggest the nearby presence of DNAPL. PCE and TCE plumes in the overburden originate at the Hematite Facility and extend southeastward toward Joachim Creek. One component of contamination in the Jefferson City-Cotter HSU has migrated in a southeasterly direction beneath Joachim Creek; a second component has migrated down dip from the Hematite Facility towards the northeast. Deeper contamination in bedrock only has been confirmed in association with private wells PW-19, PW-16, and PW-06 in a residential community to the southeast of the Hematite Facility across Joachim Creek and with PW-03 located east-northeast of the Hematite Facility. PW-06, PW-16, and PW-19 are no longer used as domestic water supply wells and have been converted to dual-completion groundwater monitoring wells as part of this RI.

Polycyclic aromatic hydrocarbons also are commonly found in surface and subsurface soil samples from on-Site locations. They are common products of combustion of coal and other fuels, and also frequently are associated with asphalt-paving material. Their presence is likely from one or a combination of these sources. Localized occurrences of dioxin, polychlorinated biphenyls, and petroleum contamination also were observed.

The presence of organic constituents in surface water is rarely encountered except for several low-level detections of PCE and TCE downstream from the Hematite Facility. Methylene chloride was also detected in a number of surface water samples but these detections were associated with method blanks, suggesting that the results represent common laboratory contaminants rather than Site conditions.

Biological degradation of PCE and TCE is occurring at the Hematite Site, but appears not to have proceeded past the production of 1,1-dichloroethylene (DCE); *cis*-1,2-DCE; and *trans*-1,2-DCE, except in relatively few samples.

CONCEPTUAL SITE MODEL AND NUMERICAL MODELING

The CSM that was developed for this RI focuses on the following key conclusions:

- Flow and transport in a southeasterly direction within the overburden is facilitated by a hydraulic gradient caused by groundwater mounding under the Hematite Facility and discharge to the surface in Joachim Creek

- With increasing depth below the surface, flow/transport directions gradually shift from southeasterly (overburden), to a blend of southeasterly and a regionally imposed northeasterly component (Jefferson City-Cotter HSU), and finally to a regional northeasterly direction (Jefferson City-Roubidoux contact zone and Roubidoux HSUs)

- Contaminant transport in all geologic units projects back to the footprint of the Hematite Facility (and associated disposal areas) as the ultimate source area

Flow and contaminant migration in bedrock at the Hematite Site may have been potentially impacted by pumping in deep production wells operated by the city of Festus. These wells were operational until the summer of 2003 and caused regionally extensive drawdown in the Roubidoux Formation of up to 50 ft in the vicinity of the Hematite Site. In August 2003, the Jefferson County Water Authority brought online a new production facility that draws water from the sediments marginal to and underlying the Mississippi River using horizontal wells and now provides nearly all of the water needs for the city of Festus and other surrounding communities. Startup of this well permitted Festus to place its four production wells located on the west side of the city on standby. These wells had been pumping approximately 1 million gpd from the lower Roubidoux Formation. Currently, they are used only during periods of peak demand in mid- to late summer, or when the collector well is off-line. When supplementing production from the collector well, the pumping rate on these wells is much less than before August 2003.

In the residential community southeast of the Hematite Facility, a number of private wells were completed open hole, which provided a hydraulic connection between the Jefferson City Dolomite and Roubidoux Formation. Full-capacity pumping of the Festus production wells before the new water facility was brought on line in August 2003 probably impacted contaminant distribution at the Hematite Site in several ways. First, hydraulic stresses in the Roubidoux Formation were transferred to the upper Jefferson City-Cotter Dolomite through these wells (e.g., PW-06, PW-16, and PW-19) and facilitated flow and contaminant migration in the Jefferson City-Cotter HSU from the Hematite Facility to the location of the wells. Secondly, downward flow of groundwater and contaminants in these wells spread contaminants to deeper zones at lower heads imposed by pumping of the Festus production wells. A similar mechanism is responsible for vertical migration of contaminants at PW-03.

Once the Festus wells were placed on stand by, rebound of water levels in the Roubidoux Formation progressed rapidly and the potential for downward flow through the private wells declined. The changes in the hydrologic regime since the Festus production wells were no longer pumping at full capacity will likely eventually eliminate future downward vertical migration of contamination once water levels stabilize in the Roubidoux Formation.

A numerical model was constructed for the Hematite Site by: (1) using the CSM to identify hydraulic boundaries, (2) defining a suite of five layers corresponding to the shallow and deep overburden and the three HSUs in bedrock, and (3) establishing the geometric (e.g., thickness and orientation) and

hydraulic properties for each layer. The flow model was calibrated against water level data obtained during the RI (i.e., following shutdown of both the private residential and Festus city wells). The principal conclusions from the modeling investigation include:

- The shallow groundwater mound in a localized area (northeastern corner) of the Hematite Facility plays a major role in flow/transport in both layers of the overburden as well as in the Jefferson City-Cotter HSU.

- The assignment of reasonable downhole flow rates to the open boreholes in the vicinity of PW-19 is essential for creating the observed transport to the southeast in the Jefferson City-Cotter HSU and is supportive of the CSM.

- Particle tracking suggests that contaminant transport directions for layers responding to either the locally imposed or regional flow systems can be rationalized with observed contaminant distribution patterns. Backward particle tracking from contaminated bedrock wells (BR-08-JC, BR-09-JC, and BR-04-JC) suggest that the Burial Pits are the source of contamination in these wells. Particle travel times vary depending on the location of their release points within the Hematite Facility. Particles "released" within the southwestern part of the Hematite Facility (i.e., the process buildings) tend to have longer travel times towards their discharge point (Joachim Creek) when compared to particles "released" within the northeastern part of the Hematite Facility (i.e., the Burial Pits). This is due to the mounding in the northeastern corner of the Hematite Facility that causes downward migration in this area to the transmissive bedrock formations that are conductive and were assumed to have lower porosities than the overburden.

- Contaminant transport modeling of PCE and TCE in groundwater indicates that sorption and degradation can significantly attenuate contaminant migration such that organic contamination levels can decrease by one to two orders of magnitude within close proximity of the source areas.

- Contaminant transport modeling of uranium in groundwater indicates very limited spreading of contamination from source areas, consistent with what was observed in groundwater sample data. The site-specific partition coefficient for uranium is two orders of magnitude higher than the sorption coefficient for organics, resulting in significantly less migration for uranium in groundwater at the Hematite Site when compared to PCE and TCE.

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