

DOCUMENTATION OF ENVIRONMENTAL INDICATOR DETERMINATION

**RCRA Corrective Action
Environmental Indicator (EI) RCRA Info code (CA750)
Migration of Contaminated Groundwater Under Control**

Facility Name: Clariant LSM Missouri, Inc.
Facility Address: 2460 W. Bennett St., Springfield, Missouri, 65807
Facility EPA ID #: MOD095038329

1. Has **all** available relevant/significant information on known and reasonably suspected releases to the groundwater media, subject to RCRA Corrective Action (e.g., from Solid Waste Management Units (SWMU), Regulated Units (RU), and Areas of Concern (AOC)), been **considered** in this EI determination?

If yes - check here and continue with #2 below.

If no - re-evaluate existing data, or

if data are not available, skip to #8 and enter "IN" (more information needed) status code.

The Clariant LSM Missouri Inc. (Clariant) facility is located on about 63 acres in Springfield, Missouri (see Figure 1). The facility has gone through a number of ownership changes since it was opened by Hoffman-Taff Chemical Company around 1949. In 1969, the facility was purchased by Syntex Agribusiness Inc. (Syntex), which expanded the facility from 7.4 acres to 63 acres in 1988 (Syntex 1996). Most facility manufacturing operations have been confined to the original property, with Jordan and Wilson Creeks forming the eastern and southern borders, respectively. Buildings in the expansion area include offices and an idle manufacturing building (Syntex 1996). Syntex became Archimica (Missouri) Inc. in 1999 and Clariant in 2000 (Archimica 2000; Clariant 2001). Since 1949, the facility has manufactured, stored, and recovered a range of chemicals (Syntex 1996). Manufacturing processes have included extraction of hormone; production of vitamins, vitamin precursors, and food additives; manufacture of herbicides (including 2,4,5-trichlorophenol and hexachlorophene); and production of pharmaceutical ingredients, bromides and organic bromides, catalysts, and other chemicals (Syntex 1996). The manufacture of herbicides produced dioxin (2,3,7,8-TCDD) as a by-product (Syntex 1996). Since 1965, Clariant also has operated a wastewater treatment plant (WWTS) that discharges to the municipal, publicly-owned, treatment works (POTW) (Syntex 1996). The facility holds a National Pollutant Discharge Elimination System (NPDES) permit, issued in October 2003, for discharging non-contact cooling water and storm water (U.S. Environmental Protection Agency [EPA] 2004).

The Clariant facility has been monitored and investigated since at least 1983, when the facility began investigating possible groundwater contamination in conjunction with closure and remediation of an on-site surface impoundment (Syntex 1996). Syntex entered into a consent order with EPA in 1989 that required the facility to conduct a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) to determine the nature and extent of releases from 11 solid-waste management units (SWMU) at the facility (Syntex 1996) (see Figure 2). The RFI began in 1992 and included four years of investigations with EPA and the Missouri Department of Natural Resources (MDNR) (Syntex 1996). The facility also began operating a pump and treat interim measures groundwater remediation system (IM system) as a requirement of the consent order (Syntex 1996). Since the RFI, the facility has investigated the physical hydrogeology of the area, and has continued to monitor groundwater and surface water (Duke Engineering & Services 1999; Archimica 2000; Clariant 2001, 2002GW, 2003GW). The facility completed the final draft of its Corrective Measures Study in 2002 (Clariant 2002CMS). Primary contaminants released to soil and groundwater from Clariant's SWMUs are volatile organic compounds (VOC), semivolatile organic compounds (SVOC), organic and inorganic bromides, and dioxin. The following paragraphs are SWMU descriptions.

Former Chemical Sewer Lines (FCSL). Liquid chemical wastes were routed from manufacturing areas primarily via the FCSLs during the facility's operation (Syntex 1996). Composed of a vitrified clay pipe and fiberglass mix with

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variable resistance to acids, the FCSLs carried VOCs, phenols, dioxin, and corrosive chemicals (Syntex 1996). Before 1958, the FCSLs emptied into a ditch on the western boundary of the property. After 1958, the FCSLs were routed to the former surface impoundment. After 1965, the FCSLs were routed to the WWTS aeration basin (Syntex 1996). In 1984, the FCSLs were remediated for dioxin. They were replaced with overhead lines by 1989 (Syntex 1996). The FCSLs are considered a likely source of groundwater and soil contamination, and the area around the lines remains contaminated with VOCs, SVOCs, and bromides (Syntex 1996).

Former Surface Impoundment (FSI). The unlined FSI was constructed in clay-rich alluvium in 1960 as a settling pond for plant wastewater (Syntex 1996). Before 1965, the FSI emptied directly into Jordan Creek. However, in 1965, the wastewater treatment system was installed, and the outflow from the FSI was directed to the municipal publically owned treatment works (POTW) (Syntex 1996). The southern half of the FSI was closed in 1975 by backfilling with native soil, while leaving 500 tons of sludge in place (Syntex 1996). The remaining portion of the FSI was used until 1982. In 1985, the FSI was remediated by excavation and filled in with compacted clay. A French drain and sump were installed to collect groundwater, which was pumped to the facility groundwater treatment system (Syntex 1996). The FSI is considered a likely source of groundwater and soil contamination, and the area around the lines remains contaminated with VOCs, SVOCs, and bromides (Syntex 1996). Sludge collected during closure contained VOCs, SVOCs, organometallic compounds, metals, pesticides, and dioxin, (Syntex 1996). In addition, two historic floods breached the FSI wall, causing discharge to surface-water bodies (Syntex 1996).

Wastewater Treatment System (WWTS). The facility first used the original WWTS in 1960 to receive wastewater directly from the FCSLs; the WWTS originally consisted of a brick-lined settling pit with area of 10 feet by 10 feet and depth of 12 feet (Syntex 1996). An aeration basin added in 1965 received wastewater from the settling pit and the FSI. In 1974, neutralization and equalization cells were added to treat wastewater further before discharge to the municipal POTW (Syntex 1996). The original WWTS was decommissioned and decontaminated in 1983 when dioxin was detected (Syntex 1996). A new WWTS was built in 1989 when the FCSLs and the aeration basin were closed. The new WWTS consists of a 30,000-gallon aboveground tank that discharges to the POTW (Syntex 1996). The old brick-lined settling pit is considered a likely source of groundwater and soil contamination, and the area remains contaminated with VOCs and SVOCs (Syntex 1996).

Site Sewer Lines (SSL). The SSLs consist of at least four primary SSLs, three of which have been in service since about 1965 (Syntex 1996). Three lines at first transported untreated wastewater and later conveyed treated wastewater from the WWTS to the municipal POTW. Of these three lines, only one is currently in use. The fourth line transported treated groundwater from the groundwater treatment system (Syntex 1996). Additional short segments of abandoned lines of unknown origins and dates of use have been discovered at the facility (Syntex 1996). Two of the older site sewer lines are considered likely sources of groundwater and soil contamination, and the area is contaminated with VOCs, SVOCs, and bromides (Syntex 1996).

West Ditch/Retention Basin/NPDES Outfall (WWDS). The West Ditch area historically was used for process and storm water discharge (Syntex 1996). During Hoffman-Taff operations, liquid and solid process waste also was dumped in the area (Syntex 1996). With construction of the FSI and the FCSLs, use of the West Ditch area decreased substantially after 1960. In 1972, it was paved with concrete and used to receive storm water and boiler blow-down water through a NPDES-regulated outfall. In early 1980s, it was covered with concrete culvert pipe, which is still in use for storm water discharge (Syntex 1996). The concrete culvert pipe originally discharged into an uncovered wastewater detention structure (WWDS). In 1993, a larger WWDS was constructed (Syntex 1996). Waste disposal areas in the West Ditch area are considered likely sources of groundwater and soil contamination, but the short period of use and "limited chemicals" disposed of there reduce the level of concern (Syntex 1996). Soil-vapor and soil sampling indicated no evidence of chemical release or impact other than very low SVOC concentrations in soil (Syntex 1996).

Solvent Recovery Areas (SRA). The facility reclaimed methanol and toluene in these areas from 1955 to 1988. Solvents now are recovered within individual manufacturing operations (Syntex 1996). The SRAs also were used for steam cleaning sodium cyanide drums (Syntex 1996). Soil-vapor and soil sampling indicated no evidence of chemical release or impact other than very low SVOC concentrations in soil (Syntex 1996).

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Waste Solvent Tanks (WST). The WSTs primarily contained toluene until about 1975, and methanol (Syntex 1996). The tanks were contained within secondary containment dikes some time in the 1970s (Syntex 1996). Soil-vapor and soil sampling indicated no evidence of chemical release or impact (Syntex 1996).

Drum Storage Areas (DSA). Drums of waste and raw materials have been stored all over the facility, but the RFI identified two primary DSAs. One was used in the 1950s to store drums of chloroform. The other is the current DSA, an interim status unit where drums are held on a concrete slab with a sump. This DSA is used for hazardous waste that is disposed of off site (Syntex 1996). Soil-vapor and soil sampling indicated no evidence of chemical release or impact other than very low SVOC concentrations in soil (Syntex 1996).

Interim Storage Pad (ISP). The ISP is an interim status unit constructed as a soil staging area during excavation of the FSI (Syntex 1996). It consists of a concrete slab with a curb and liner (Syntex 1996). The ISP also has been used for containerized waste (Syntex 1996). Soil-vapor sampling indicated no evidence of chemical release or impact (Syntex 1996).

Sludge Storage Facility (SSF). The SSF is an interim status unit constructed for the single purpose of providing secure storage until sludge removed from FSI could be disposed of (Syntex 1996). The aboveground concrete structure consists of a concrete slab, liner, and leachate collection system (Syntex 1996). The SSF was used from 1985 until 1988. It subsequently was decontaminated, and its closure was approved in 1994 (Syntex 1996). Soil-vapor sampling indicated no evidence of chemical release or impact (Syntex 1996).

Groundwater Treatment System (GWTS). Since 1983, the GWTS has separated groundwater and dense nonaqueous phase liquid (DNAPL) pumped as part of the IM system (Syntex 1996). At the time of the RFI, it treated about 250,000 gallons of combined groundwater and DNAPL each month (Syntex 1996). Soil-vapor sampling indicated no evidence of chemical release or impact (Syntex 1996).

BACKGROUND

Definition of Environmental Indicators (for the RCRA Corrective Action)

Environmental Indicators (EI) are measures being used by the RCRA Corrective Action program to go beyond programmatic activity measures (e.g., reports received and approved, etc.) to track changes in the quality of the environment. The two EI developed to-date indicate the quality of the environment in relation to current human exposures to contamination and the migration of contaminated groundwater. An EI for non-human (ecological) receptors is intended to be developed in the future.

Definition of "Migration of Contaminated Groundwater Under Control" EI

A positive "Migration of Contaminated Groundwater Under Control" EI determination ("YE" status code) indicates that the migration of "contaminated" groundwater has stabilized, and that monitoring will be conducted to confirm that contaminated groundwater remains within the original "area of contaminated groundwater" (for all groundwater "contamination" subject to RCRA corrective action at or from the identified facility (i.e., site-wide)).

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Relationship of EI to Final Remedies

While Final remedies remain the long-term objective of the RCRA Corrective Action program the EI are near-term objectives currently being used as Program measures for the Government Performance and Results Act of 1993 (GPRA). The “Migration of Contaminated Groundwater Under Control” EI pertains ONLY to the physical migration (i.e., further spread) of contaminated ground water and contaminants within groundwater (e.g., non-aqueous phase liquids or NAPLs). Achieving this EI does not substitute for achieving other stabilization or final remedy requirements and expectations associated with sources of contamination and the need to restore, wherever practicable, contaminated groundwater to be suitable for its designated current and future uses.

Duration / Applicability of EI Determinations

EI Determinations status codes should remain in RCRA Info national database ONLY as long as they remain true (i.e., RCRA Info status codes must be changed when the regulatory authorities become aware of contrary information).

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2. Is **groundwater** known or reasonably suspected to be “**contaminated**”¹ above appropriately protective “levels” (i.e., applicable promulgated standards, as well as other appropriate standards, guidelines, guidance, or criteria [e.g., Maximum Contaminant Levels (MCLs), the maximum permissible level of a contaminant in water delivered to any user of a public water system under the Safe Drinking Water Act]) from releases subject to RCRA Corrective Action, anywhere at, or from, the facility?

 X If yes - continue after identifying key contaminants, citing appropriate “levels,” and referencing supporting documentation.

_____ If no - skip to #8 and enter “YE” status code, after citing appropriate “levels,” and referencing supporting documentation to demonstrate that groundwater is not “contaminated.”

_____ If unknown - skip to #8 and enter “IN” status code.

Rationale and Reference(s):

The Clariant facility is located on about 63 acres in Springfield, Missouri, in an industrial-zoned rural area (see Figure 1) (Syntex 1996). The surrounding land is used for a mix of residential, commercial, and light industrial activities (Syntex 1996). Railroad tracks and a railroad easement form the western boundary of the northern half of the property, and a public park is immediately west of the railroad tracks (Syntex 1996). A concrete manufacturer and small residential properties form the western boundary on the southern half of the property (Syntex 1996). Undeveloped land and small commercial businesses are north of Bennett Street, which is the northern property boundary (Syntex 1996). A trash transfer station forms the eastern boundary of the northern part of property, and undeveloped land and multi-family housing lie to the southeast (Syntex 1996). Sunshine Avenue is the southern boundary, but the operational areas of the facility are bounded on the south by undeveloped land within the Clariant property lines (Syntex 1996). A nearby sewage treatment plant and solid waste disposal unit may have contained hazardous constituents, but the regional impact of these other contamination sources on groundwater in the area was not investigated during the RFI (Syntex 1996).

The Clariant facility sits in the alluvial flood plain formed by the Jordan, Fassnight, and Wilson Creeks—perennial streams that flow through the property (Syntex 1996). However, site buildup and flood walls have prevented flooding of the facility, and extensive excavation and regrading at the facility have redirected the streams (Syntex 1996). The creeks receive storm water from the facility and from mixed-use areas upstream and downstream; the streams also receive treated wastewater from the facility’s NPDES-permitted outfalls (EPA 2004). Under normal groundwater flow regimes, all three creeks are classified as gaining streams in the area of the facility—recharged from groundwater in the alluvium (Syntex 1996; Clariant 2002CMS). When the IM system is pumping, much of the groundwater flows away from the streams and toward the pumping wells (Clariant 2003GW). Treated groundwater is stored in four holding tanks prior to discharge to the City of Springfield POTW (Clariant 2002CMS).

Geology

¹“Contamination” and “contaminated” describes media containing contaminants (in any form, NAPL and/or dissolved, vapors, or solids, that are subject to RCRA) in concentrations in excess of appropriate “levels” (appropriate for the protection of the groundwater resource and its beneficial uses).

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Variable and complex bedrock surfaces at the facility affect movement of DNAPL. The top of bedrock north of Fassnigh and Wilson Creeks varies between 1185 and 1209 feet above mean sea level (AMSL), and rises above 1250 feet AMSL south of the creeks (Syntex 1996). Depth to bedrock ranges from 0 feet on hillsides to about 50 feet in valley areas (Syntex 1996).

Site geology from ground surface down is alluvium, upper Burlington (B1), middle Burlington (B2), lower Burlington/upper Elsey (E), and Pierson (P) (see Figure 3). Permeabilities at the facility range from very restricted or absent to moderate. In order from lowest to highest permeability, the units are B2, P, B1 (massive Burlington limestone), E, A, B1 (fractured, karstic) (Syntex 1996). Upper bedrock, above 40 feet below ground surface (bgs), and unconsolidated surficial materials are hydraulically connected to the streams that cross the facility property. Bedrock between 40 and 55 feet bgs yielded some groundwater (Syntex 1996). Fassnigh Fault had been thought to be in the area of the facility, but no evidence of the fault appeared in stratigraphy or in hydrology (Syntex 1996).

Hydrogeology

A conceptual hydrogeologic model of the Clariant facility subdivides formation stratigraphy into three water-bearing zones, each with an underlying aquitard (see Figure 4). These water-bearing zones, from the surface downward, are (Syntex 1996):

1. Alluvium/soil/fill (unconsolidated materials) and the upper karstic Burlington bedrock (A and B1), and the middle Burlington chert (upper B2) water-bearing zone; and massive Burlington limestone aquitard (lower B2).
2. Lower Burlington chert and upper Elsey dolomite (E) water-bearing zone; and Lower Elsey limestone aquitard.
3. Pierson (P) water bearing zone; and Northview and Compton Formations of the Ozark Confining Unit.

Unconsolidated materials at the facility are comprised of fill overlying native soils and alluvial sediments. Fill beneath the developed part of the site is typically 4 to 7 feet thick. Beneath the fill, native alluvial sediments and soils are predominantly firm to hard, silty clay, and clay with gravel. The clay-rich soils extend across the facility and interfinger with coarser-grained stream sediments, including sands and gravels. The coarser-grained sediments are most prominent around the FSI (Syntex 1996).

Porosity in the near-surface bedrock is limited to solution cavities and fractures in B1 and intercrystalline porosity in upper E (and to a limited degree in P); and intercrystalline porosity in cherts in the B1, E, and P formations. Matrix porosity in the E dolomite is an order of magnitude greater than limestone porosity, and the pore system is well interconnected. Fractures in the E formation likely enhance the interconnectedness of dolomite matrix porosity, as well as the interconnection of dolomite and cherts (Syntex 1996).

Solution cavities have been observed in B1; the B1 zone has many cavities, most occurring at about 1180 to 1199 feet AMSL. Sparse fractures and discontinuous bedding planes occur in the B1 zone, the deepest occurrence of which is found at 80 feet, and in the B2 zone, the deepest occurrence of which is found at 130 ftbfs. Dense limestone, believed to be largely impermeable, separates the lowermost zone of contamination at 130 ftbfs from deeper, uncontaminated bedrock. The Northview Shale, a regional aquitard, underlies deeper, dense limestones (Clariant 2002 CMS). Large solution cavities that may be interconnected have been observed in the northern portion of the facility. Solution cavities at the facility tend to be horizontal (following bedding features), but about 30% are vertical (following fractures). Solution cavities commonly are filled with sediment (Syntex 1996). Open bedding features have been found in all geologic zones at the facility (Syntex 1996). Vertical fractures occur in all zones, especially in cherty intervals, and commonly are filled with cement.

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Porosity and permeability in near-surface bedrock (to a depth of about 400 feet) at the facility is associated with chert horizons within massive and impermeable limestone (Syntex 1996). Fracturing also provides porosity and permeability. Regionally, solution-enhanced fractures have been observed to a depth of about 70 feet (Syntex 1996).

Groundwater flow at the facility varies according to unit and according to the level of pumping activity of the IM wells. When the IM wells are not pumping, the shallowest groundwater in the alluvial unit is in the northern part of the facility at about 6 feet bgs (Syntex 1996). (Pumping wells do not operate continuously, as they sometimes are shut down for repair or investigation.) At the time of the RFI, groundwater contamination was being captured by the facility's IM pump and treat system—consisting of four pumping wells (in the B1 zone) that induced much steeper gradients than the natural gradient. The highest pumping rate at the time of the RFI was in well ITD6 (Syntex 1996). Recovery well IT06 was shut down in 1996.

A total of 67 monitoring wells were in use in 1996. Of these, 39 had been installed beginning in 1983, 6 subsequently were closed permanently, and 34 were installed during the RFI (Syntex 1996). The active monitoring well system at the time of the RFI consisted of 20 wells in the alluvium (A), 27 wells in the upper Burlington (B1), 7 wells in the middle Burlington (B2), 7 wells in the lower Burlington/upper Elsey (E), 5 wells in the Pierson (P), and 1 deep well in the Cotter (C) (Syntex 1996). Four new monitoring wells were installed in 2000, as required by the CMS, to monitor the weathered zone (zone with fractures and solution cavities) in B1 (Clariant 2002 CMS). Figure 5 shows the active monitoring well network in 2002 (Clariant 2003GW).

Observed DNAPL at the site is dark brown and more viscous than water. This DNAPL is primarily composed of – in decreasing relative quantities – xylene; toluene; methylene chloride; ethyl benzene; 1,2-dichloroethane; and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) in parts per billion (micrograms per kilogram, or $\mu\text{g}/\text{kg}$) quantities. DNAPL also contains semi-volatile compounds (primarily naphthalated compounds), as well as 2-bromo-6-methoxynaphthalene (BMN) – a non-toxic, solid material. Aqueous phase 2,3,7,8-TCDD is limited to five DNAPL-containing B1 wells located near the FSI, with concentrations ranging from 0.0037 to 0.068 $\mu\text{g}/\text{L}$ (Clariant 2002 CMS).

The actual quantity of DNAPL in the subsurface is not known; DNAPL has been documented in the different zones. Estimates indicate a few thousand gallons of residual DNAPL may be present within the soil and held in-place by the low permeability of the matrix (Clariant 2002 CMS).

DNAPL is present in soil and bedrock in both free-phase and residual forms (Syntex 1996). DNAPL in the B1 zone occurs both horizontally and vertically within a north-south area of 700 feet, and east-west of 200 to 400 feet. Vertically, DNAPL extends downward from top of bedrock (about 24 ftbfs) to 80 ftbfs (elevations 1139 to about 1192). The contaminated B2 zone underlies the B1 zone by 11 to 33 feet. DNAPL in the B2 zone occurs sporadically both horizontally and vertically within an area 250 feet wide by 500 feet long, and vertically from 90 ftbfs to 126 ftbfs (elevations 1093 to 1129). From 24 to 40 feet of dense, impermeable limestone separates the lowermost zone of (B2) of contamination from deeper, uncontaminated bedrock (Clariant 2002 CMS).

DNAPL was released into the subsurface over 20 years ago; five production activities operating from the 1950s to the mid-1980s using methylene chloride, toluene, xylene, and chloroform as raw materials, are the suspected chemicals of concern. Waste disposal practices from 1960 to 1982 involved the use of SWMUs, likely leading to the introduction of chemicals to the environment. (Clariant 2002 CMS). Residual DNAPL is in unconsolidated material over bedrock mainly in the north-central parts of the FCSL, the brick sump at the eastern end of the east-west FCSL, the S-14 FCSL and building, and the FSI (Syntex 1996). Pooled and residual DNAPL in bedrock (most commonly encountered at about 1100 feet AMSL) is limited to the southern portion of the facility. Of the 75 occurrences of DNAPL in bedrock, 60 are associated with chert lenses, 14 with open bedding features, and 1 with a solution cavity (see Figure 6). Wells SXD1, SXD2, SXD5, TCD2, TCD3, and TCD4, and 9 core boreholes have accumulated DNAPL (Syntex 1996). The volume of DNAPL recovered during 2003 was less than one gallon (Clariant 2004GW).

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Groundwater contamination is present to about 130 feet bgs in alluvial material and bedrock. Contaminants are the same chemicals as DNAPL, with highest concentrations of contamination near the central plant source areas and restricted by IM system pumping (Syntex 1996). The most contaminated wells in the alluvial zone are TCA5, ITA3, and TCA7, downgradient of the FSI (Syntex 1996). The most contaminated wells in B1 are ITD3 and ITD4. Well ITD3 contains DNAPL. Well ITD4 is an IM system DNAPL recovery well. Wells 8D1, ITD1, ITD4, ITO1, and ITP1D all contain DNAPL and dioxin (Syntex 1996). Locations of contaminated groundwater strongly correlate to locations of DNAPL contamination in soil (Archemica 2000). APL occurs in the same Alluvial, B1, and B2 hydrogeologic zones as DNAPL, and occupies approximately the same horizontal area as DNAPL in each zone due to the formation of APL from the DNAPL (Clariant 2002CMS).

Table 1 provides concentrations of dissolved contaminants in groundwater.

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Table 1 – Concentrations of Contaminants in Performance Wells, April 2002

| Compound | EPA MCL (mg/l) | ITD4 | | ITD6 | | SXD1 | | TCA5 | |
|---------------------------|----------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|
| | | Hist. Range (mg/l) | Apr. 2002 (mg/l) | Hist. Range (mg/l) | Apr. 2002 (mg/l) | Hist. Range (mg/l) | Apr. 2002 (mg/l) | Hist. Range (mg/l) | Apr. 2002 (mg/l) |
| Acetone | 0.61 | BRL - 290 | BRL | BRL | BRL | BRL - 130 | 3.3 | BRL | 7.4 |
| Benzene | 0.005 | BRL - 0.03 | 0.007 | BRL | BRL | BRL - 0.35 | 0.0076 | BRL - 296 | 0.061 |
| Carbon disulfide | 1* | BRL | BRL | BRL | BRL | BRL | BRL | BRL | BRL |
| Carbon tetrachloride | 0.005 | BRL | 0.16 | BRL | BRL | BRL | BRL | BRL | BRL |
| Chloroform | 0.08** | BRL - 56 | BRL | BRL | BRL | BRL - 7.4 | 0.33 | BRL - 10 | 0.066 |
| Chloromethane | 0.0015* | 0.015 - 38.7 | 0.096 B | 0.015 - 38.7 | BRL | 0.015 - 38.7 | BRL | 0.015 - 38.7 | BRL |
| 1,2-Dichloroethane | 0.005 | 43 - 140 | 19 | BRL - 0.79 | BRL | BRL - 71 | 0.99 | BRL - 230 | 4.4 |
| 1,1-Dichloroethene | 0.007 | BRL - 1.2 | 0.019 | BRL - 1.2 | BRL | BRL - 1.2 | BRL | BRL - 1.2 | BRL |
| 1,2-Dichloroethene | 0.07*** | BRL | 0.18 | BRL | BRL | BRL | BRL | BRL - 0.075 | 0.006 |
| 1,2-Dichloropropane | 0.005 | BRL | 0.069 | BRL | BRL | BRL | BRL | BRL | BRL |
| cis-1,3-Dichloropropene | 0.0004† | BRL | 0.005 | BRL | BRL | BRL | BRL | BRL | BRL |
| trans-1,3-Dichloropropene | 0.0004† | BRL | 0.007 | BRL | BRL | BRL | BRL | BRL | BRL |
| Ethylbenzene | 0.7 | BRL - 540 | BRL | BRL - 2.5 | BRL | BRL - 280 | 0.32 | BRL - 3.7 | 4.5 |
| Methylene chloride | 0.005 | 300 - 2,400 | 1,400 B | BRL - 3.6 | BRL | BRL - 610 | 5.8 B | BRL - 2,250 | 14 |
| 4-Methyl-2-pentanone | 0.160* | BRL - 2.0 | 0.11 | BRL - 2.0 | BRL | BRL - 2.0 | BRL | BRL - 2.0 | BRL |
| Styrene | 0.1 | BRL | BRL | BRL | BRL | BRL | BRL | BRL | BRL |
| 2,3,7,8-TCDD (Dioxin) | 3.00E-08 | BRL - 610 | BRL | BRL | BRL | BRL | BRL | BRL - 2.5 | BRL |
| Tetrachloroethene | 0.005 | BRL | BRL | BRL | BRL | BRL | BRL | BRL - 0.026 | BRL |
| 1,1,2-Trichloroethane | 0.005 | BRL | 0.024 | BRL | BRL | BRL | BRL | BRL | BRL |
| Trichloroethene | 0.005 | BRL | 0.038 | BRL | BRL | BRL | BRL | BRL | BRL |
| Toluene | 1 | BRL - 1,200 | BRL | 0.041 - 2.6 | BRL | BRL - 410 | 2.3 | BRL - 73 | 16 |
| Xylenes (total) | 10 | BRL - 3,200 | BRL | 0.048 - 15 | BRL | 0.011 - 1,700 | 3.9 | BRL - 21 | 23 |

| Compound | EPA MCL (mg/l) | 9Core | | 7B1 | | 5Core | | 6B2 | |
|---------------------------|----------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|
| | | Hist. Range (mg/l) | Apr. 2002 (mg/l) | Hist. Range (mg/l) | Apr. 2002 (mg/l) | Hist. Range (mg/l) | Apr. 2002 (mg/l) | Hist. Range (mg/l) | Apr. 2002 (mg/l) |
| Acetone | 0.61 | BRL - 9.1 | BRL | BRL - 0.04 | 0.028 | BRL - 6 | 0.023 | BRL | BRL |
| Benzene | 0.005 | BRL - 0.16 | 0.11 | BRL | 0.009 | BRL - 0.022 | 0.0179 | BRL - 0.032 | BRL |
| Carbon disulfide | 1* | BRL - 0.14 | 0.11 | BRL | BRL | BRL - 0.03 | 0.025 | BRL | BRL |
| Carbon tetrachloride | 0.005 | BRL - 1.9 | 0.069 | BRL | BRL | BRL - 0.12 | 0.015 | BRL | 0.01 |
| Chloroform | 0.08** | BRL - 19 | 3.1 | BRL - 2.27 | BRL | 1.3 - 26 | 5.19 | 0.30 - 6.18 | 0.21 |
| Chloromethane | 0.0015* | 0.015 - 38.7 | 0.016 B | NA | NA | BRL | 0.015 B | NA | NA |
| 1,2-Dichloroethane | 0.005 | 2.4 - 5.2 | 10 | BRL - 25 | 2.3 | BRL - 8.3 | 6.5 | 0.49 - 3.51 | 1.4 |
| 1,1-Dichloroethene | 0.007 | BRL - 1.2 | BRL | NA | NA | NA | NA | NA | NA |
| 1,2-Dichloroethene | 0.07*** | BRL - 0.027 | 0.022 | BRL | BRL | BRL | 0.0027 | BRL | BRL |
| 1,2-Dichloropropane | 0.005 | BRL | 0.021 | NA | NA | NA | NA | NA | NA |
| cis-1,3-Dichloropropene | 0.0004† | BRL | BRL | NA | NA | NA | NA | NA | NA |
| trans-1,3-Dichloropropene | 0.0004† | BRL | 0.02 | NA | NA | NA | NA | NA | NA |
| Ethylbenzene | 0.7 | BRL - 9.4 | 7.3 | BRL - 1.6 | 0.11 | 0.29 - 5.1 | 1.63 | BRL - 6.8 | BRL |
| Methylene chloride | 0.005 | 5.9 - 180 | 71 | 2.9 - 180 | 19 B | 2.1 - 13 | 6.8 | 0.59 - 2.64 | 3 |
| 4-Methyl-2-pentanone | 0.160* | BRL - 2.0BRL | NANA | NANA | NANA | | | | |
| Styrene | 0.1 | BRL | 0.079 | NA | NA | BRL | 0.027 | NA | NA |
| 2,3,7,8-TCDD | 3.00E-08 | BRL | BRL | BRL | BRL | BRL | BRL | BRL - 1.7 | BRL |
| Tetrachloroethene | 0.005 | BRL | 0.007 | NA | NA | NA | NA | NA | NA |
| 1,1,2-Trichloroethane | 0.005 | BRL | BRL | NA | NA | NA | NA | NA | NA |
| Trichloroethene | 0.005 | BRL | 0.01 | NA | NA | NA | NA | NA | NA |
| Toluene | 1 | BRL - 74 | 15 | BRL - 7.6 | 1.5 | 3.4 - 44 | 13 | 0.36 - 45.2 | 2.9 |
| Xylenes (total) | 10 | BRL - 50 | 39 | BRL - 3.6 | 0.99 | 2.1 - 29 | 12 | 0.41 - 44 | 8.5 |

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Table derived from the 2002 Annual Groundwater Report (Clariant 2003GW). Values in bold exceed the EPA MCL, MDNR GTARC, or EPA Region 9 PRG.

* = EPA Region 9 PRG. No EPA MCL or MDNR GTARC is available for this compound.

** = MDNR GTARC. No EPA MCL is available for this compound.

*** = This value is the EPA MCL for *cis*-1,2-dichloroethene.

† = MDNR GTARC for total 1,3-dichloropropene.

B = Estimated. This compound was also detected in the blank.

BRL = Below reporting limits

EPA = U.S. Environmental Protection Agency

GTARC = Missouri groundwater target concentration

MCL = Maximum contaminant level

MDNR = Missouri Department of Natural Resources

NA = Not analyzed

PRG = Preliminary remediation goal

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3. Has the **migration** of contaminated groundwater **stabilized** (such that contaminated groundwater is expected to remain within “existing area of contaminated groundwater”² as defined by the monitoring locations designated at the time of this determination)?

If yes - continue, after presenting or referencing the physical evidence (e.g., groundwater sampling/measurement/migration barrier data) and rationale why contaminated groundwater is expected to remain within the (horizontal or vertical) dimensions of the “existing area of groundwater contamination”²).

If no (contaminated groundwater is observed or expected to migrate beyond the designated locations defining the “existing area of groundwater contamination”²) - skip to #8 and enter “NO” status code, after providing an explanation.

If unknown - skip to #8 and enter “IN” status code.

Rationale and Reference(s):

Several thousand gallons of residual DNAPL is believed to be trapped in bedrock, in the southern half of the facility, and to be completely contained on-site. The vast majority of the residual DNAPL is thought to occur within solution cavities found in the 20 to 40 ftbls B1 zone, and is believed to be held in-place largely by capillary forces in sparse fractures and discontinuous bedding planes in the B1 zone, the deepest of which is found at 80 feet, and in the B2 zone, the deepest occurrence of which is found at 130 ftbls (Clariant 2002 CMS). The “box” where the DNAPL is located has been defined, but the exact quantities and locations of DNAPL within the box cannot be specifically determined due to the complex geology within the box. The geologic conditions and occurrence of isolated DNAPL not only limit DNAPL’s mobility under natural conditions, but also limit the ability to recover the DNAPL (Clariant 2002 CMS). The current distribution in the subsurface is dominantly stable and large-scale future movement of DNAPL itself is unlikely. However, the DNAPL is dissolved by passing groundwater, and dissolved constituents are still mobile, but largely contained by the IM pumping system (Clariant 2002 CMS). DNAPL is present in soil and bedrock in both free-phase and residual forms (Syntex 1996). Deep DNAPL was observed in two higher permeability zones, separated by about 33 feet of dense, non-permeable limestone. The deepest observed DNAPL is separated from the deeper uncontaminated bedrock zones by about 40 feet of dense, low-permeability limestone

² “existing area of contaminated groundwater” is an area (with horizontal and vertical dimensions) that has been verifiably demonstrated to contain all relevant groundwater contamination for this determination, and is defined by designated (monitoring) locations proximate to the outer perimeter of “contamination” that can and will be sampled/tested in the future to physically verify that all “contaminated” groundwater remains within this area, and that the further migration of “contaminated” groundwater is not occurring. Reasonable allowances in the proximity of the monitoring locations are permissible to incorporate formal remedy decisions (i.e., including public participation) allowing a limited area for natural attenuation.

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(Syntex 1996). All DNAPL in bedrock occupies an area of a few hundred feet in diameter, limited to the southern part of the facility, and confined within property boundaries (Syntex 1996).

Residual DNAPL is located in unconsolidated material over bedrock mainly in the north-central parts of the FCSL, the brick sump at the eastern end of the east-west FCSL, the S-14 FCSL and building, and the FSI (Syntex 1996). Pooled and residual DNAPL in bedrock is limited to the southern portion of facility and most commonly encountered at about 1100 feet AMSL. Of the 75 occurrences of DNAPL in bedrock, 60 are associated with chert lenses, 14 with open bedding features, and 1 with a solution cavity. Wells SXD1, SXD2, SXD5, TCD2, TCD3, and TCD4, and 9 Core boreholes have accumulated DNAPL at borehole bottoms (Syntex 1996).

Groundwater contamination is present to about 130 feet bgs in alluvial material and bedrock. Contaminants are the same chemicals as DNAPL, with highest concentrations of contamination near the central plant source areas and restricted by IM system pumping (Syntex 1996). The most contaminated wells in the alluvial zone are TCA5, ITA3, and TCA7—all downgradient of the FSI (Syntex 1996). The most contaminated wells in B1 are ITD3 and ITD4. Well ITD3 contains DNAPL. Well ITD4 is an IM system DNAPL recovery well. Wells 8D1, ITD1, ITD4, ITO1, and ITP1D all contain DNAPL and dioxin (Syntex 1996). Locations of contaminated groundwater strongly correlate to locations of DNAPL contamination in soil (Archemica 2000).

DNAPL is primarily in solution cavities about 20-40 feet bgs, largely immobile, and held in place by capillary and adhesion forces. The denser limestone underneath limits downward migration. Except for movement due to drilling in the area of the new boreholes, DNAPL migration seems to have stopped. DNAPL is isolated from sources, limiting gravity drainage into wells (Clariant 2002 CMS).

The horizontal and vertical extent of contaminated groundwater is essentially the same as the extent of DNAPL within each respective zone (Syntex 1996) (see Figures 7, 8, and 9). In general, bedrock limestone stops vertical migration of DNAPL and contaminated groundwater. Limestone immediately beneath the lowest zone of contaminated bedrock is a laterally extensive aquitard, limiting the potential downward migration of groundwater (Syntex 1996). However, movement is possible along fractures and solution openings (Syntex 1996).

The most continuously porous and permeable layer beneath the facility is at about 180 feet bgs, below an aquitard. This is the lower Burlington and upper Elsey (E) water-bearing zone. This zone has good horizontal flow. The groundwater in the E zone is not contaminated, as no hydraulic connection exists between the Elsey and the higher contaminated bedrock zone (Syntex 1996). Contaminated groundwater (pore water) in the soil and upper bedrock is hydraulically connected, and is captured by the pump and treat system (Syntex 1996). Geologic evaluation of solution cavities during the RFI and CMS field testing indicated solution cavities are commonly filled with clay sediment, restricting groundwater flow and supporting slower than theoretical groundwater flow rates. The high theoretical groundwater flow rates calculated for karst wells, if actually occurring, are only present over very short distances and are not believed to be representative of the actual groundwater flow across the site. Theoretical groundwater flow velocities calculated for any given well are particular for that well and cannot be extrapolated to apply over the whole site. Any groundwater movement across the site can only occur from a combination of flow through discontinuous, secondary porosity features (karst, fractures, and horizontal bedding/contact plants). Consequently, the complex routes for movement of water across the site, combined with small hydraulic gradients outside the influence of IM pumping, result in low actual groundwater flow rates across the site (Clariant 2002 CMS).

Conclusions regarding DNAPL relative immobility have been supported by field observations. DNAPL recovery records illustrate that the rate of DNAPL recovery has decreased exponentially in IM wells located close to the original source areas since September, 1989. Since 1992, all wells show a substantial decrease in DNAPL recovery over time. These decreases are caused by residual DNAPL, being small in volume or size, which is rapidly depleted when encountered following installation of a well. This implies DNAPL migration has largely ceased, except for small occurrences of non-recoverable seepage in the immediate vicinity of boreholes (Clariant 2002 CMS).

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Maintenance wells monitor the hydrogeologic zones underlying the zones with contaminated groundwater. Wells 9E, 1P, and 9P monitor the vertical perimeter (Clariant 2001). No reliable detections of contaminants have been observed in perimeter or maintenance wells. Pumping wells control the horizontal extent of contaminants. Samples from semi-annual groundwater monitoring sometimes indicate trace amounts of VOCs that are ascribed variously to lab or sampling cross-contamination, or spurious airborne exposure (Archemica 2000; Clariant 2001, 2002GW, 2003GW).

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4. Does “contaminated” groundwater **discharge** into **surface water** bodies?

If yes - continue after identifying potentially affected surface water bodies.

If no - skip to #7 (and enter a “YE” status code in #8, if #7 = yes) after providing an explanation and/or referencing documentation supporting that groundwater “contamination” does not enter surface water bodies.

If unknown - skip to #8 and enter “IN” status code.

Rationale and Reference(s):

Operation of the IM pumping system controls groundwater flow beneath the site except in the alluvium in the southwest part of the site. The southwest portion of the site has no evidence of WB1 karst porosity, apparently due erosion. Contaminant levels and groundwater flow velocity are low in this area. The IM pumping system will become part of the final remedy along with pumping augmentation to optimize containment.

Jordan, Fassnight, and Wilson Creeks are gaining streams in the area of the Facility, and with observations of perennial flow during the RFI. A temperature comparison of ITD6 groundwater and Jordan Creek surface water was conducted in September, 2002 (Bob Lanning, Memo 2002). The comparison indicates an open, hydraulic connection between ITD6 and Jordan Creek exists based on the following:

1. Sharp groundwater level increases occur nearly simultaneously in ITD6 with sharp increases in Jordan Creek water level during precipitation events.
2. An immediate and distinct decrease in ITD6 groundwater temperature and increase in water level, coincident with a precipitation-induced rise in Jordan Creek water level, suggests that increased creek head pushes cooler groundwater into the ITD6 well bore via the solution cavity.
3. Gradual rise and fall of ITD6 groundwater temperature has a high degree of statistical correlation with rise and fall of Jordan Creek water temperature, with a consistent lag time. Without a direct hydraulic connection, groundwater temperatures in ITD6 would be expected to remain stable and consistent.
4. In addition to the temperature and water level relationship evidence, the following also support a direct physical connection between ITD6 and the creek:

ITD6 has historically had the highest water production rate of the IM pumping wells on-site, with sustainable pumping rates of up to 6 gpm. This rate is five times greater than SXD1’s pumping rate, and SXD1 contains a solution cavity with demonstrated hydraulic connection to Jordan Creek.

No significant drawdown can be induced by pumping in ITD6 since converting the well from a screened interval to an open borehole. This suggests that the direct physical connection has always existed in the bedrock, but was restricted by the screen and sand-pack.

The presence of large quantities of suspected bacteria supports high levels of natural organics as would be derived from a stream.

5. The effect of changing ITD6 pumping rate is inconclusive regarding connectivity between ITD6 and the creek.

The initial response to increased pumping rate was a decrease in groundwater temperature; however, the period of higher pumping rate was insufficient to fully evaluate the temperature trend.

The groundwater temperature appeared to begin increasing following a reduction in pumping rate, but the trend was significantly affected by the effects of a major precipitation event after 2.5 days.

The CMS calls for continued surface-water sampling (Clariant 2002CMS). Additionally, perimeter wells in the alluvium on the contaminated side of Jordan Creek (including ITA7 and 7A) and B1 wells on the contaminated side of Jordan Creek (7B1 and 10B1) would detect contamination before it reaches the creek (Clariant 2002CMS).

5. Is the **discharge** of “contaminated” groundwater into surface water likely to be **“insignificant”** (i.e., the

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maximum concentration³ of each contaminant discharging into surface water is less than 10 times their appropriate groundwater “level,” and there are no other conditions (e.g., the nature, and number, of discharging contaminants, or environmental setting), which significantly increase the potential for unacceptable impacts to surface water, sediments, or eco-systems at these concentrations)?

If yes - skip to #7 (and enter “YE” status code in #8 if #7 = yes), after documenting: 1) the maximum known or reasonably suspected concentration³ of key contaminants discharged above their groundwater “level,” the value of the appropriate “level(s),” and if there is evidence that the concentrations are increasing; and 2) provide a statement of professional judgement/explanation (or reference documentation) supporting that the discharge of groundwater contaminants into the surface water is not anticipated to have unacceptable impacts to the receiving surface water, sediments, or eco-system.

If no - (the discharge of “contaminated” groundwater into surface water is potentially significant) - continue after documenting: 1) the maximum known or reasonably suspected concentration³ of each contaminant discharged above its groundwater “level,” the value of the appropriate “level(s),” and if there is evidence that the concentrations are increasing; and 2) for any contaminants discharging into surface water in concentrations³ greater than 100 times their appropriate groundwater “levels,” the estimated total amount (mass in kg/yr) of each of these contaminants that are being discharged (loaded) into the surface water body (at the time of the determination), and identify if there is evidence that the amount of discharging contaminants is increasing.

If unknown - enter “IN” status code in #8.

Rationale and Reference(s):

³ As measured in groundwater prior to entry to the groundwater-surface water/sediment interaction (e.g., hyporheic) zone.

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6. Can the **discharge** of “contaminated” groundwater into surface water be shown to be “**currently acceptable**” (i.e., not cause impacts to surface water, sediments or eco-systems that should not be allowed to continue until a final remedy decision can be made and implemented⁴)?

_____ If yes - continue after either: 1) identifying the Final Remedy decision incorporating these conditions, or other site-specific criteria (developed for the protection of the site’s surface water, sediments, and eco-systems), and referencing supporting documentation demonstrating that these criteria are not exceeded by the discharging groundwater; OR 2) providing or referencing an interim-assessment⁵, appropriate to the potential for impact, that shows the discharge of groundwater contaminants into the surface water is (in the opinion of a trained specialists, including ecologist) adequately protective of receiving surface water, sediments, and eco-systems, until such time when a full assessment and final remedy decision can be made. Factors which should be considered in the interim-assessment (where appropriate to help identify the impact associated with discharging groundwater) include: surface water body size, flow, use/classification/habitats and contaminant loading limits, other sources of surface water/sediment contamination, surface water and sediment sample results and comparisons to available and appropriate surface water and sediment “levels,” as well as any other factors, such as effects on ecological receptors (e.g., via bio-assays/benthic surveys or site-specific ecological Risk Assessments), that the overseeing regulatory agency would deem appropriate for making the EI determination.

_____ If no - (the discharge of “contaminated” groundwater can not be shown to be “**currently acceptable**”) - skip to #8 and enter “NO” status code, after

⁴ Note, because areas of inflowing groundwater can be critical habitats (e.g., nurseries or thermal refugia) for many species, appropriate specialist (e.g., ecologist) should be included in management decisions that could eliminate these areas by significantly altering or reversing groundwater flow pathways near surface water bodies.

⁵The understanding of the impacts of contaminated groundwater discharges into surface water bodies is a rapidly developing field and reviewers are encouraged to look to the latest guidance for the appropriate methods and scale of demonstration to be reasonably certain that discharges are not causing currently unacceptable impacts to the surface waters, sediments or eco-systems.

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documenting the currently unacceptable impacts to the surface water body, sediments, and/or eco-systems.

_____ If unknown - skip to 8 and enter "IN" status code.

Rationale and Reference(s):

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7. Will groundwater **monitoring** / measurement data (and surface water/sediment/ecological data, as necessary) be collected in the future to verify that contaminated groundwater has remained within the horizontal (or vertical, as necessary) dimensions of the “existing area of contaminated groundwater?”

If yes - continue after providing or citing documentation for planned activities or future sampling/measurement events. Specifically identify the well/measurement locations which will be tested in the future to verify the expectation (identified in #3) that groundwater contamination will not be migrating horizontally (or vertically, as necessary) beyond the “existing area of groundwater contamination.”

If no - enter “NO” status code in #8.

If unknown - enter “IN” status code in #8.

Rationale and Reference(s):

The 1999 annual groundwater report described a groundwater sampling plan specifying that perimeter wells be sampled in April and October, and all other wells be sampled in October—with samples analyzed for VOCs and dioxin (Archemica 2000). Additionally, water levels are measured at least quarterly in all wells (Clariant 2001).

The 2002 Corrective Measures Study (CMS) recommended adding three pumping wells by pumping two existing monitoring wells periodically and installing an additional pumping well (Clariant 2002CMS).

The final remedy recommended by the CMS calls for enhanced groundwater monitoring and for continued surface-water sampling (Clariant 2002CMS). In 2002, automatic data collection systems were installed in the monitoring network to track water levels in wells and at Jordan Creek (Clariant 2003GW).

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8. Check the appropriate RCRA Info status codes for the Migration of Contaminated Groundwater Under Control EI (event code CA750), and obtain Supervisor (or appropriate Manager) signature and date on the EI determination below (attach appropriate supporting documentation as well as a map of the facility).

YE - Yes, "Migration of Contaminated Groundwater Under Control" has been verified.
Based on a review of the information contained in this EI determination, it has been determined that the "Migration of Contaminated Groundwater" is "Under Control" at the Clariant LSM Missouri, Inc. facility, EPA ID #MOD095038329, located at 2460 W. Bennett St., Springfield, Missouri, 65807. Specifically, this determination indicates that the migration of "contaminated" groundwater is under control, and that monitoring will be conducted to confirm that contaminated groundwater remains within the "existing area of contaminated groundwater" This determination will be re-evaluated when the Agency becomes aware of significant changes at the facility.

NO - Unacceptable migration of contaminated groundwater is observed or expected.

IN - More information is needed to make a determination.

Completed by _____ Date 9/22/04
(signature)

R. Bruce Stuart, P.E., R.G.
Unit Chief, Groundwater Unit
Permits Section, Hazardous Waste Program

Locations where References may be found:

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RCRA Files
901 North 5th Street
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FIGURES

(9 pages)