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FINAL USACE/OR/DACW45-1050

GROUNDWATER CHARACTERIZATION REPORT OF 1997/1998 BASELINE DATA FOR THE ST. LOUIS DOWNTOWN SITE

ST. LOUIS, MISSOURI

JULY 1998



U.S. Army Corps of Engineers St. Louis District Office Formerly Utilized Sites Remedial Action Program

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prepared by

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LIST OF ACRONYMS AND SYMBOLS

μg/l	-	micrograms per liter
1,2-DCE	-	1,2-dichloroethene
AI	-	analyte of interest
AMSL	-	above mean sea level
bgs	-	below ground surface
BNI	-	Bechtel National Inc.
Ca	-	calcium
Cl	-	chloride
EPA	-	United States Environmental Protection Agency
$HCO_3 + CO_3$	-	alkalinity
K	-	potassium
MCL	-	maximum contaminant level
MDNR	-	Missouri Department of Natural Resources
MED/AEC	-	Manhattan Engineering District/Atomic Energy Commission
meq/l	-	milliequivalent per liter
Mg	-	magnesium
Na	-	sodium
PCBs	-	polychlorinated biphenyls
PCOCs	-	potential constituents of concern
pCi/l	-	picocuries per liter
RI	-	remedial investigation
RI/FS	-	remedial investigation/feasibility study
SAIC	-	Science Applications International Corporation
SLDS	-	St. Louis Downtown Site
SMCL	-	secondary maximum contaminant level
SO4	-	sulfate
SVOC	-	semi-volatile organic compound
TCE	-	trichloroethene
TDS	-	total dissolved solid
TWG	-	technical working group
VC	-	vinyl chloride
VOC	-	volatile organic compound
USACE	-	United States Army Corps of Engineers

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1.0 INTRODUCTION

1.1 **Purpose and Scope**

This report has been prepared to present the findings and interpretations of ground-water conditions at the St. Louis Downtown Site (SLDS), based on the most recent baseline sampling and data collection effort. This new information in tandem with existing site hydrogeologic information is used to interpret site ground-water flow conditions, identify the distribution of potential constituents of concern (PCOCs), and compare the analytical data to environmental/regulatory levels. No assessment or inference for ground-water analytes, if any, caused by former Manhattan Engineering District/Atomic Energy Commission (MED/AEC) processes has been made in this report. The site ground-water sampling effort was performed by Bechtel National Inc. (BNI) in December 1997 and January 1998. Specifically, the ground-water samples were collected on the following days: December 12, 1997, December 15 through 19, 1997, December 22 to 23, 1997, December 29 to 30, 1997, and January 5, 1998. This effort represented a comprehensive baseline sampling event for radiological and non-radiological constituents, and was the result of recommendations made by the technical working group (TWG) associated with the site.

The task and procedures of the sampling work and other site-related tasks were described in a document entitled "Abbreviated Plan for Providing Baseline Sampling and Data Collection for Groundwater at the St. Louis Downtown Site, St. Louis, Missouri" (November 1997), prepared by SAIC. The objectives of the plan were to gain data for a better understanding of the potential constituents of concern (PCOCs) in site ground water and background ground-water quality conditions. The complete set of field and laboratory data of this sampling event has been provided to United States Army Corps of Engineers (USACE) by BNI as a separate document. In general, the data provided by BNI is in accordance with the sampling plan.

A brief description of the site setting and previous ground-water sampling work is included in the remaining part of Chapter 1.0. The monitoring well network at SLDS is discussed in Chapter 2.0. Chapter 3.0 contains an evaluation of the ground-water potentiometric surfaces and ground-water chemistry data to identify ground-water regimes at the site. The occurrence and distribution of radiological and non-radiological PCOCs in site ground water, as well as a comparison of the new baseline data to historical data, are contained in Chapter 4.0. An evaluation of compliance with the abbreviated sampling plan requirements for the recent sampling work at SLDS is contained in Chapter 5.0. Conclusions regarding the hydrogeology and groundwater chemistry conditions at the site are included in Chapter 6.0.

1.2 Site Setting

SLDS occupies 18.2 hectares (45.0 acres) on the eastern border of St. Louis, Missouri, about five kilometers (three miles) north of downtown, as shown on Figure 1-1. SLDS is located approximately within the area bounded by McKinley Bridge to the north, Angelrodt Street to the



south, North Broadway to the west, and the Mississippi River to the east, as shown on Figure 1-2. A large portion of the property is currently owned by Mallinckrodt, Inc., and includes numerous buildings and facilities which produce various specialty chemical products. Part of the site is surrounded by a security fence. An extensive network of underground utilities exists on the site, including sewer, sprinkler, water, telephone, electric, and natural gas lines (BNI, 1991). The site is covered, for the most part, with buildings and paved surfaces. The elevation at SLDS varies from approximately 128 to 134 meters (420 to 440 feet) above mean sea level (AMSL) from west to east, respectively, and the land surface ranges from 8 to 14 meters (27 to 47 feet) above the elevation of the Mississippi River during normal river stage. In general, the property ground surface is relatively flat.

1.3 Previous Work

Ground-water monitoring wells were installed at SLDS by previous investigators from 1988 to 1992. A total of 17 ground-water monitoring wells exist at SLDS. These wells were installed to identify site stratigraphy and ground-water chemistry, and to determine ground-water migration pathways. Ground-water samples have been collected from the existing wells for both radiological and non-radiological constituents. Ground-water sample collection was conducted from 1988 to 1989. The recent 1997/1998 baseline sampling is the first comprehensive ground-water sampling effort conducted since the 1989 sampling event.

Results of previous ground-water sampling efforts have been presented in various reports. BNI issued a report in 1990 that determined the nature and extent of contamination in soil and ground water and characterized the geologic and hydrogeologic features at SLDS. A work plan for a remedial investigation/feasibility study (RI/FS) was completed in 1991 by BNI, and a remedial investigation (RI) report was completed by BNI in 1994.

2.0 REVIEW OF GROUND-WATER MONITORING WELL NETWORK

The ground-water monitoring well network at SLDS was reviewed and assessed to identify the configuration of the monitoring well system and to determine its adequacy to monitor the important ground-water zones beneath the site. The locations of the monitoring wells at SLDS are shown on Figure 2-1. Geologic and well construction logs were reviewed to determine site stratigraphy and completion/screened depths of site wells. A summary of monitoring well information at SLDS is provided in Table 2-1.

2.1 Stratigraphic Analysis

The generalized stratigraphy beneath SLDS is presented on Figure 2-2. The site stratigraphic profile used in the RI is suitable for the site. These units were interpreted from the lithologies described on the geologic logs. Overall, a fining-upward (sand to clay) sequence of alluvial deposits occurs on top of limestone bedrock beneath SLDS. The amount of the alluvial deposits thicken eastward towards the Mississippi River.

The surficial stratigraphy at SLDS consists of a fill layer composed of wood and coal combustion products, rubble, sand, silt, and clay with varied degrees of compaction. The fill layer ranges in thickness from approximately 0 to 8 meters (0 to 25 feet). Below the Fill Subunit is a mixed layer of predominantly silts and clays, which contain isolated lenses of fine sand. This layer ranges in thickness from 2 to 9 meters (5 to 30 feet). The next underlying stratigraphic layer is composed mostly of sand deposits. This layer is absent beneath the western portion of the site and increases up to 16 meters (54 feet) and more in thickness eastward. Beneath the Fill Subunit and layers of silt, clay, and sand is Mississipian-aged limestone bedrock of the St. Genevieve Formation. The limestone bedrock is shallowest (5.8 meters [19 feet] below ground surface [bgs]) at the western portion of the SLDS and deepens eastward to about 20 meters (80 feet) bgs near the Mississippi River.

Based on the interpretation of site information, three main hydrostratigraphic zones occur beneath SLDS as shown on Figure 2-3. The surficial Fill Subunit and the underlying silts and clays (Upper Stratigraphic Unit) comprise the Upper Hydrostratigraphic Zone. The Fill Subunit may be a separate minor hydrostratigraphic zone within the Upper Zone given its varied composition, different hydraulic conductivity, and other physical parameters relative to the more uniform underlying clay/silt units. The varied properties could cause "perched" saturation at certain locations in the Fill Subunit, which may act as a separate ground-water interval within the Upper Hydrostratigraphic Zone. The Lower Hydrostratigraphic Zone is comprised of the sand deposits of the Lower Stratigraphic Unit and lies between the fine-grained Upper Zone sediments and limestone bedrock. Based on the lithologic descriptions contained on the well logs, the Lower Zone is believed to possess a relatively greater hydraulic conductivity than that of the clay/silt-rich Upper Zone. The limestone bedrock comprises the third hydrostratigraphic zone.



2.2 Monitoring Well Configuration

The 17 monitoring wells at SLDS are completed at various depths. The letter designation "S" and "D" were provided for initial project planning (BNI, 1990) and should not be interpreted as shallow (S) or Upper Zone wells versus deep (D) or Lower Zone wells. An example of this condition is monitoring well B16W03S, which is screened in both the Upper and Lower Zones.

Table 2-1 indicates the stratigraphic units penetrated by the open interval of each monitoring well. Four of the seventeen wells are exposed to both the Fill Subunit and Upper Unit; one well monitors the Upper Unit and Bedrock Unit; one well is exposed to the Upper and Lower Units, and eleven wells are constructed to monitor ground water from either the Upper or Lower Unit (5 wells monitor exclusively the Upper Unit, while 6 wells monitor only the Lower Unit). The interval from the top of the sandpack to the bottom of the well screen is used to determine the representative unit(s) of a well.

3.0 EVALUATION OF GROUND-WATER REGIMES

The ground-water regimes and their flow patterns at SLDS are herein evaluated based on hydrogeologic information that includes potentiometric surface analysis and ground-water chemistry comparisons.

3.1 Potentiometric Surfaces

Potentiometric surface elevations from wells completed in both the Upper and the Lower Hydrostratigraphic Zones were recorded for the SLDS in November/December 1997 and January 1998 as shown in Table 3-1. The depth to ground water ranged between approximately 2 and 10 meters (5 and 34 feet) bgs. Ground-water surface elevation contours were drawn using the 1997 and 1998 data for the Upper and Lower Hydrostratigraphic Zones. The January 1998 ground-water contour maps for the Upper and Lower Hydrostratigraphic Zones (presented as Figures 3-1 and 3-2, respectively), are included to illustrate the most current potentiometric surface elevation conditions. The configuration of both the 1997 and 1998 ground-water potentiometric surfaces of each zone are similar.

Potentiometric surface contours for the Upper and Lower Hydrostratigraphic Zones were constructed using ground-water levels measured in monitoring wells screened exclusively in either the Upper or Lower Zone. Monitoring wells which are exposed to more than one zone were not used in the construction of ground-water potentiometric surface maps because the ground-water level would not be representative of conditions within a distinct zone. Therefore, wells B16W02S, B16W04S, B16W06S, B16W10S, and B16W11S were used to construct the Upper Zone map; wells B16W05D, B16W06D, B16W07D, B16W08S, B16W08D, and B16W09D were used to construct the Lower Zone potentiometric surface map. The remaining wells, which are exposed to more than one hydrostratigraphic zone, are as follows: Fill Subunit and Upper Zone - B16W05S, B16W07S, B16W12S, B16W13SR; Upper and Lower Zones - B16W03S; and Upper Zone and Bedrock - B16W01S.

The potentiometric surface occurs in the Upper Zone beneath most of the site and may occur in the Fill Subunit at certain locations or seasonally during high precipitation periods. Because of the lack of wells completed exclusively in the Fill Subunit and the construction method of wells in the Upper Zone (cased below the upper potentiometric surface) the degree of saturation in the Fill Subunit cannot be determined. Based on the potentiometric surface data, the Fill Subunit may be partially saturated beneath the central portion of SLDS. The potentiometric surface within or above fine-grained sediment in this subunit may reflect perched ground water or ground water restricted from vertical flow.

Buried utilities at SLDS are likely to have an affect on the potentiometric surface of the Upper Zone. Backfill around underground piping may act as conduits to drain shallow ground water towards lower elevations. Leakage also may occur from sewers or water supply piping at the site.



In general, the ground-water flow direction at SLDS is interpreted to be perpendicular to groundwater equipotential contour lines. As such, the Upper Zone ground-water flow is interpreted to be generally eastward toward the river beneath most of the site (Figure 3-1). Only one monitoring well level measurement (B16W06S) exists on the eastern one-third of the site, so interpretations on the direction of ground-water flow on this portion of SLDS are conjectural. The horizontal gradient is approximately 0.027 towards the east on the western two-thirds of the site and is not well defined on the eastern one-third of the site because of incomplete data. Hydraulic connection between the Upper Zone and the Mississippi River is normally isolated during low to normal river stages (BNI, 1990).

The Lower Zone potentiometric surface is illustrated on Figure 3-2. No lower zone potentiometric data exists for the western and southern portions of the site. Beneath the northeastern quarter of the site, the interpreted ground-water flow direction is to the south and west towards an apparent ground-water surface depression at well B16W05D. The horizontal hydraulic gradient is approximately 0.012 towards this Lower Zone depression or trough. This gradient was determined by dividing the difference in hydraulic head between two wells by the lateral distance between the two wells.

The potentiometric surface of the Lower Zone is hydraulically connected to the Mississippi River (BNI, 1990). The general ground-water flow direction in the Lower Zone would, therefore, be expected to be towards the river during low river stage and away from the river during high river stages. The Mississippi River stage (water level elevation) near SLDS was at an elevation of approximately 119 meters (392 feet) AMSL on January 6, 1998. The river stage was rising at approximately 0.85 meters (2.8 feet) per day between January 4 and 9 in response to several days of rainfall. The ground-water flow direction and/or gradient would, therefore, be expected to adjust to the rising river stage at the time of the January ground-water level measurements. Ground-water surface levels used to construct the Lower Zone potentiometric surface man (Figure 3-2) were measured on January 6, 1998, except at wells B16W08S and B16W08D which were measured on January 7, 1998. The potentiometric surface elevations in these two wells were likely approximately 0.85 meters (2.8 feet) lower on the previous day (January 6, 1998). Assuming wells B16W08S and B16W08D exhibited potentiometric surface elevations on January 6, 1998, of 119 meters (391 feet), which is 0.85 meters (2.8 feet) lower than their January 7 elevations, the configuration of the potentiometric surface of the Lower Zone would not be significantly different than the surface shown on Figure 3-2.

Comparisons of the current interpreted piezometric configuration to the previous 1989 configuration (BNI, 1990) indicate different results. The previous interpreted configuration indicates a north-south trending trough in the Upper Zone potentiometric surface near well B16W07D. This trough is absent on the current interpretation (Figure 3-1) primarily because several wells used to construct the 1989 potentiometric surface were not used for the current evaluation for reasons previously described. No comparison of the current Lower Zone piezometric configuration to previous results can be made since the Upper and Lower Zones were contoured together in past reports (BNI, 1990; BNI, 1991; and BNI, 1994).

The vertical head differential between the Upper and Lower Zones is determined to be downward based on data from one well cluster during the baseline sampling event (B16W06S and B16W06D). This location is the only well cluster at SLDS with each well completed exclusively in either the Upper or Lower Zones. All other well clusters partially penetrate more than one hydrostratigraphic zone and, therefore, cannot be used to evaluate vertical gradients. The vertical head differential at the well cluster was 0.94 meters (3.10 feet) and 0.36 meters (1.17 feet), based on the November/December 1997 and January 1998 ground-water level measurements. Vertical gradients or head differentials of previous data were not determined for SLDS, but it is expected that vertical gradients are related to river stage.

3.2 Analysis of Ground-Water Chemistry

As presented in Section 2.0, wells completed in the shallow Fill Subunit, clay, and silt deposits are considered to be in the Upper Hydrostratigraphic Zone, and wells completed in the deeper unconsolidated sands are considered to be in the Lower Hydrostratigraphic Zone. The separation of wells into these two groups is based on a stratigraphic and hydrogeologic analyses and is used in this section to attempt to differentiate ground-water quality between Upper and Lower Hydrostratigraphic Zones.

A mass balance analysis of the major cation and anion concentrations in the baseline groundwater samples collected at SLDS was conducted to determine similarities and/or differences in ground-water composition between various site monitoring wells. The major cations were identified as sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg). The major anions were identified as chloride (Cl), alkalinity (HCO₃ + CO₃), and sulfate (SO₄). These cation and anion suites were considered as major ground-water components based on aqueous concentrations that were typically dominant in each sample.

It must be noted that the anionic ground-water samples were unfiltered, whereas the cation samples were both filtered and unfiltered. Therefore, this evaluation is based on unfiltered ground-water samples. Results of analyses performed on unfiltered samples may reflect the composition of any solid or foreign material present in the sample.

The major cation and anion constituents at each well location for SLDS are plotted as Stiff Diagrams on Figure 3-3. The configuration of each diagram represents the character of ground water sampled from a particular well. The major cations (Na + K, Ca, Mg) are shown to the left of center, and the major anions (Cl, $HCO_3 + CO_3$, SO_4) are shown to right of center. Aqueous concentrations are plotted in milliequivalent per liter (meq/l) units to show sample composition relative to charge balance and the dominant constituents. In general, the relative amounts of cations and anions, or charge balance, should be equal. The charge balance was generally within 10 percent at all well locations except B16W13SR and B16W11S where the charge balance ratio increased to 20 percent. The charge balance analysis of these ground-water samples are presented in Table 3-2. In this evaluation, the ground-water quality data set is presented in its entirety regardless of cation to anion ratios, as an imbalance may suggest an impact to ground-water chemistry. In-situ ground water is theoretically in ionic charge

equilibrium or balance with equal positively charged and negatively charged constituents. Ground water impacted by a contaminant source near a monitoring well may not have reached complete chemical equilibrium due to a relatively short resonance time. A charge imbalance (or a parameter imbalance) may also suggest that ground water originating at different intervals within a saturated zone, containing different ionic species, was combined.

The Stiff Diagrams on Figure 3-3 are ranked in order of increasing Total Dissolved Solid (TDS) concentrations as determined by the sum of the major detected cations and anions. From this ranking, the ground-water quality at these well locations can be divided into three relative categories: Low TDS, Moderate TDS, and High TDS. The secondary maximum contaminant level (SMCL) for TDS is 500 mg/l. Within each of these three categories, the general ground-water quality can be further defined based on the dominant cation--anion relationships, which are shown in Table 3-3. Ca and $HCO_3 + CO_3$ appear to be the dominant constituents overall, but at several well locations, there are increased relative concentrations of Na, K, and Cl, mainly at wells in the Moderate TDS category.

A trilinear diagram of the major cation and anion data is plotted on Figure 3-4. This diagram allows eight major cations and anions to be plotted as a single point on the diamond-shaped field. Wells that are completed in the Upper Zone are shown in red. Wells completed in the Lower Zone are shown in blue. The single well location completed in both the Upper and Lower Zones (B16W03S) is shown in black.

3.2.1 Upper Hydrostratigraphic Zone

The chemical composition of ground water in the Upper Hydrostratigraphic Zone is variable and cannot be characterized into an average overall water type. Ground water in the Upper Zone has both the lowest and the highest TDS concentrations during the baseline sampling event at wells B16W13SR and B16W03S, respectively. As indicated on the trilinear diagram (Figure 3-4), the distribution of ground-water quality relative to the major cations and anions in the Upper Zone does not indicate any particular chemical character. These results suggest that shallow ground water at the site is susceptible to surficial source impact (high TDS), as well as possible dilution or improved ground-water quality (low TDS) from infiltrating precipitation. Even though much of the site is paved as previously mentioned, several areas are unpaved and are susceptible to influences by direct infiltration of precipitation or by preferential conduit flow of precipitation along buried utility lines. Two well cluster locations (B16W06S/B16W06D and B16W07S/B16W07D) exhibit a concentration gradient between the Upper and Lower Zone ground-water quality. The Upper Zone wells, B16W06S and B16W07S, have typically low TDS concentrations, and the lower zone wells, B16W06D and B16W07D, have typically moderate TDS. Again, one possible cause of this characteristic is cation and anion dilution in the shallow ground water as a response to precipitation.

3.2.2 Lower Hydrostratigraphic Zone

Based on the recent baseline data, ground-water composition in Lower Zone wells can be categorized as having moderate TDS, as shown on Figure 3-3. Ground-water quality in these lower zone wells is also more uniform, as shown by the relatively tight cluster of Lower Zone well data on the trilinear diagram of Figure 3-4. Four of the six lower zone wells (B16W06D, B16W07D, B16W08D, B16W09D) have ground-water quality with very similar overall cation and anion compositions. Well B16W08S would plot in the same relative cluster with the other four well locations on the trilinear diagram except for its relatively high sulfate concentration. Well B16W05D would follow a similar Lower Zone character if not for its low relative sulfate and chloride concentrations.

Overall, a general chemical characteristic of ground-water quality for the Lower Zone wells is evident. The dominant cation is Ca with a distinct Ca-Mg-Na+K relative distribution, as shown in the Stiff Diagrams of Figure 3-3. The dominant anion character of the lower zone wells is less distinct, but can be characterized as follows:

- 1. Similar amounts of alkalinity.
- 2. Relatively high sulfate in B16W08S.
- 3. Relatively high chloride in B16W09D, B16W07D, and B16W06D.

Without the relatively elevated concentrations of sulfate and chloride in wells B16W06D, B16W07D, B16W08S, and B16W09D, the cation and anion character of the lower zone wells would be very similar.

3.2.3 Summary

The chemical composition of ground water in the Upper Hydrostratigraphic Zone is variable. Ground water in the Lower Zone exhibits fairly uniform chemical characteristics. No clear chemical distinction of cation/anion parameters is evident between the two zones based on the analysis of 1997/1998 baseline data.



4.0 OCCURRENCE OF GROUND-WATER CONTAMINANTS

The type, occurrence, and distribution of ground-water contamination at SLDS are identified and evaluated in this section. Constituents that are known or suspected to occur in ground water at SLDS based on historical information and ground-water data are initially considered to be analytes of interest (AIs). An assessment is then made to determine potential constituents of concern (PCOCs) in site ground water, based mainly on the detection of AIs in historical ground-water data. The occurrence and distribution of the determined PCOCs are discussed using the 1997/1998 baseline data. A comparison of the PCOCs to historical ground-water data is also presented to help define any changes to chemical concentrations in site ground water occurring over time.

4.1 Potential Constituents of Concern

The baseline ground-water quality data provided by BNI were evaluated and are presented as summary tables in this report. The baseline data were provided with "laboratory" and "review" qualifiers. The data were compiled to a fraction of the original amount based on "Review Qualifiers" which indicate analyte compounds which were detected in a sample. Many compounds, which were analyzed, were not detected. The compounds which were detected above their associated maximum contaminant level (MCL) or SMCL are of primary interest in this evaluation.

Because radiological and inorganic background data for the ground water at SLDS are not available, it is not possible to determine which constituents that occur at trace to low concentrations have impacted the ground water at SLDS. Therefore, MCLs/SMCLs are used herein to determine radiological, organic, and inorganic constituents of concern from a health-based perspective.

4.1.1 Radionuclides

Various radionuclides and their daughter products are associated with SLDS. The radionuclides radium-226, thorium-230, and total uranium ("total" refers to the combined analyses of uranium isotopes U-234, U-235, and U-238) were analyzed in ground-water samples collected from eight monitoring wells on a quarterly basis (four collection events) between July 1988 and April 1989. These and other radionuclides are considered AIs and are presented in Table 4-1 for the baseline data from 1997/1998. These compounds were selected because of their potential presence in the former ore processing materials or in the former waste at SLDS.

Of the nine identified AIs, only total uranium was detected in the 1997/1998 filtered groundwater samples at concentrations exceeding the United States Environmental Protection Agency (EPA) MCLs or SMCLs. The proposed MCL for total uranium is 20 μ g/l. Total uranium is, therefore, considered a PCOC. Primarily, the filtered ground-water samples for radionuclides and metals are being evaluated because the filtered samples represent the dissolved contaminants in ground water which are not influenced by suspended sediment in the sample.



It should be noted that protactinium-231 was detected in three unfiltered ground-water samples (B16W03S, B16W07D, and B16W13SR) at concentrations up to approximately three times its MCL during the recent baseline sampling effort. The MCL for protactinium-231 is 15 picocuries per liter (pCi/l). These samples are not representative of the dissolved radionuclide fraction and are interpreted to contain sediment containing protactinium-231. The filtered ground-water samples for all wells contained concentrations below its detection limit and MCL for this compound. Proactinium-231 is, therefore, not considered a PCOC in ground-water at SLDS.

4.1.2 Non-Radionuclides

Numerous inorganic constituents, as shown in Table 4-1, have been included as analytes of interest due to their potential presence in the former uranium ore processing and associated waste streams and residues. These 25 inorganic parameters were also determined from the 1988/1989 ground-water samples. Six of these inorganic AIs were detected in the 1997/1998 filtered samples at concentrations exceeding MCLs or SMCLs (aluminum, arsenic, chloride, iron, manganese, and sulfate) as shown in Table 4-2. These inorganic compounds are, therefore, considered PCOCs, although they probably occur naturally in site ground water. Ground-water analyses performed historically at SLDS have included priority pollutant volatile organic compounds (VOCs), priority pollutant semi-volatile organics (SVOCs), pesticides/herbicides, and polychlorinated biphenyls (PCBs). Of these analytes, only six VOCs and one SVOC (hexachlorobenzene) were detected in the 1997/1998 samples above their associated MCLs as shown in Table 4-2. None of these VOCs occur naturally in the site ground water, and they are considered PCOCs for ground water at SLDS without evaluation of whether any of these VOCs were used in MED/AEC processes.

4.2 Distribution of PCOCs in Ground Water

The distribution of dissolved radionuclides, dissolved inorganic constituents, and VOCs/SVOCs based on the results of the 1997/1998 baseline ground-water analyses is discussed in this section. Only the previously defined PCOCs are discussed based on exceedances relative to federal and Missouri Department of Natural Resources (MDNR) MCLs for ground water as shown in Table 4-2. The background concentrations of the PCOCs were not estimated due to inadequate background data for ground water at SLDS. With the long history of industrial activity at SLDS and the surrounding area and the limited monitoring well network with no confirmed upgradient background well locations, the estimated background concentrations were not determined; thus, no comparison of detected chemical concentrations to background values are made in this report.

4.2.1 Radiological Data

Elevated dissolved total uranium concentrations above its proposed MCL ($20 \mu g/l$) were detected in ground-water samples from three wells. These exceedances were detected in ground water collected from Upper Zone monitoring wells. Well B16W13SR is completed in both the Fill Subunit and Upper Zone, while wells B16W02S and B16W11S are screened exclusively in the Upper Zone's fine-grained sediment. The highest total uranium concentration was detected in the well B16W02S sample. Well B16W02S is located at the northwestern portion of SLDS near Plant No. 1, which functioned as a research and development and pilot ore processing area (BNI, 1998). Total uranium concentrations in samples collected from the Lower Zone wells were below its MCL. A comparison of filtered and unfiltered baseline sample pairs show similar total uranium concentrations from a well.

The distribution of radionuclides in ground water at SLDS may suggest that the Upper Zone has, to date, retarded the migration of radionuclides above MCLs into the Lower Zone ground water at SLDS. The detection of total uranium in ground-water samples is partially influenced by the Eh and pH of the ground water. Ground water with a lower Eh or pH may have more detectable uranium due to its increased solubility in a reducing or acidic environment. The lateral distribution of dissolved total uranium in ground water at SLDS using the baseline data is illustrated on Figure 4-1.

4.2.2 Non-Radiological Data

Ground water at the site was analyzed for EPA Method 8260 priority pollutant VOCs and EPA Method 8270 semi-volatile organics. Six VOCs and one SVOC were detected above their associated MCLs. 1,2-Dichloroethene (total) (1,2-DCE) was detected above its MCL of 70 μ g/l in three wells (B16W03S, B16W07D, and B16W09D). The locations of these wells are shown on Figure 2-1. The highest 1997/1998 concentration of 1,2-DCE was detected in a ground-water sample collected from B16W03S (340 μ g/l) located near the central portion of SLDS. This well is completed in both the Upper and Lower Zones, whereas the other MCL exceedances for this VOC were from wells completed in the Lower Zone.

Vinyl chloride (VC) was detected above its MCL (2 μ g/l) in four wells (B16W03S, B16W06D, B16W07D, and B16W08D). The highest concentration of VC was detected in the B16W03S sample at 45 μ g/l. Well B16W07D contained VC at a concentration of 21 μ g/l, while the two remaining wells contained VC at concentrations less than 10 μ g/l. Wells B16W06D, B16W07D, and B16W08D are Lower Zone wells located near the eastern site boundary, while B16W03S monitors the Upper and Lower Zones near the central portion of SLDS.

Other detected VOCs at SLDS are benzene, dichloromethane, tetrachloroethene, and trichloroethene (TCE). These compounds were detected at concentrations, in most cases, slightly above their MCLs. Benzene, tetrachloroethene, and TCE were detected in well B16W03S. Dichloromethane was only detected in the well B16W07S sample. Well B16W07D is completed in the Lower Zone, while well B16W03S monitors the Upper and Lower Zones. The only detected SVOC in SLDS ground water is hexachlorobenzene. This compound was detected at 2 μ g/l in well B16W07D, which is slightly above its MCL of 1 μ g/l.

Several inorganic constituents exceeding MCLs were detected in the 1997/1998 ground-water samples collected from SLDS. Elevated concentrations of inorganic constituents may be caused by the coal ash and cinders in the fill material. Of these, dissolved iron and manganese were most prevalent. Iron was detected in 12 of the 17 wells above its SMCL (300 μ g/l), while



manganese was detected above its SMCL (50 μ g/l) in ground water from all wells except well B16W12S. The highest iron and manganese concentrations were detected in well B16W03S at 86,000 μ g/l and 7,280 μ g/l, respectively. The distribution of dissolved iron is shown on Figure 4-2. In general, the iron concentrations increase towards the east in the Upper Zone wells, while the concentrations increase towards the south in the Lower Zone wells. The dissolved iron concentrations in the Lower Zone wells are much higher than in the Upper Zone wells. The manganese concentrations generally increase toward the south in both the Upper and Lower Zones as shown on Figure 4-3. The Upper and Lower Zones exhibit similar dissolved manganese concentrations.

Dissolved aluminum in excess of its SMCL of 200 μ g/l was detected in three wells as shown in Table 4-3. Well B16W07S contained the highest concentration at 637 μ g/l, while ground-water samples from wells B16W02S and B16W03S contained concentrations slightly above the SMCL. These three wells are screened in different zones, so no vertical or horizontal concentration gradient is apparent. The dissolved aluminum concentration in the well B16W07S sample appears anomalous because it exceeds its solubility in water at its field pH value of 6.06.

Dissolved arsenic above its MCL (50 μ g/l) was detected in a ground-water sample collected from one well (B16W06S) at a concentration of 196 μ g/l. This well is completed in the Upper Zone near the northeastern portion of SLDS.

Chloride concentrations at SLDS in excess of its SMCL (250 mg/l) were measured in seven 1997/1998 monitoring well samples at concentrations ranging between 297 and 1,240 mg/l. Figure 4-4 shows the distribution of chloride at SLDS. No vertical or horizontal concentration gradients are apparent. The presence of elevated chloride concentrations at SLDS may be related to road salting activities during the winter. The elevated chloride concentrations in the Lower Zone may suggest natural and/or manmade hydraulic connections between the Upper and Lower Zones.

Sulfate has an MCL of 250 mg/l, according to the current Missouri Code of State Regulations. Ground-water samples from four wells contained sulfate concentrations exceeding this MCL. The highest concentration was detected in a sample from B16W03S (3,670 mg/l), which monitors both the Upper and Lower Zones. The three other samples exhibited similar concentrations (511 mg/l to 756 mg/l) from the Upper and Lower Zones.

4.3 Comparison of Historical Data

Comparisons of the recent 1997/1998 baseline ground-water sampling data to available historic data are made in this section of the report. Previous monitoring of ground water at SLDS (July 1988 through April 1989) included analyses for VOCs, SVOCs, total metals, and total radionuclides. Some variations in concentrations over time in collected ground-water samples may be related or caused by varied ground-water sampling techniques or changes in subsurface conditions such as turbidity or ground-water surface elevation. One important factor that should be noted is that the recent metals and radionuclide analyses presented in this report represent the

"dissolved" and "total" fraction in the samples, whereas the 1988/1989 samples represent total concentrations. The tables for this portion of the report compare both recent dissolved and total concentrations with historical total concentrations.

4.3.1 Radiological Data

A summary of historical and recent total concentrations of total uranium in wells at SLDS is given in Table 4-4. During the 1988/1989 sampling events, only 8 of the currently existing 17 wells were sampled and analyzed for total uranium (BNI, 1990). As indicated in the historical analyses, total uranium was detected at the highest average concentration at well B16W02S (228 $\mu g/l$). The current ground-water sample from well B16W02S also contained the highest total concentration (1,175 $\mu g/l$) of total uranium at SLDS and is greater than 5 times the average historical concentration. One explanation for the greater concentration detected in the recent sample from well B16W02S is that ground water containing a higher total uranium concentration has migrated closer to this well from a nearby source area. Historically, well B16W01S was the only other location where average concentrations of total uranium were detected (6 $\mu g/l$). This value is similar to the result of the recent sample from well B16W01S (4.22 $\mu g/l$). All other historical samples contained total uranium average concentrations below detection limits. These historical results are in agreement with the recent samples analyzed for total uranium.

4.3.2 Non-Radiological Data

The non-radiological data from SLDS consists of VOCs, SVOCs, and inorganic ground-water analyses. The inorganic metals analyses from 1988/1989 were not filtered. The 1997/1998 baseline samples were filtered and unfiltered. The following discussion compares the historical total concentrations with the baseline total concentrations for metals. A comparison of several filtered and unfiltered baseline sample pairs collected from the same well generally indicate similar concentrations.

4.3.2.1 VOCs and SVOCs - Six VOCs and one SVOC (hexachlorobenzene) identified as PCOCs are shown in Tables 4-3 and 4-5. Table 4-5 compares historical maximum VOC and SVOC concentrations to the recent maximum values. Four of the recently identified PCOCs were also detected in the historical samples but at slightly lower concentrations. The compound 1,2-DCE was detected in both historical and recent baseline samples at the highest concentrations of any VOC. Benzene, TCE, and VC were also detected in historical and baseline samples. Dichloromethane (methylene chloride), tetrachloroethene, and hexachlorobenzene were detected in the recent samples but not in the historical samples. The VOC analysis performed on the 1988/1989 samples is EPA Method 8240, while the 1997/1998 baseline samples were analyzed by EPA Method 8260A. Higher detection limits are normally achieved using the 8240 method, which may explain why these three PCOCs were not detected in the historical samples.

Both the historical and baseline samples indicate that the well most impacted by VOCs is well B16W03S. Benzene was the only VOC detected historically in three wells (B16W02S, B16W04S, and B16W06S). Other VOCs/SVOCs detected in ground-water samples from four

wells and blank samples of 1988/1989 were not detected in the baseline sampling results. Well B16W07D is impacted by VOCs and one SVOC based on recent ground-water quality data, whereas VOCs or SVOCs were not previously detected at this monitoring location. Other wells where VOCs or SVOCs were detected above MCLs, based on the recent baseline data, are B16W06D, B16W08D, and B16W09D. Only benzene was detected at a concentration of 9 μ g/l in the historical ground water sample from well B16W06D. Other VOCs and SVOCs were not detected in this sample or the historical B16W08D sample. Well B16W09D was installed after the historical samples were collected, so only recent sample analyses are available.

4.3.2.2 Inorganic - Six inorganic PCOCs, as shown in Tables 4-3 and 4-5, are discussed in this section. Aluminum, arsenic, iron, and manganese concentrations are higher in the 1997/1998 samples compared to the 1988/1989 sampling results. Chloride and sulfate concentrations in some recent samples exceed their respective SMCL/MCL, but are not compared because historical data were not available or did not exist for these two parameters. Aluminum and iron were the only inorganic parameters that were significantly higher in the 1997/1998 samples in comparison to the historical concentrations. Aluminum, arsenic, iron, and manganese were detected in particular historical samples at elevated concentrations. Elevated concentrations of these inorganics are typical for ground-water in Mississippi River alluvial deposits (Miller, 1974). The maximum concentrations of these metals detected in the baseline samples were from different wells in comparison to the historical samples.

4.4 Summary

Ground water of the Upper and Lower Zones beneath SLDS has elevated concentrations of several PCOCs. Ground water in the Upper Hydrostratigraphic Zone contains total uranium, six VOCs, and six inorganic constituents. Total uranium in excess of its MCL is detected only in the Upper Zone. Several VOCs and inorganics above their respective MCLs/SMCLs are found in both the Upper and Lower Zones. One SVOC was detected above its MCL in the Lower Zone.

The highest concentration of total uranium in 1997/1998 is located near the northwestern part of SLDS at well B16W02S, where total uranium concentrations in ground water were higher compared to previous analytical results. This location is the only well where significantly higher total uranium concentrations were detected; all other wells exhibited similar historical versus recent baseline concentrations. Nine of the currently existing seventeen wells at SLDS were installed subsequent to the 1988/1989 sampling events, so historical comparisons cannot be made for these wells.

Several VOCs and one SVOC were detected above their associated MCLs in the baseline sampling results. The predominant VOCs (ones which exceeded their MCL by approximately 5 times) are vinyl chloride, benzene, and 1,2-DCE (total). The only SVOC, hexachlorobenzene, was detected slightly above its MCL. The greatest concentrations, based on historical and recent baseline data, are found in well B16W03S located near the central portion of the site. Other

elevated VOC concentrations were detected in a recent sample from well B16W07D. The VOC concentrations are higher in the recent samples relative to 1988/1989 data.

Six inorganic PCOCs were detected in the ground-water samples at SLDS at elevated concentrations relative to their respective MCLs or SMCLs. Elevated concentrations of these inorganics are common to the alluvial deposits at this site. In the Upper Zone, dissolved iron concentrations increase towards the east. Dissolved iron concentrations are higher in the Lower Zone where it increases from north to south. Dissolved manganese concentrations are distributed uniformly in the Upper and Lower Zones and generally increase in concentration towards the south. Aluminum, iron, and manganese concentrations were higher in the 1997/1998 baseline ground-water samples than in the 1988/1989 samples.

5.0 REVIEW OF ABBREVIATED SAMPLING PLAN REQUIREMENTS

A review of the "Abbreviated Plan for Providing Baseline Sampling and Data Collection for Groundwater at the St. Louis Downtown Site" (Baseline Sampling Plan), dated November 1997, was performed as part of the data validation protocol for this project. The Baseline Sampling Plan was compared to the actual field data collected and to ground-water laboratory analyses. Some concerns about the baseline data could be resolved by examining the original laboratory data reports, if made available. Future work by USACE may address these issues by providing analytically verified and complete data sets. Comments about the proposed ground-water sampling work and associated laboratory data, as presented in the abbreviated plan, follow:

- 1. Ground-water surface levels for the site were measured over a period of three days during the January 1998 measurement event. Because ground-water levels are dynamic and are influenced by the river stage at SLDS, some deviation to the interpreted potentiometric surface maps may have existed compared to the actual configuration of the potentiometric surface.
- 2. The sampling plan recommended that redevelopment of the wells should begin at least two weeks prior to sampling to allow for a sufficient recovery period. The field data indicates that 5 of the 17 wells were sampled less than two weeks after redevelopment, which is not in accordance with the plan. The five wells which were sampled less than 2 weeks after redevelopment are B16W02S (sampled 13 days after redevelopment), B16W03S (sampled 13 days after redevelopment), B16W03S (sampled 13 days after redevelopment), B16W08S (sampled 11 days after redevelopment), and B16W13SR (sampled 6 days after redevelopment). According to BNI, these five wells were sampled before the specified two-week period because stabilization of the water quality parameters occurred in these wells indicating a sufficient recovery period.
- 3. Laboratory analytical reports for this baseline ground-water sampling event were not made available to SAIC. The review and validation of the data set by the laboratory and independent reviewer are assumed to be satisfactory regarding the quality of the data as it relates to holding time exceedances, instrument calibration, analysis of standard solutions, etc.
- 4. The analytical method for total organic carbon listed in the sampling plan is EPA Method 415.2. The method listed in the ground-water data is EPA Method 415.1. The analytical method required by the plan for ammonia is EPA Method 350.1. The method listed in the data base is EPA Method 350.3. The available data set does not clearly indicate the EPA method used for radiological analyses.
- 5. Specific detection limits given in the Baseline Sampling Plan were not always achieved in the reported analytical data. The specified detection limits for volatile organic compounds (VOCs), nitrate/nitrite, phosphate, and alkalinity were not achieved for various



samples. According to BNI, some detection limits specified in the sampling plan were not achieved because they were below the analytical capabilities of the laboratory.

- 6. No information regarding the data validation review was made available to SAIC by the contractor or the laboratory. The review and validation of the data set by the laboratory and independent reviewer are assumed to be satisfactory. It should be noted that several parameter results were qualified as rejected in this data set without an explanation.
- 7. The analytical results of any split samples or other water samples collected by the MDNR or EPA were not provided.
- 8. The analytical results for bromoform, 2-chloroethyl vinyl ether, benzidine, bis(2chloroisopropyl)ether, and 1,2-diphenylhydrazine were not provided in the baseline data set. These analyses were specified in the sampling plan.
- 9. The analytical results for well B16W03S were duplicated, but the laboratory data provided does not indicate if the sample was split and analyzed twice by the laboratory or if blind duplicate samples were submitted in this instance.
- 10. Numerous analyses were reported in the original chemical data base with contradictory qualifiers. For example, numerous analytes reported as "U" (not detected) by the laboratory were not qualified by the reviewers, thus indicating a detection. The converse of this example is reported as well in many instances.

6.0 CONCLUSIONS

Based on existing historical hydrogeologic information and the findings of the 1997/1998 baseline ground-water sampling event at SLDS, the following conclusions have been drawn regarding hydrogeology and ground-water chemistry at the site.

- 1. Three main hydrostratigraphic zones are interpreted to occur beneath SLDS. The Upper Zone is composed of a surficial Fill Subunit and underlying silts, clays, and isolated sand lenses. The Upper Zone ranges in thickness from approximately 2 to 14 meters (5 to 47 feet). The Fill Subunit is considered a separate minor hydrostratigraphic zone within the Upper Zone. The unit beneath the Upper Zone is referred to as the Lower Zone, which is composed mostly of sands. This unit is absent beneath the western portion of the site and is 16 meters (54 feet) thick near the Mississippi River. The third hydrostratigraphic zone is composed of limestone bedrock and lies beneath the Lower Zone and is shallowest 5.8 meters (19 feet) bgs beneath the western portion of SLDS.
- 2. Seventeen ground-water monitoring wells currently exist at SLDS. Five wells penetrate the Upper Zone exclusively; six wells penetrate only the Lower Zone; four wells penetrate the Fill Subunit and Upper Zone; one well penetrates both the Upper and Lower Zones; and one well penetrates the Upper Zone and Bedrock Zone.
- 3. Based on available data, the potentiometric surface is interpreted to occur in the Upper Zone beneath the site. A perched saturated condition may occur in the Fill Subunit at certain locations. The depth to ground water at SLDS ranged between approximately 2 to 10 meters (5 to 34 feet) bgs during the baseline sampling event.
- 4. The ground-water flow direction in the Upper Zone is generally eastward beneath most of the site. The Lower Zone flow directions are defined at the northeastern quarter of the site and flow to the south and west towards an apparent ground-water surface depression near well B16W05D.
- 5. Interpretations of the current potentiometric surface configuration compared to previous results are different. The current potentiometric surface maps were constructed using only ground-water data from wells completed in a distinct hydrostratigraphic zone, whereas the historical maps included data originating from several wells which are exposed to two zones.
- 6. Ground water in the Lower Zone is hydraulically connected to the Mississippi River. The potentiometric surface and ground-water flow directions of this zone vary and are influenced by river stage.



- 7. The potentiometric surface is higher in the Upper Zone than in the Lower Zone beneath the northeastern portion of SLDS.
- 8. The chemical character (cations and anions) of the ground water in the Upper and Lower Zones do not exhibit a discernable chemical character between the two hydrostratigraphic zones.
- 9. Ground water in the Upper Hydrostratigraphic Zone at SLDS contained elevated concentrations of total uranium, six VOCs, and six inorganic constituents. Total uranium and arsenic in excess of their respective MCLs occur exclusively in the Upper Zone.
- 10. Ground water in the Lower Hydrostratigraphic Zone at SLDS contained elevated concentrations of six VOCs, one SVOC, and five inorganic constituents.
- 11. Total uranium in ground water at SLDS was detected at concentrations exceeding its proposed MCL ($20 \mu g/l$) in three Upper Zone wells (B16W02S, B16W11S, and B16W13SR). Total uranium concentrations in the recent samples from the Lower Zone were below its MCL. Recent and historical ground-water quality data indicate that well B16W02S, located at the northwestern area of the site, contains the highest total uranium concentrations.
- 12. The predominant VOCs in ground water at SLDS are vinyl chloride, benzene, and 1,2-DCE. Recent and historical ground-water quality data indicates that well B16W03S, located near the central portion of the site, contains the highest VOC concentrations. VOC concentrations at SLDS are higher in the 1997/1998 baseline samples than in the 1988/1989 samples.
- 13. The only SVOC detected above its MCL in the baseline sampling was hexachlorobenzene. This compound was detected slightly above its MCL in a single Lower Zone well (B16W07D).
- 14. Elevated iron and manganese concentrations were detected in the Upper and Lower Zone ground water at SLDS. Dissolved iron is higher in the Lower Zone. Manganese concentrations are distributed uniformly in the Upper and Lower Zones. Both iron and manganese concentrations at SLDS are higher in the recent baseline samples compared to the 1988/1989 samples. Arsenic was detected at elevated concentrations in only Upper Zone ground water. Three other inorganics (aluminum, chloride, and sulfate) were also detected at elevated concentrations in Upper and Lower Zone ground water.

7.0 **REFERENCES**

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- Miller, D.E., 1974. Water Resources of the St. Louis Area, Missouri, in Water Resources Report 30: USGS and Missouri Geological Survey and Water Resources.
- SAIC, 1997. Abbreviated Plan for Providing Baseline Sampling and Data Collection for Groundwater at the St. Louis Downtown Site, November.
- United States Environmental Protection Agency, Office of Water, 1996. Drinking Water Regulations and Health Advisories, October.

FIGURES



FIGURE 1-1 SITE LOCATION MAP (MODIFIED FROM BECHTEL, 1990)



Figure 1-2 Site Map (MODIFIED FROM HTEL, 1990)

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Figure 2-1 Monitoring Well Location Map

FIGURE 2-2 GENERALIZED STRATIGRAPHIC COLUMN FOR SLDS

Unit Designation	Graphic Column	Approximate Thickness (ft)	Description
Unit		0-25	RUBBLE and FILL Grayish black (N2) to brownish black (5YR2/1). Dry to slightly moist, generally becoming moist at 5-6 ft and saturated at 10-12 ft. Slight cohesion, variable with depth, moisture content and percentage of fines present. Consistency of relative density is unrepresentative, due to large rubble fragments. Rubble is concrete, brick, glass, and coal slag. Percentage of fines as silt or clay increases with depth from 5 to 30 percent. Some weakly cemented aggregations of soil particles. Adhesion of fines to rubble increases with depth and higher moisture content. Degree of compaction is slight to moderate with frequent large voids.
ratigraphic		0-10	Silty CLAY (ML-CL) Layers are mostly olive gray (5Y2/1), with some olive black (5Y2/1). Predominantly occurs at contact of undisturbed material, or at boundary of material with elevated activity. Abundant dark, decomposed organics. Variable percentages of silt and clay composition.
Hydro St		0-5	CLAY (CL) Layers are light olive gray (5Y5/2), or dark greenish gray (5GY4/1). Slightly moist to moist, moderate cohesion, medium stiff consistency. Tends to have lowest moisture content. Slight to moderate plasticity.
Upper		0-2.5	Interbedded CLAY, silty CLAY, SILT and Sandy SILT (CL, CL-ML, ML) Dark greenish gray (5GY4/1) to Light olive gray (5Y6/1). Moist to saturated, dependent on percentage of particle size. Contacts are sharp, with structure normal to sampler axis to less than 15 degrees downdip. Layer thicknesses are variable, random in alternation with no predictable vertical gradiation or lateral continuity. Some very fine-grained, rounded silica sand as stringers. Silt in dark mafic, biotite flakes. Some decomposed organics.
dro : Unit		0-10	Sandy SILT (ML) Olive gray (5Y4/1). Moist with zones of higher sand content saturated. Slight to moderate cohesion, moderate compaction. Stiff to very stiff consistency, rapid dilatancy, nonplastic. Sand is well sorted, very fine and fine-grained rounded quartz particles.
Lower Hyc Stratigraphic		0-50	Silty SAND and SAND (SM, SP, SW) Olive gray (5Y4/1). Saturated, slight cohesion, becoming noncohesive with decrease of silt particles with depth. Dense, moderate compaction. Moderate to well-graded, mostly fine- and medium-grained, with some fine- and coarse- grained particles. Mostly rounded with coarse grains slightly subrounded. Gradual gradation from upper unit, silty sand has abundant dark mafic/biotite flakes. Sand is well-graded, fine gravel to fine sand. Mostly medium-grained, with some fine- grained and few coarse-grained and fine gravel.
Bedrock Unit		Total thickness not penetratcd during drilling	LIMESTONE Light olive gray (5Y4/1) with interbedded chert nodules. Generally hard to very hard; difficult to scratch with knife. Slightly weathered, moderately fresh with little to no discoloration or staining. Top 5 ft is moderately fractured, with 99 percent of joints normal to the core axis. Joints are open, planar, and smooth. Some are slightly discolored with trace of hematite staining.

Note: The codes in parentheses following lithologies are the Unified Soil Classification Systems codes. Source: Modified from BNI 1992

East West Mallinckrodt Plant 1 Mallinckrodt Plant 6 A' A Levee 440 KEY 430 note Water Surfoc 420 Unit 9 Fill 410 Unit 8 Silty Cloy Elevation (feet AMSL) 062 000 000 000 nc u IFLED HYDROSTRATIO Unit 7 Clay and Clay Lense Unit 6 Interbedded Cloys & Silts Including Lense Unit 5 Sandy Silt Unit 4 Silty Sand and Sand Unit 3 Basal Grave 370 LOWER NON-LITHIFTED HYDROSTRATIGRAPHIC UNIT (B) Unit 2 Weathered Lim 360 Unit 1 Limestone BEDROCK UN (TT (C) - AND REAL PROPERTY. 350 Vertical Exaggeration 12.5X 340 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 0 Feet



Figure 2-3 Generalized Cross-Section Illustrating Hydrostratigraphic Units of the SLDS Area



Potentiometric Surface Map of Upper Hydrostratigraphic Zone (1/98)





Potentiometric Surface Map of Lower Hydrostratigraphic Zone (1/98)



Groundwater Chemical Composition



Figure 3-3 (Cont) Groundwater Chemical Composition



Tri-Liner Plot of Major Ionic Species for Upper and Lower Zones



Figure 4-1 1997/98 Dissolved Total Uranium Concentrations in Groundwater



Figure 4-2 1997/98 Dissolved Iron Concentrations in Groundwater



1997/98 Dissolved Manganese Concentrations in Groundwater



Figure 4-4 1997/98 Chloride Concentrations in Groundwater

TABLES

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TABLE 2-1 MONITORING WELL SUMMARY DATA FOR SLDS										
Well Information Construction Parameters					Open Ir	ntervals				
ID No.	Ground	Ground	Type*	Diameter	Grout Depth	S	creen	Sar	d Pack	Monitored Stratigraphic
	(feet MSL)	PVC or Steel	(inches)	(feet bgs)	Top (feet bgs)	Bottom (feet bgs)	Top (feet bgs)	Bottom (feet bgs)	Units**	
B16W01S	426.7	FG/SS	2.4	16.0	18.0	23.0	16.0	24.5	U/B	
B16W02S	420.2	FG/SS	2.4	18.0	20.4	30.7	18.0	33.1	U	
B16W03S	418.8	FG/SS	2.4	20.7	22.6	32.6	20.7	35.7	U/L	
B16W04S	425.5	FG/SS	2.4	19.9	22.2	27.2	19.9	31.3	U	
B16W05S	423.1	SS/SS	4.0	8.0	9.7	19.7	8.0	20.0	F/U	
B16W05D	423.0	FG/SS	2.4	53.7	57.3	67.7	53.7	74.8	L	
B16W06S	424.1	SS/SS	4.0	30.3	32.7	42.5	30.3	43.0	U	
B16W06D	423.5	FG/SS	2.4	66.7	70.2	80.2	66.7	94.2	L	
B16W07S	422.1	SS/SS	4.0	7.8	10.6	20.6	7.9	(22)	F/U	
B16W07D	421.9	FG/SS	2.4	62.2	66.5	76.8	62.2	94.1	L	
B16W08S	422.4	SS/SS	4.0	26.0	27.7	37.7	26.0	38.0	L (top portion)	
B16W08D	423.5	FG/SS	2.4	53.7	59.7	70.1	53.7	80.7	L (bottom portion)	
B16W09D	421.9	FG/FG	2	42.0	44.8	54.8	42.0	61.7	L	
B16W010S	420.6	SS/SS	4.0	12.8	14.2	24.2	12.8	25.0	U	
B16W011S	424.2	SS/SS	4.0	27.0	29.7	39.7	27.0	(41)	U	
B16W012S	427.2	SS/SS	4.0	7.8	9.7	19.7	7.8	20.0	F/U	
B16W013SR	420.5	SS/SS	4.0	6.5	8.7	18.7	6.5	19.0	F/U	

Notes:

1. • Types:

FG - fiberglass SS - stainless steel

- 2. ** Monitored Stratigraphic Units

 - F Fill Subunit (fill/rubble)
 U Upper Unit (clays/silts)
 L Lower Unit (sands)
 B Bedrock Unit (limestone)
- 3. () indicates approximate values due to data discrepancies.

			TAI	BLE 3-1			
	S	UMMARY OF G	ROUND-WAT	ER LEVEL ELEV	VATIONS AT SI	DS	
WELL ID	TOP OF CASING (TOC) ELEVATION (ft AMSL)	MEASUREMENT DATE	MEASURED WATER LEVEL BELOW TOC (ft)	GROUND-WATER LEVEL ELEVATION (ft AMSL)	MEASUREMENT DATE	MEASURED WATER LEVEL BELOW TOC (ft)	GROUND-WATER LEVEL ELEVATION (ft AMSL)
B16W01S	426.5	11/23/97	11.40	415.10	1/6/98	11.30	415.20
B16W02S	419.6	11/23/97	5.48	414.12	1/7/98	5.21	414.39
B16W03S	418.2	11/23/97	10.39	407.81	1/7/98	9.95	408.25
B16W04S	424.8	12/4/97	6.95	417.85	1/6/98	5.86	418.94
B16W05S	423.3	11/23/97	10.99	412.31	1/6/98	11.45	411.85
B16W05D	422.4	11/23/97	33.05	389.35	1/6/98	33.37	389.03
B16W06S	424.2	11/23/97	31.95	392.25	1/6/98	29.45	394.75
B16W06D	423.0	11/23/97	33.85	389.15	1/6/98	29.42	393.58
B16W07S	422.4	11/23/97	10.00	412.40	1/6/98	10.65	411.75
B16W07D	421.3	11/23/97	32.34	388.96	1/6/98	30.28	391.02
B16W08S	422.6	11/23/97	29.72	392.88	1/7/98	28.65	393.95
B16W08D	422.0	11/23/97	32.25	389.75	1/7/98	28.09	393.91
B16W09D	421.4	11/23/97	31.68	389.72	1/6/98	31.05	390.35
B16W10S	421.1	11/23/97	19.45	401.65	1/6/98	19.50	401.60
B16W11S	424.5	11/23/97	32.92	391.58	1/6/98	30.60	393.90
B16W12S	427.6	11/23/97	16.35	411.25	1/6/98	16.90	410.70
B16W13SR	420.3	11/23/97	9.75	410.55	1/5/98	9.45	410.85

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AMSL - Above Mean Sea Level

Approximate Mississippi River stage at SLDS: 11/23/97 = 388.8 ft AMSL; 1/6/98 = 392.2 ft AMSL.

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TABLE 3-2CHARGE BALANCEANALYSIS OF 1997/1998 GROUND-WATER SAMPLES

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Well Locations	B16	W01S	B16	W02S	B 16	W03S	B16	W04S	B16	W05D	B16V	V05S
Parameter	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Sodium (Na)	375.0	16.31	111.0	4.83	1150.0	50.03	447.0	19.44	117.0	5.09	97.6	4.25
Potassium (K)	5.2	0.13	17.3	0.44	168.0	4.30	22.1	0.57	16.8	0.43	92.9	2.38
Calcium (Ca)	375.0	18.71	109.0	5.44	376.0	18.76	267.0	13.32	262.0	13.07	326.0	16.27
Magnesium (Mg)	71.5	5.88	20.8	1.71	69.0	5.68	45.6	3.75	68.5	5.64	64.8	5.33
Chloride (Cl)	1240.0	34.98	84.0	2.37	161.0	4.54	965.0	27.22	197.0	5.56	106.0	2.99
Bicarbonate (HCO ₃)	378.0	6.20	413.0	6.77	330.0	5.41	299.0	4.90	907.0	14.87	1200.0	19.67
Carbonate (CO ₃)	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Sulfate (SO₄)	195.0	4.06	105.0	2.19	3670.0	76.41	42.4	0.88	80.5	1.68	160.0	3.33
Total Dissolved Solids	2,64	0 mg/l	860	mg/l	5, 9 2	4 mg/l	2,08	8 mg/l	1,64	9 mg/l	2,047	mg/l
Cations/Anions	C).9	1	.1	().9		1.1		1.1	1.	1

Well Locations	B16	W06D	B16	W06S	B 16	W07D	B16	W07S	B16	W08D	B16V	V08S
Parameter	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Sodium (Na)	340.0	14.79	27.8	1.21	166.0	7.22	74.9	3.26	134.0	5.83	54.2	2.36
Potassium (K)	19.6	0.50	8.6	0.22	31.3	0.80	24.6	0.63	34.1	0.87	12.5	0.32
Calcium (Ca)	329.0	16.42	136.0	6.79	443.0	22.11	111.0	5.54	359.0	17.91	382.0	19.06
Magnesium (Mg)	82.1	6.76	47.0	3.87	113.0	9.30	19.8	1.63	71.0	5.84	71.7	5.90
Chloride (Cl)	832.0	23.47	46.0	1.30	671.0	18.93	79.0	2.23	371.0	10.47	20.0	0.56
Bicarbonate (HCO ₃)	949.0	15.55	574.0	9.41	908.0	14.88	321.0	5.26	822.0	13.47	623.0	10.21
Carbonate (CO ₃)	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Sulfate (SO₄)	109.0	2.27	0.3	0.01	189.0	3.93	106.0	2.21	194.0	4.04	698.0	14.53
Total Dissolved Solids	2,66	l mg/l	840	mg/l	2,52	21 mg/l	736	mg/l	1,98	5 mg/l	1,861	mg/l
Cations/Anions	C).9	1	.1		1.0		1.1		1.1	1.	1

Well Locations	B16	W09D	B16V	V010S	B16V	W011S	B 16	W12S	B 16V	V13SR
Parameter	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Sodium (Na)	160.0	6.96	462.0	20.10	244.0	10.61	96.2	4.18	28.3	1.23
Potassium (K)	64.5	1.65	98.4	2.52	22.2	0.57	11.2	0.29	17.9	0.46
Calcium (Ca)	332.0	16.57	112.0	5.59	420.0	20.96	160.0	7.98	166.0	8.28
Magnesium (Mg)	99.7	8.20	14.1	1.16	106.0	8.72	15.6	1.28	13.0	1.07
Chloride (Cl)	685.0	19.32	297.0	8.38	42.0	1.18	49.0	1.38	29.0	0.82
Bicarbonate (HCO ₃)	807.0	13.23	562.0	9.21	1110.0	18.19	451.0	7.39	330.0	5.41
Carbonate (CO ₃)	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Sulfate (SO₄)	129.0	2.69	511.0	10.64	756.0	15.74	226.0	4.71	150.0	3.12
Total Dissolved Solids	2,27	7 mg/l	2,056	6 mg/l	2,70	0 mg/l	1,00	9 mg/l	734	mg/l
Cations/Anions	C).9	1	.0	1	.2	1	.0	1	.2

TABLE 3-2 (cont'd)CHARGE BALANCEANALYSIS OF 1997/1998 GROUND-WATER SAMPLES

	GRO	JND-WA S' (decembe	TABLE 3-3 TER CHARA TIFF ANALY ER 1997/JANUAR	ACTERIZA (SIS Y 1998 DATA)	TION	
LOW TDS	(<1500 mg/l)		MODERATE TD	S (1500-3000 m	ng/l)	HIGH TDS (>3000 mg/l)
Ca-HCO3 B16W13SR	N+K+Ca-HCO3 B16W07S	Ca-HCO3 B16W05S	Ca-HCO3+SO4 B16W08S	Ca-HCO3+Cl B16W07D	(Ca+)Na+K-Cl B16W01S	Na+K-SO4 B16W03S
B16WC6S	B16W02S B16W12S	B16W05D	B16W11S	B16W08D B16W09D	B16W04S B16W06D B16W10S	

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TABLE 4-1 ANALYTES OF INTEREST FOR GROUND WATER AT SLDS							
RADIOLOGICAL CONSTITUENT	INORGANIC CHEMICAL CONSTITUENT	ORGANIC CHEMICAL CONSTITUENT					
Actinium-227	Aluminum	Priority Pollutant Volatile					
Lead-210	Antimony	Organics					
Protactinium-231	Arsenic						
Radium-226	Barium	Priority Pollutant					
Radium-228	Beryllium	Semivolatile Organics					
Thorium-228	Boron						
Thorium-230	Cadmium						
Thorium-232	Calcium						
Total Uranium	Chromium						
	Cobalt						
	Copper						
	Iron						
	Lead						
	Magnesium						
	Manganese						
	Molybdenum						
	Nickel						
	Nitrate						
	Potassium						
	Selenium						
	Silver						
	Sodium						
	Sulfate						
	Vanadium						
	Zinc						

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	TABLE 4-2 radiological and chemical anal	YTES
	WITH REGULATORY CONCENTRATION FOR GROUND WATER AT SLDS	DNS,
ANALYTE TYPE	ANALYTE NAME	EPA-MCL/SMCL (ug/l)
RADIONUCLIDES	TOTAL URANIUM	20
VOCs/SVOCs	1,2-DICHLOROETHENE (TOTAL)	70
	BENZENE DICHLOROMETHANE	5
	VINYL CHLORIDE	2
	TRICHLOROETHENE	5
• •	HEXACHLOROBENZENE	· · . 1 ·
INORGANICS	ALUMINUM	200
	ARSENIC	50
	IRON	300
•	MANGANESE	50
·	CHLORIDE	250,000
	SULFATE	250.000(MO MCL)

NOTES:

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MCL-Maximum Contaminant Level

SMCL-Secondary Maximum Contaminant Level

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TABLE 4-3
SUMMARY OF DETECTIONS ABOVE RESPECTIVE
MCLs/SMCLs IN GROUND WATER AT SLDS

ANALYTE TYPE	WELL NAME	ANALYTE NAME	RESULT	UNITS	EPA MCL/SMCL
RADIONUCLIDES	B16W11S	TOTAL URANIUM	71.71	UG/L	20
	B16W13SR	TOTAL URANIUM	137.25	UG/L	
	B16W02S	TOTAL URANIUM	1187.54	UG/L	
VOCs/SVOCs	B16W09D	1.2-DICHLOROETHENE (TOTAL)	98	UG/L	70
	BI6W07D	1.2-DICHLOBOETHENE (TOTAL)	120		
	B16W03S	1.2-DICHLOROETHENE (TOTAL)	340		
	B16W03S	BENZENE	33		5
	B16W07D	DICHLOROMETHANE	13	UG/L	5
	B16W03S	TETRACHLOROETHENE	7	UG/L	5
	BI6W03S	TRICHLOROETHENE	13	UG/L	5
	B16W06D	VINYL CHLORIDE	3	UG/L	2
	B16W08D	VINYL CHLORIDE	7	UG/L	_
	B16W07D	VINYL CHLORIDE	21	UG/L	
	B16W03S	VINYL CHLORIDE	45	UG/L	
	B16W07D	HEXACHLOROBENZENE	2	UG/L	1
INORGANICS	B16W03S	ALUMINUM	208	UG/L	200
	BI6W02S	ALUMINUM	245	UG/1	200
	BI6W07S	ALUMINUM	637		
	BI6W06S	ARSENIC	196	UG/1	50
	BIGWIOS	CHLORIDE *	297	00/L	250
	BI6W08D	CHLORIDE *	371	MG/L	250
	B16W07D	CHLORIDE *	671	MG/L MG/L	
	B16W09D	CHLORIDE *	685	MG/L	
	B16W06D	CHLORIDE *	832	MG/L	
	B16W04S	CHLORIDE *	965	MG/L	
	BI6W0IS	CHLORIDE *	1,240	MG/L	
	BI6W04S	IRON	958	UG/L	300
	B16W08S	IRON	2,690	UG/L	
	BI6WIIS	IRON	4,010	UG/L	
	B16W05S	IRON	15,100	UG/L	
	B16W06S	IRON	16,100	UG/L	
	BI6W06D	IRON	18,200	UG/L	
	B16W05D	IRON	26,400	UG/L	
	BI6W09D	IRON	29,200	UG/L	
	BI6W07D	IRON	38,500	UG/L	
	BI6W08D	IRON	38,900	UG/L	
	B16W07S	IRON	50,200	UG/L	
	BI6W03S	IRON	86,000	UG/L	
	BI6WI3SR	MANGANESE	151	UG/L	50
	BI6W0IS	MANGANESE	230	UG/L	
	B16W06S	MANGANESE	349	UG/L	
	B16W06D	MANGANESE	I,130	UG/L	
	B16W09D	MANGANESE	1,140	UG/L	
	BI6WI0S	MANGANESE	1,380	UG/L	
	B16W08S	MANGANESE	1,560	UG/L	
	B16W05D	MANGANESE	1,750	UG/L	
	B16W07S	MANGANESE	1,840	UG/L	
	BI6WIIS	MANGANESE	2,130	UG/L	
	B16W08D	MANGANESE	2,890	UG/L	
	BI6W07D	MANGANESE	3,120	UG/L	
	B16W05S	MANGANESE	3,330	UG/L	
	B16W02S	MANGANESE	3,580	UG/L	
	BIOW04S	MANGANESE	3,780	UG/L	
	B16W03S	MANGANESE	7,280	UG/L	00000000000
	BIOWIOS	SULFAIL *	511	MG/L	250(MO MCL)
	BIOWU85	SULFAIE +	098	MG/L	
	B10W115	SULFAIE +	2 670	MG/L	1
	1 0100033	BULFAIE *	3,0/0	MO/L	

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NOTES:

*** indicates Chloride and Sulfate analytes were unfiltered and represent "total" concentrations; all radionuclides and remaining inorganics were filtered and represent "dissolved" concentrations.

	TABLE 4-4				
COMPARISON OF HISTORICAL AND RECENT TOTAL URANIUM					
	CONCENTR	ATIONS IN GROUN	D WATER AT SLDS		
SAMPLE LOCATION	ASSOCIATED STRATIGRAPHIC UNIT *	1988/1989 AVERAGE "TOTAL" CONCENTRATION (ug/l)	1997/1998 "TOTAL" CONCENTRATION (ug/l)	1997/1998 "DISSOLVED" CONCENTRATION (ug/l)	
B16W05S	F/U		1.62	1.60	
B16W07S	F/U		0.24	0.33	
B16W12S	F/U		6.29	6.23	
B16W13SR	F/U		121	137	
B16W02S	U	228	1,175	1,187	
B16W04S	U	<4	7.48	1.74	
B16W06S	U		< 0.03	< 0.03	
B16W10S	U		3.69	4.12	
B16W11S	U		49.9	71.7	
B16W01S	U/B	6	4.22	5.42	
B16W03S	U/L	<4	7.39	4.84	
B16W05D	L	<4	0.22	< 0.03	
B16W06D	L	<4	0.3	< 0.03	
B16W07D	L	<4	2.45	2.00	
B16W08S	L(top)	'	1.62	1.56	
B16W08D	L(bottom)	<4	0.38	0.34	
B16W09D	L		< 0.03	< 0.03	

Notes:

1988/1989 average concentration based on four analytical results from each well.

-- = not analyzed; well did not exist at time of sampling.

* = monitored stratigraphic unit:

F - Fill Subunit (fill/rubble)

U - Upper Unit (clays/silts)

L - Lower Unit (sands)

B - Bedrock Unit (limestone)

TABLE 4-5				
COMPARISON OF HISTORICAL AND RECENT DETECTED				
CONCENTRATIONS IN GROUND WATER AT SLDS				
ANALYTE TYPE	ANALYTE NAME	1988/89 MAXIMUM "TOTAL" CONCENTRATION (ug/i)	1997/98 MAXIMUM "TOTAL" CONCENTRATION (ug/l)	1997/98 MAXIMUM "DISSOLVED" CONCENTRATION (ug/l)
RADIONUCLIDES	TOTAL URANIUM	272	1,175	1,188
VOCs/SVOCs	1,2-DICHLOROETHENE (TOTAL)	150	340	*
	BENZENE	21	33	*
	DICHLOROMETHANE		13	*
	TETRACHLOROETHENE		7	*
	TRICHLOROETHENE	5	13	*
	VINYL CHLORIDE	29	45	*
	HEXACHLOROBENZENE		2	*
INORGANICS	ALUMINUM	400	31,200	637
	ARSENIC	126	203	196
	IRON	20,800	93,200	86,000
	MANGANESE	4,520	7,440	7,280
	CHLORIDE		1,240,000	*
	SULFATE		3,670,000	*

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NOTES:

" -- " indicates historical data not available.

" * " indicates analyte reported as "total" concentration only.

Mallinckrodt Inc. Comments on the Preliminary Draft Groundwater Characterization Report of 1997/1998 Baseline Data for the St. Louis Downtown Site, St. Louis, Missouri, May 1988

Page 1, para 3: Mallinckrodt does not operate underground process piping.

- Page 3, para 6: Mallinckrodt recommends that the wells which are screened in both the Upper and Lower hydrostratigraphic zones be abandoned and closed. These wells create a communication channel between the Upper and Lower Zones. Abandoning the wells will eliminate this channel and act to protect the Lower Zone. As the wells are screened in both zones, analytical results cannot be clearly attributed to either and are therefore of limited value in describing the current or future subsurface conditions.
- Page 5, para 5: Revise the last sentence to state: Previous piezometric data (BNI 1990) demonstrate the absence of a direct hydraulic connection between the Upper Zone and both the Lower Zone and the Mississippi River.
- Page 6, para 2: Revise the first sentence. It is the Lower Zone, not the monitoring wells completed in it, that is hydraulically connected to the Mississippi River.
- Page 7, para 3: Comparison of concentration data to Secondary MCLs may be inappropriate for several reasons:
 - 1. Background concentrations have not been determined and the appropriate corrections have not been made.
 - 2. The Lower Zone is subject to saline groundwater intrusion from bedrock. This may result in naturally elevated inorganic concentrations.
 - 3. The characteristics of fill give rise to potentially elevated and highly variable concentrations.
 - 4. SMCLs are unenforceable guidelines regarding aesthetic values (taste, color, etc.) and are not appropriate measures of water quality, particularly in the absence of background reference concentrations.
- Page 7, para 5: Mallinckrodt and others typically refer to the Upper Zone as a perched zone. It is essentially an accumulation of water in fill material atop a low permeability layer of floodplain alluvium. The Upper saturated zone would not exist were it not for the existence of the fill and the low permeability material beneath it. We believe this is an important characteristic of the Upper Zone and recommend that it be identified and described in the report.
- Page 7, para 5: The sentence beginning "These results suggest..." is speculative and ignores the potential contribution of fill constituents to the observed concentrations of TDS and other inorganic analytes. Mallinckrodt recommends that the sentence be deleted or alternate interpretations be presented.
- Page 10, para 2: Installation of one or more upgradient or off-site wells is recommended so that the background concentrations can be established and monitoring results appropriately interpreted.

Page 10, para 3: Mallinckrodt agrees that historic monitoring data (BNI 1990) substantiate the retardation of migration and lack of direct hydraulic communication between the Upper and Lower Zones.

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- Page 11, para 6: Insert a comment that elevated organic and inorganic concentrations may be due to the coal ash and cinders in fill. As discussed elsewhere in these comments, an upgradient background well would provide valuable information in interpreting the significance of these data.
- Page 11, para 7: Mallinckrodt believes that the expected variability of constituent concentrations and the inherent variability in sampling and analytical techniques make comparisons of the two data sets speculative and potentially misleading. Evaluation of data collected in additional sampling events is required before constituent concentrations can be reliably determined and trends assessed. Mallinckrodt recommends that a statement to this effect be included in this paragraph.
- Page 12, para 2: The sentence beginning "Iron was the only inorganic..." is inconsistent with the data presented in Table 4-5. Provide supporting data or delete the sentence.
- Page 14, 15: Mallinckrodt believes that the groundwater analytical results, particularly those for the Lower Zone are problematic. Two specific data quality issues are of concern to Mallinckrodt: the potential that improper well installation has resulted in vertical cross contamination between the Upper and Lower Zone, and the potential that reported concentrations may represent laboratory contaminants instead of groundwater constituents. The first issue can only be addressed by abandonment and replacement of wells that straddle the Upper and Lower Zones and by performance of additional sampling events over an extended period of time. The second issue should be addressed by the completion and documentation of data validation to ensure that the specified constituents were indeed detected at the reported concentrations.
- Page 16, No. 9: Revise first sentence to read: "Groundwater data from the Upper Hydrostratigraphic Zone at SLDS indicates total uranium, six VOCs, one SVOC, and six inorganic constituents above established MCLs, prior to correction for background concentrations.
- Page 16: Add a conclusion before item number 6 that the Upper and Lower Zones are separated by a low permeability layer which limits hydraulic communication between the two zones and retards downward migration of constituents into the Lower Zone.
- Page 16: Add a conclusion that one or more upgradient background wells are required to allow meaningful interpretation of the data.
- Figure 3-2: Mallinckrodt questions whether the single water level measurement at B16W09D is sufficient to justify the curvature and closure of the contours depicted in Figure 3-2. Conventional models of groundwater flow in the alluvium would suggest that the contours would more closely parallel the river.

Table 4-3As discussed elsewhere in these comments, meaningful interpretation of inorganic
constituent concentrations cannot be performed without comparison to background
concentrations. In addition, comparison to SMCLs is inappropriate.

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