Hydrogeology and Water Quality at the St. Francois County Landfill and Vicinity—Southeastern Missouri, 1990–94

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Abstract

An investigation of the hydrogeology and water quality at the St. Francois County Landfill was conducted because of concern about possible ground-water contamination. The 53-acre landfill is located in the southern part of an abandoned lead-mine tailings pile and was operated from 1973 to 1993. The tailings pile is one of several that are the remains of more than a century of lead mining in the Old Lead Belt of southeastern Missouri. The bedrock directly beneath the tailings pile consists of massively bedded dolostone of the Bonneterre Formation. The formation at the site is about 300 feet thick, and the lower 100 feet were mined extensively. The Bonneterre Formation and underlying Lamotte Sandstone comprise the St. Francois aquifer, which is used extensively in the region for domestic and public-water supply. The abandoned water-filled mine cavities are used locally for domestic and public-water supply.

The landfill is located in an area where the tailings filled a small creek valley that contained a tributary to the Big River. The buried creek valley slopes toward the Big River to the northeast where the tailings are more than 100 feet thick. Within the buried valley near the middle of the site, a portion of the tailings is saturated to a thickness of more than 50 feet, and the water table is within 15 feet of buried refuse. A ground-water mound extends east-west across most of the landfill site—the nose of which coincides with the middle part of the buried creek valley. In this area a downward vertical gradient exists between the tailings, the underlying Bonneterre Formation, and the abandoned mine cavities about 200 feet below the tailings surface.

The landfill has affected the ground-water quality in the tailings and shallow bedrock at the site. Landfill leachate has migrated into these media as evidenced by increased specific conductance values and increased concentrations of calcium, sodium, total alkalinity, chloride, total ammonia, barium, iron, pesticides (diazinon and terbacil), and volatile organic compounds (for example, dichloromethane, chlorofluoromethane, dichlorofluoromethane, chloroethane, 1,1-dichloroethane, vinyl chloride, cis-1,2-dichloroethene, trans-1,2,-dichloroethene, and ethyl ether). In general, the effects of the landfill were greatest in the tailings and Big River alluvium northeast of the landfill. With the exception of this area, the available data indicate that contaminants from the landfill have not migrated offsite. Although samples from several bedrock piezometers contained large concentrations of inorganic constituents indicative of landfill leachate, only small (less than 4 nanograms per liter) concentrations of diazinon attributable to the landfill were detected in those samples.

Small concentrations of two pesticides (diazinon and prometon) and volatile organic compounds (1,1,1-trichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, 1,1,2-trichloroethene, 1,1,2,2-tetrachloroethene, and methyl-tertiarybutylether) were detected in the abandoned mine cavities beneath the landfill. Prometon, 1,1,2-trichloroethene, 1,1,2,2-tetra-

chloroethene, and methyltertiarybutylether, however, were detected in samples from background mine sites several miles from the landfill, indicating other sources of contamination in the mines unrelated to the landfill.

INTRODUCTION

The State of Missouri enacted legislation in 1972 governing the disposal of municipal solid waste because of concerns regarding the effect of municipal solid waste landfills on ground-water quality. Legislation governing permitting and ground-water monitoring at municipal solid waste landfills (MSWLF) was promulgated in 1976 and revised in 1988. These rules require installation of ground-water monitoring networks at facilities of particular concern to the Missouri Department of Natural Resources (Missouri DNR) and at all facilities applying for expansion permits. The goal of this legislation is to protect ground-water supplies by gaining information relating to site geology, source and direction of ground-water flow, and ground-water quality. In 1991, the U.S. Environmental Protection Agency (USEPA) enacted legislation containing stringent design and monitoring requirements on all MSWLF in the United States. Most provisions under legislation were delayed until October 9, 1993, when all MSWLF became regulated under 40 CFR part 258 (Code of Federal Regulations, 1992).

Ground water supplies all of the drinking water in St. Francois County. In 1990 the U.S. Geological Survey (USGS), in cooperation with the St. Francois County Environmental Corporation, began a hydrologic and water-quality investigation at the St. Francois County Landfill and vicinity to determine the water quality in the vicinity of the landfill and the effects of the landfill on ground- and surface-water quality in the area.

Purpose and Scope

This report presents the results of a hydrogeologic investigation at the St. Francois County Landfill from 1990 to 1994. This report describes: (1) the methods of investigation used in this study; (2) the general characteristics of municipal solid waste and leachate production; (3) the regional hydrogeology and water quality of the St. Francois aquifer in the vicinity of the St. Francois County Landfill; (4) the hydrogeology and water quality of the St. Francois County Landfill site; and (5) the effects of the landfill on ground- and surface-water quality, including the distribution of landfill contaminants in ground water.

From 1990 to 1994 more than 100 water-quality samples were collected from 32 ground-water and 5 surface-water sites by the USGS. Analytical results of water-quality samples collected during previous investigations in the area by the USGS (Smith and Schumacher, 1991), the St. Francois County Landfill, the Missouri DNR, and the USEPA also were used in this investigation. The geochemical controls on trace-element mobility were evaluated through laboratory leaching studies performed at the Department of Geology, Kansas State University. The laboratory studies included more than 25 individual experiments interacting landfill leachate with mine tailings from the site. Interpretation of ground-water geochemistry was aided by the use of statistical and graphical techniques and by the geochemical code WATEQ4F (Ball and others, 1987).

Description of the Study Area

The St. Francois County Landfill is located about 70 mi (miles) south of St. Louis (fig. 1) and about 0.5 mi west of the city of Desloge in St. Francois County, Missouri. The landfill, closed on October 6, 1993, is one of two landfills in Missouri where municipal solid wastes have been placed within an abandoned lead mine tailings pile. The 600-acre tailings pile, known locally as the Desloge tailings pile, is one of six large tailings piles that are the remains of more than a century of lead mining in the Old Lead Belt of southeastern Missouri. The landfill site is located within the Salem Plateau of the Ozark Plateaus physiographic province (Fenneman, 1938). Topography in the area is rugged with narrow, steep drainages and several hundred feet of relief. Mean annual precipitation in the area is about 40 in. (inches; National Oceanic and Atmospheric Administration, 1988); however, seasonal thunderstorms can produce intense precipitation. For example, a series of severe thunderstorms at the landfill site on September 22 and 23, 1993, deposited 7.5 in. of rainfall in 18 hours.

Most of the Desloge tailings pile is located within a meander loop of the Big River, a perennial stream with an annual mean discharge of 190 ft^3/s (cubic feet per second; Reed and others, 1995) at Irondale, about 15 mi upstream of the tailings pile. The

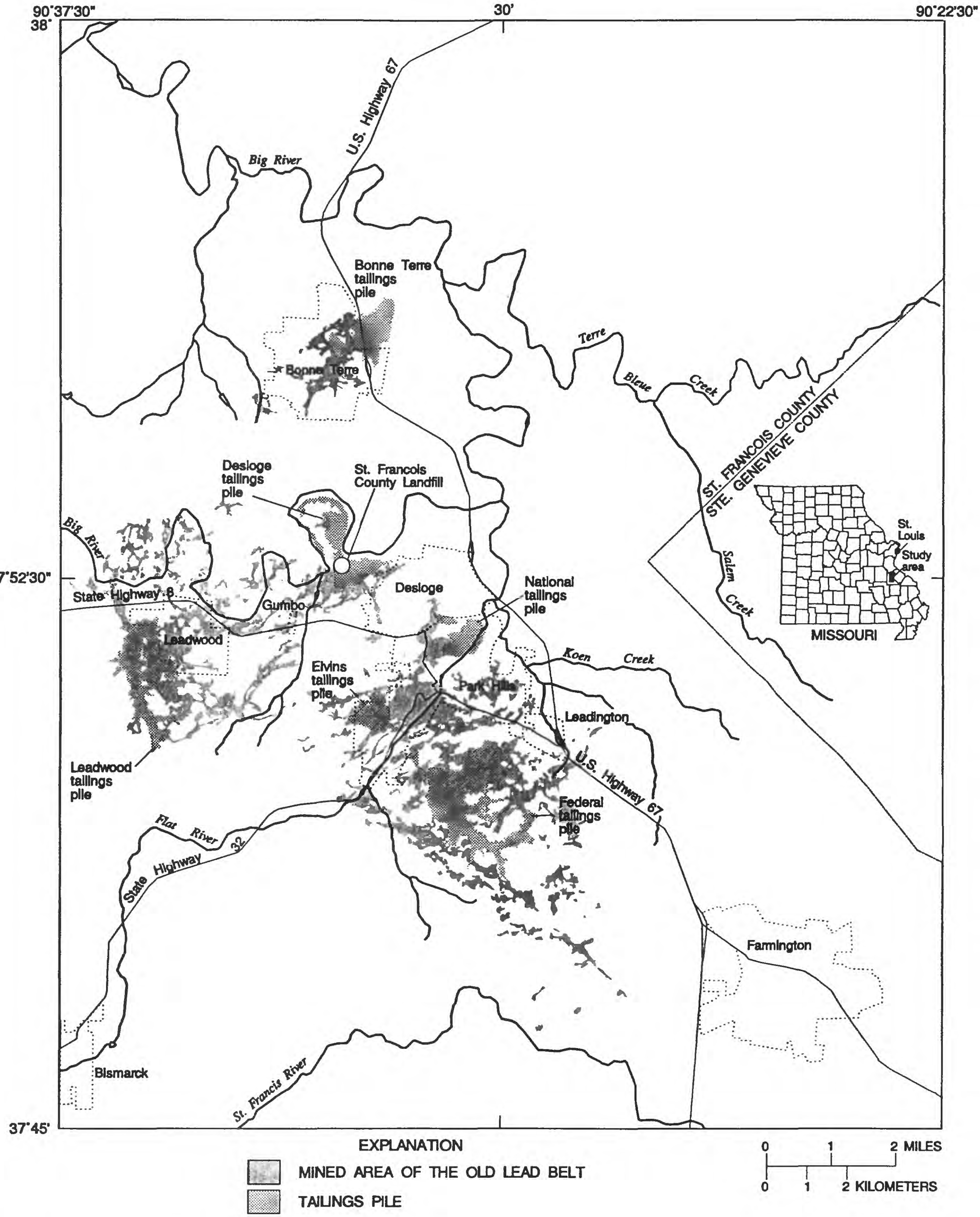


Figure 1. Location of the St. Francois County Landfill site.

tailings pile borders the Big River for more than 3 mi along this meander loop. The tailings were deposited on either side of a north-trending ridge located in the middle of the meander loop (fig. 2). Much of the ridge was not covered by tailings and consists of hardwood forest with scattered pine trees. The northeast corner of the permitted sanitary landfill is within 500 ft (feet) of the Big River along the east side of the meander loop (fig. 3). Hereinafter, the term landfill site refers to approximately a 100-acre tract in the southern part of the Desloge tailings pile containing the former 43-acre sanitary landfill, former 10-acre demolition fill, landfill office-machine shop, scale house, and recently (1994) constructed transfer and recycling stations (fig. 3). The term landfill refers to the 53-acre tract used for the disposal of municipal solid waste (sanitary landfill) and demolition wastes (demolition fill). The location and size of the sanitary landfill (43 acres) and demolition fill (10 acres) vary from the tracts originally permitted by the Missouri DNR for the disposal of sanitary refuse (permitted sanitary landfill) and demolition wastes (permitted demolition fill) as shown in figure 3.

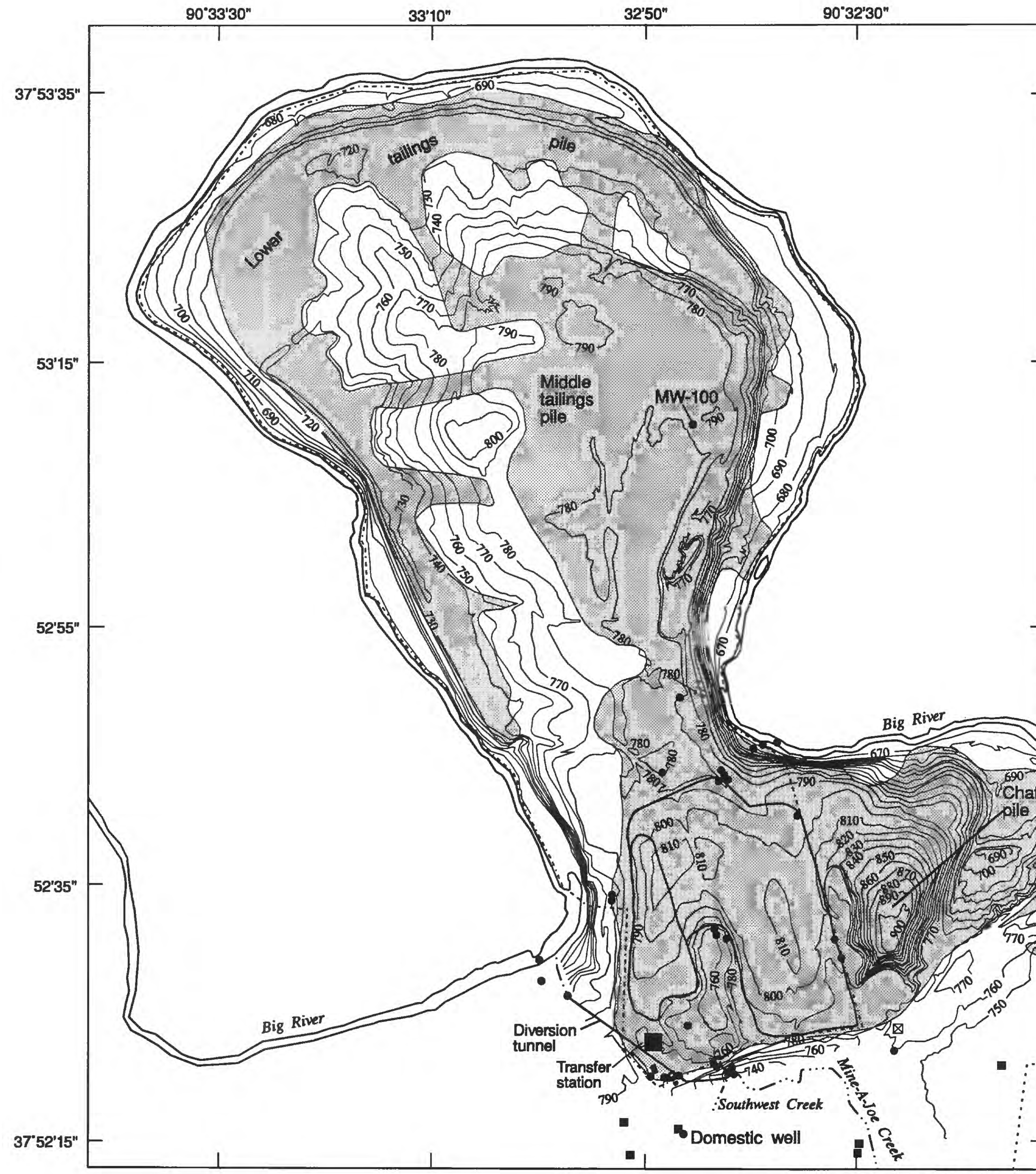
The Desloge tailings pile can be separated into three general regions: the large 100-acre chat pile to the east and the middle and lower tailings piles (about 504 acres) in the south-central and northern areas of the site (fig. 2). The chat pile, consisting of medium to coarse sand-size particles, rises more than 200 ft above the Big River and is one of the highest topographic features in the area. Tailings comprising the middle and lower piles generally are fine silt- and clay-size particles with some fine to medium sand-size particles. These areas are referred to locally as "slime" ponds because of their soupy consistency when wet. The middle tailings pile, containing the landfill, consists of tailings generally east of the north-trending ridge. The nearly flat surface of this pile extends about 100 to 110 ft above the Big River. Tailings west and north of the ridge comprise the lower pile that extends about 30 to 40 ft above the Big River. Excluding the landfill, the tailings generally are devoid of vegetation except for scattered small trees where the tailings are less than a few feet thick or along the toe of slopes.

The middle and lower tailings piles, including the landfill, are currently owned by the St. Francois County Environmental Corporation. The chat pile and several acres south of the landfill are owned by the St. Joseph Minerals Corporation. About 12 acres immediately west of the landfill site between the tailings pile and Big River are owned by St. Francois County. The remaining land southwest, north, and east of the tailings pile is privately owned. Subdivisions of the city of Desloge are less than 0.5 mi east of the landfill site. Several private homes along the access road immediately southwest of the landfill obtain drinking water from domestic wells, several of which are within 500 ft of the landfill site. The nearest public-supply well is located in the city of Desloge about 1 mi east of the landfill site.

History of the Study Area

The discovery of vast deposits of disseminated lead ore in the Old Lead Belt was facilitated by the introduction of the diamond core drill by the St. Joseph Lead Company in 1869 (Snyder and Gerdemann, 1968). Exploration increased rapidly, and as many as 15 companies operated in the region in the late 1800's. Mining operations ceased in the Old Lead Belt in 1972 with depletion of the ore body and discovery of richer ore about 40 mi southwest near Viburnum, Missouri. Presently (1994) about 8 mi^2 (square miles) are underlain by abandoned, water-filled mine cavities (shown in fig. 1 as mined area).

Subsurface mining operations were conducted at and in the vicinity of the landfill site from 1893 to 1958 when the ore body was depleted (St. Joseph Minerals Corporation, 1993). The 286-ft deep Desloge No. 3 mine shaft was located about 300 ft east of the southeast corner of the landfill property (fig. 2). Most of the mining was conducted using a room and pillar method with a network of interconnecting stopes. Many rooms were large enough to contain working faces of 50 ft or more (fig. 4). Early milling operations used a gravity method to separate ore minerals from the dolomitic host rock. Waste from this process, called chat, consisting of medium to coarse sand-size particles, was placed in large piles with heights in excess of 100 ft by conveyors. This is the origin of the chat pile immediately east of the landfill. In 1910 the flotation separation process was introduced. This process involved grinding the ore much finer and the use of chemical reagents, such as sodium cyanide (NaCN), creosote, and xanthate (short-chain aliphatic organic compounds containing two sulfur atoms), to extract fine particles of galena. Waste from the flotation process was called tailings. The tailings were finer than chat and ranged from fine silt- and clay- to medium sand-size particles. A series of dams comprised of chat and



EXPLANATION

TAILINGS	· · · DESLOGE CITY LIMIT
—750— TOPOGRAPHIC CONTOUR—Interval 10 feet. Datum is sea level	● GROUND- OR SURFACE-WATER SAMPLING SITE
-·-·- ST. FRANCOIS COUNTY ENVIRONMENTAL CORPORATION PROPERTY LINE	■ RESIDENCE
—— LANDFILL	⊠ DESLOGE NO. 3 MINE SHAFT

Figure 2. Location of major features and topography of the Desloge tailings pile, including the St. Francois County Landfill site, Missouri.

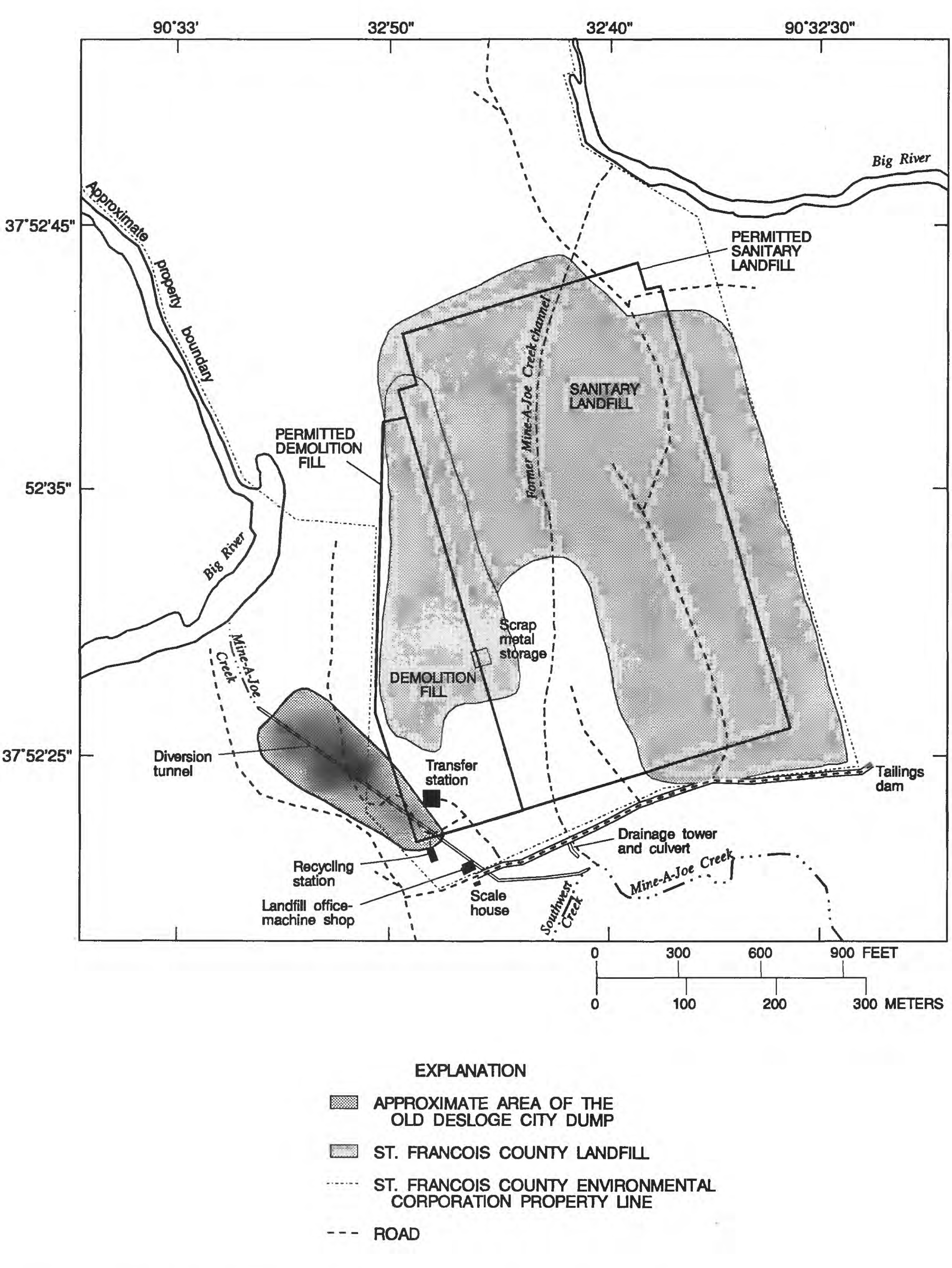


Figure 3. Current (1994) features at the St. Francois County Landfill site, Missouri.

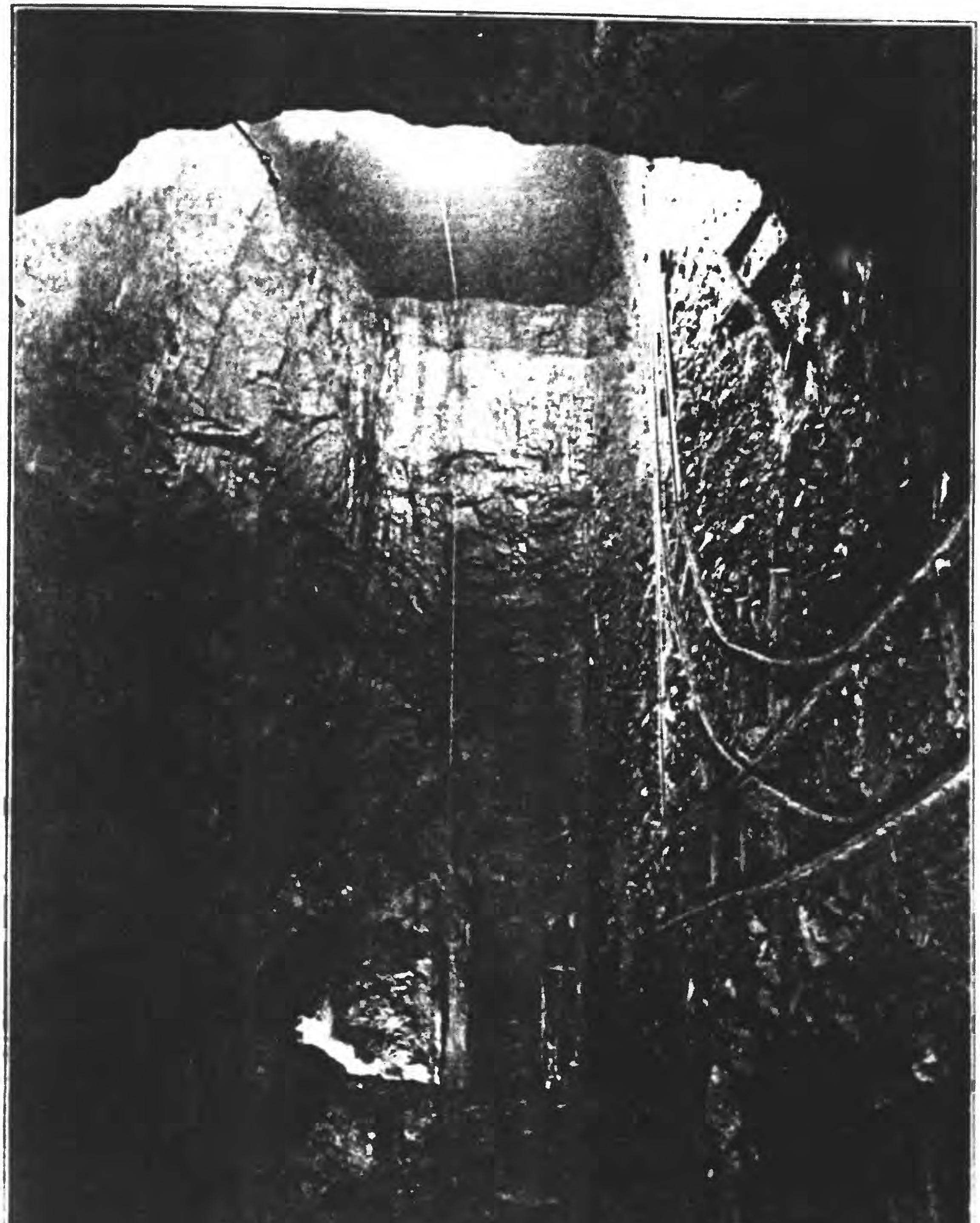


Figure 4. Typical underground workings in the Old Lead Belt, southeastern Missouri (from Buckley, 1908).

coarser tailings was constructed across the Mine-A-Joe Creek valley immediately west of the chat pile and mill complex to contain the tailings. The creek valley was filled, and a diversion tunnel was cut through the north trending ridge to divert Mine-A-Joe Creek around the tailings pond (fig. 2). Part of the filled Mine-A-Joe Creek valley is now overlain by the St. Francois County Landfill.

Between closing of the mine and mill at Desloge in 1958 and the early 1970's, about 5 acres along the southwest corner of the Desloge tailings pile were used as a dump by the city of Desloge (T.O. Seiberling Engineering and Surveying Company, Bonne Terre, Missouri, written commun., 1974). The location of this dump is uncertain; however, during a site reconnaissance in 1989, trash and debris were observed several hundred feet northwest of the landfill office in what is shown in figure 3 as the old Desloge City Dump.

The St. Francois County Landfill began operation on July 2, 1973. The landfill was designed as a moving trench landfill in which sanitary refuse was to be placed in a series of shallow trenches. Initial design specifications called for a series of north-south trending trenches 100 ft long, approximately 25 ft wide, and 8 to 10 ft deep to be constructed along the eastern edge of the permitted sanitary landfill. The refuse was to be placed in alternating "lifts" no more than 2 ft thick and covered daily with 6 in. of fine tailings. Refuse placement occurred in two general phases—phase I and phase II.

During phase I (1973 to about 1983) refuse was placed in excavations along the eastern one-third of the permitted sanitary landfill area, and a demolition fill was operated (sometime between about 1974 and 1983) along the western boundary of the permitted demolition fill area (fig. 3). The first refuse trench was constructed in the southeast corner of the site and the trench was filled in a south to north manner. Refuse in this area was placed at depths less than 15 ft. Shortly after the landfill opened, however, the original trench design was modified, trenches were excavated as wide and deep as possible, and the landfill was operated essentially as an area fill. Refuse was placed to and possibly across the east property line near the chat pile (fig. 3). Several areas along this boundary were excavated to bedrock, which was encountered at relatively shallow depths (less than 20 ft) in some places. The shallow excavations in this area were overfilled, and refuse was piled into a large mound and left exposed for some time. During the late 1970's and early 1980's, refuse was placed into a large excavation more than 40 ft deep in the northeast corner of the site. This area was also left exposed for some time.

Phase II began about 1983 when a large central trench 20 to 30 ft deep, more than 300 ft wide, and extending the entire length of the permitted area, was excavated in the middle part of the permitted sanitary landfill. Material removed during the excavation of this trench was placed over exposed refuse in the northeast corner of the permitted area and stockpiled on top of the demolition fill. The altitude of the trench floor was about 760 ft with a gradual slope to the south where runoff entered Mine-A-Joe Creek through a breach in the south tailings dam adjacent to the drainage tower (fig. 3). The western part of the original phase I fill that was placed at shallow depths was removed and placed in the phase II trench. Refuse disposal began in the northern end of the phase II trench and progressed southward until about one-half the trench was filled before the landfill ceased operation. The western slope of this fill extended over the northern part of the demolition fill. Between 20 and 40 ft of refuse was placed in the northern one-half of the trench. Unlike phase I, however, the refuse was placed in lifts and compacted, daily covers were applied, and attempts at controlling runoff were implemented gradually.

In the late 1970's, brush and thousands of tires were dumped into two large gullies several hundred yards north of the permitted area. Since the late 1980's, brush has been placed along the slopes and across the top of the northern end of the middle tailings pile in an attempt to control erosion. Beginning in about 1988, appliances and scrap metal were separated and stockpiled north of the landfill office for recycling (fig. 3). In addition, the breach through the south tailings dam (fig. 2) was closed and replaced by a culvert and a new drainage structure in an attempt to control the release of tailings into Mine-A-Joe Creek. The south end of the phase II trench was excavated down to bedrock (approximately an altitude of 730 ft) to serve as a holding basin where runoff was temporarily contained to allow suspended solids to settle.

The landfill closed on October 6, 1993, leaving St. Francois County without a solid waste disposal facility. Work began on a transfer station and recycling center at the landfill site in November 1993. A permit for operation of a transfer station was issued on

December 22, 1993, and operations began in January 1994.

Previous Investigations

The final engineering report on the St. Francois County Landfill was issued in June 1974 (T.O. Seiberling Engineering and Surveying Company, written commun., 1974). This report indicated several perched water tables were encountered while excavating trenches at the site, and as a result, trench size and depth varied according to the stability of the tailings. At this time the tailings were thought to be relatively impermeable, and contamination of drinking water supplies by the landfill was believed unlikely.

Gastreich (1974) concluded that the St. Francois County Landfill had a low probability of affecting ground- and surface-water quality in the area, but suggested a ground-water monitoring network be installed and measures taken to control rainfall infiltration into exposed refuse in the trenches. Based on analytical results from water-quality samples collected in 1974, Gastreich concluded none of the water samples were affected by the landfill at that time, but suggested leachate generated in the landfill probably would migrate down the buried Mine-A-Joe Creek valley beneath the landfill toward the Big River. During trips to the site, Gastreich noticed several trenches had encountered perched water tables. Laboratory permeability tests (Gastreich, 1974) determined that the permeability of the tailings ranged from 2.5×10^{-9} ft/s (feet per second) for the fine silt-size particles to 2.5×10^{-7} ft/s for the fine sand-size particles. The permeability of the chat and coarse sand-size particles comprising the tailings dams was 2.5×10^{-4} ft/s.

In their assessment of measures to control the discharge of tailings into the Big River after a large release in 1977, Novack and Hasselwander (1980) expressed serious concerns about landfill leachate, potentially with a low pH value and a high organic content, leaching large quantities of trace elements such as lead (Pb) and zinc (Zn) from the tailings and transporting these as organo-metallic complexes to the Big River. The report recommended that the Missouri DNR begin an immediate monitoring study of the landfill to locate and characterize any leachate observed.

In response to the Novack and Hasselwander (1980) study, the Missouri DNR, Division of Environmental Quality (Missouri DEQ) and Missouri DNR, Division of Geology and Land Survey (Missouri DGLS) conducted a joint water-quality reconnaissance of the landfill site (Tom Ellis, Missouri Department of Natural Resources, Solid Waste Management Program, written commun., 1980; J.H. Williams, Missouri Department of Natural Resources, Division of Geology and Land Survey, written commun., 1980). A total of eight water-quality samples was collected from the Big River, Mine-A-Joe Creek, a seep southwest of the landfill, and a flowing drill hole about 1,000 ft west of the site. A seep southwest of the landfill (seep G, fig. 5) emerges from a concrete tunnel connected to the original drainage tower east of the landfill office. Before about 1988, the tunnel was connected to the drainage tower by an 8-in. diameter iron pipe. Based on the analytical results, the Missouri DEQ and Missouri DGLS concluded that the landfill was not contaminating the Big River or Mine-A-Joe Creek, but the large total lead (Pb_t) concentration, 106 µg/L (micrograms per liter), in a sample from a flowing drill hole west of the landfill site (fig. 5) was a concern because this drill hole is completed in the flooded mine cavities that are used as a drinking-water source in the area.

Hydro-Search, Inc. evaluated the potential for regional ground-water contamination from the Desloge tailings pile and the St. Francois County Landfill in 1986 (Craig Eison, Hydro-Search, Inc., written commun., 1986). They noted several flowing drill holes west of the landfill site along the Big River and noted orange seeps along the Big River northeast of the landfill. Based on a literature search and a site reconnaissance, they concluded that shallow ground water in the bedrock beneath and adjacent to the landfill site discharged into the Big River and did not enter the regional flow system.

As a result of a proposed expansion of the landfill in 1986, the Missouri DEQ requested a ground-water monitoring network be installed. Six monitoring wells were installed in the tailings (MW–101, MW–102, MW–103, MW–104, and MW–105; fig. 5) and the Big River alluvium (MW–106) in 1987 (Geotechnology, Inc., St. Louis, Missouri, written commun., 1987). Based on preliminary water-level data collected in early 1987, leachate that originated from the landfill would migrate along the buried Mine-A-Joe Creek valley northeast toward the Big River. A ground-water monitoring plan based on the preliminary data from these six monitoring wells was developed by the St. Francois County Environmental Corporation and

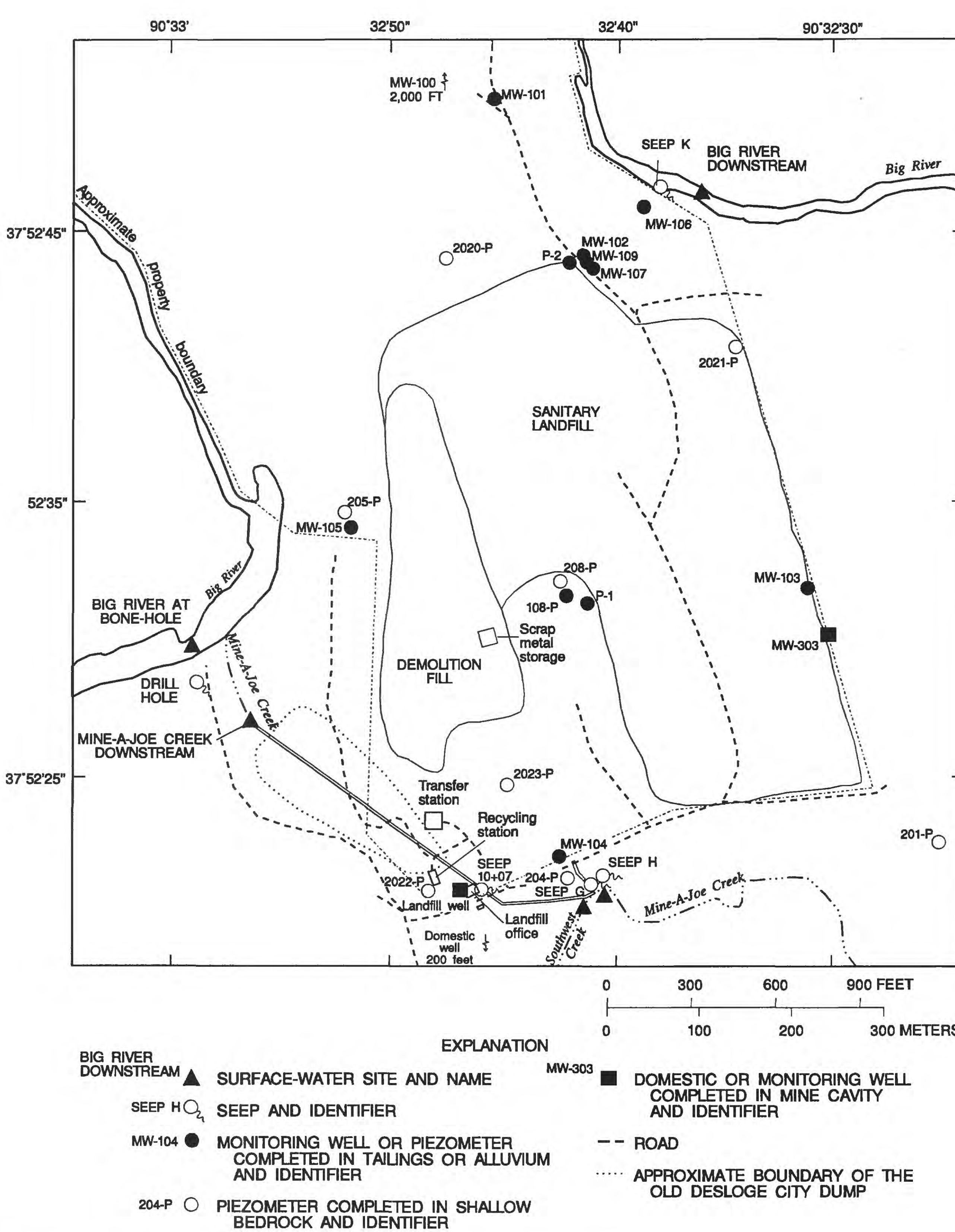


Figure 5. Sampling sites at the St. Francois County Landfill site, Missouri.

approved by the Missouri DNR in September 1987. The first water-quality samples were collected in January 1988, and monitoring has continued thereafter.

In late 1988, inspectors from the Missouri DEQ observed an orange seep emerging from the base of the tailings and a bedding plane in the bedrock at the entrance of the diversion tunnel. This seep (seep H, fig. 5) is less than 25 ft from the seep emerging from the concrete tunnel, sampled by the Missouri DEQ in 1980. Analysis of a sample from seep H indicated large concentrations of iron (Fe; 3,500 μg/L), manganese (Mn; 5,600 μg/L), and Zn (12,000 μg/L).

The USEPA conducted a Preliminary Site Assessment (PSA) and a Listing Site Inspection (LSI) of the 600-acre Desloge tailings pile in 1988 and 1990 (Ecology and Environment, 1991). Results of these investigations determined the Desloge tailings pile posed a substantial risk to the environment because of the transport of Pb-rich materials from the site by wind and water. Neither the landfill nor ground-water quality was evaluated during the PSA or LSI process. Based on results from the LSI, the Desloge tailings pile was placed on the National Priorities List on October 14, 1992. Currently (1994), the USEPA is evaluating strategies to control the release of tailings into the environment.

Rao (1991) determined that substantial quantities of Pb could be leached from tailings by landfill leachate. A synthetic landfill leachate (pH about 4.5) was constructed using acetic acid, sodium acetate, ferrous sulfate, glycine, pyrogallol, and pyrogallol-iron complex and was interacted with tailings from the landfill site in a packed column. The synthetic leachate mobilized substantial quantities of Pb and Zn within 1 hour after saturation of the column; however, the solution concentrations decreased thereafter. The decrease in Pb and Zn concentrations with time was interpreted to be the result of re-sorption or re-precipitation onto sediments farther down the column. Based on the quantity of Pb leached from the tailings samples during USEPA Toxicity Characteristic Leaching Procedure (TCLP) tests, Rao (1991) concluded the tailings could be classified as a hazardous waste.

The USGS began a hydrochemical investigation in the Old Lead Belt in 1988 (Smith and Schumacher, 1991, 1993). This investigation focused on the quality of surface water and sediment in the Big and Flat Rivers. Water-quality samples were collected from seven stream sites and four seeps from tailings piles in the area. In addition, the flowing drill hole west of the landfill previously sampled by the Missouri DGLS in 1980 was sampled. Although no seeps were sampled routinely at the Desloge tailings pile, Mine-A-Joe Creek downstream of the diversion tunnel (referred to as the Desloge tunnel seep by Smith and Schumacher, 1991) was routinely sampled, and a water-quality sample from a seep along the Big River downslope of monitoring well MW–106 (seep K, fig. 5) was collected during a seepage run and water-quality reconnaissance along the Big River in November 1989. The sample from seep K had a specific conductance of 1,770 μS/cm [microsiemens per centimeter at 25 °C (degrees Celsius)] and anomalously large sodium (Na) and chloride (Cl) concentrations [62 and 76 mg/L (milligrams per liter)] as compared to concentrations of those elements in other seeps in the region. Based on water-quality and discharge data collected from the Big River upstream and downstream of the Desloge tailings pile, Smith and Schumacher (1993) concluded that most of the increase in flow and changes in water quality in the Big River downstream of the pile could be attributed to inflow from the abandoned mine cavities.

Acknowledgments

The authors are grateful to the operator and other personnel of the St. Francois County Landfill for access to heavy equipment and repair facilities. Special acknowledgment is given to Alan Aubishon of the St. Francois County Landfill and Marvin Hudwalker of Hudwalker and Associates Incorporated for their help in obtaining access to historical data and preparation of drill sites. The authors give special thanks to Ron Warren of the Park Hills Water Department for his technical assistance and access to well information and water-level records. The authors are indebted to the staff of the Goggins Drilling Company and many citizens of St. Francois County for access to their wells and historical information.

METHODS OF INVESTIGATION

There were three phases to the USGS investigation of the St. Francois County Landfill. The first phase included an information search, preliminary reconnaissance of the landfill site and Desloge tailings pile, and a well inventory to provide information on the direction of regional ground-water flow. The second phase of the investigation involved a detailed reconnaissance of the site and screening sampling of seeps for values of pH, specific conductance, and temperature and concentrations of constituents commonly associated with landfill leachate such as Cl, total ammonia as nitrogen (NH_{3t}), total nitrite plus nitrate as nitrogen (NO_2+NO_{3t}), Fe, and ferrous iron (Fe^{2+}) using a portable spectrophotometer. Based on screening results, reconnaissance water-quality samples were collected from selected seeps, in addition to the landfill supply well (landfill well, fig. 5), and existing monitoring wells. A reconnaissance of regional water levels also was conducted during phase II. Based on the results of phase I and II investigations, a monitoring-well-network plan and sampling plan were prepared and submitted to the Missouri DEQ for approval before initiating phase III. During phase III, 13 monitoring wells and piezometers and 2 temporary piezometers were installed to supplement the existing ground-water monitoring network at the landfill site. Water-quality samples were collected from these additional monitoring points, the original monitoring wells, the Big River, selected seeps, and several domestic and public-supply wells in the vicinity of the landfill for analyses of an extensive list of physical properties and chemical constituents. This report, which concludes phase III, presents and interprets hydrologic and water-quality data collected throughout this investigation.

Information Search and Well Inventory

Information on the history of the landfill was obtained from records at the Missouri DEQ, Solid Waste Management Program in Jefferson City; the Missouri DGLS in Rolla; Hudwalker and Associates Incorporated, Farmington, Missouri; and the St. Francois County Landfill. Additional information was obtained from interviews with former mining employees, landfill employees, local water-well drilling contractors, and local citizens. Preliminary information on regional ground-water flow and water quality was obtained from published reports by Robertson (1963), Gann and others (1976), Imes (1990a, 1990b), Missouri Department of Natural Resources (1991), Smith and Imes (1991), and Imes and Emmett (1994). Water-quality data from the landfill site and surrounding area were obtained from records at the Missouri DEQ, Ecology and Environment (1991, 1992, 1993), Imes and Davis (1991), and Smith and Schumacher (1991, 1993).

A total of 81 wells was inventoried between 1992 and 1994 to obtain information on regional ground-water flow. The initial process involved a search of the drillers' log file and computer files of Missouri DGLS, Wellhead Protection Section for domestic and public-supply wells in St. Francois County. Wells within a 4- to 5-mi radius of the landfill were selected for possible inclusion in the well inventory. Because much of the information in these files cannot be verified, an attempt was made to visit well sites and obtain water-level, specific conductance, and temperature measurements. Two trips were made to the area during the fall of 1991 (preliminary reconnaissance) and 1992. Each onsite visit consisted of an interview with the well owner to obtain well completion data or driller's name, and water-level, specific conductance, and temperature measurements. The water level was measured to the nearest foot using a steel tape or a calibrated electric tape. For locations where surveyed altitudes were available or increased accuracy was required, water-level measurements were made to the nearest 0.01 ft. After measuring the water level, an outside faucet was turned on and water was allowed to flow for 10 to 15 minutes or until specific conductance and temperature measurements stabilized [plus or minus (±) 2 percent for specific conductance and within 0.5 °C for temperature] before the measurements were recorded. Specific conductance and temperature were measured using a specific conductance meter with temperature compensation designed to express values in microsiemens per centimeter at 25 °C. Meters were calibrated at least daily using standards bracketing the expected value for the water obtained from the USGS Water Quality Laboratory in Ocala, Florida. Before leaving the well site, the location and land-surface altitude were estimated using a 7.5-minute series USGS topographic map.

Monitoring Well and Piezometer Installation

Monitoring wells at the site use the prefix of MW– followed by a three-digit number. Piezometers are designated by a three- or four-digit number followed by the suffix –P. The 100–series monitoring wells and piezometers are completed in the tailings. The 200– and 2000–series piezometers are completed in the bedrock, and the 300–series monitoring wells are completed in the abandoned mine cavities. Monitoring well MW–109 was intended to be completed in the bedrock; however, debris (cast iron) encountered in the upper alluvium prevented further drilling, and the screen was set to intersect the contact between the tailings and the Big River alluvium. Completion data for monitoring wells, piezometers, and temporary piezometers at the site are listed in table 1 and locations are shown in figure 5.

Monitoring well MW–100 and piezometer 108–P were completed using a CME-75[1] drill rig and 8.25-in. inside-diameter (ID) hollow stem augers. Monitoring wells MW–107 and MW–109 were completed using an air rotary drill rig and an 8-in. diameter casing advancer. After the installation of the well and grout, the casing was pulled. Because of problems with tailings entering the auger flights, two 5-ft long, 0.01-in. slot prepacked polyvinyl chloride (PVC) screens were used for monitoring wells and piezometers scheduled to be completed in the tailings (MW–100, MW–107, and 108–P). No glue, cements, or sealers were used during monitoring well and piezometer installation.

Following installation of the screen, riser, and filter pack, a 1- to 3-ft thick annular seal of bentonite chips was placed above the filter pack and allowed to hydrate at least 3 hours. The remaining annulus above the bentonite annular seal was filled with Enviroplug grout using a grout pump and a side discharge tremie pipe. Monitoring wells and piezometers were developed by surging mechanically for 1 to 2 hours followed by pumping.

Bedrock piezometers 2020–P, 2021–P, 2022–P, and 2023–P were installed using an air rotary drill rig with a 6-in. diameter bit and a casing advance system. A 6-in. diameter steel surface casing was advanced behind the bit through the tailings about 3 ft into bedrock. The steel casing was pressure grouted in place using neat cement in piezometers 2020–P and 2021–P. After the cement was allowed to cure for a minimum of 24 hours, the rest of the hole was drilled. The steel casing in piezometers 2022–P and 2023–P was not grouted into place and was removed after the PVC screen and riser was installed and grouted.

A USGS 15-minute quadrangle map (dated 1905) and a series of auger borings through the tailings were used to establish the configuration of the original (premining) land surface beneath the tailings at the landfill site. With one exception, the auger borings penetrated the tailings and were drilled to refusal (presumed to be the top of weathered bedrock) using 3-in. ID hollow stem augers and a soil exploration drill rig. The altitude of the original land surface beneath the tailings pile and location of drill holes and mined areas were compiled using a geographic information system (GIS). Temporary piezometers (P–1 and P–2, fig. 2) were completed in two of the auger borings using 1.0-in. diameter schedule-40 PVC riser with glued joints and a 5-ft, 0.010-in. slotted screen.

Water and Soil Sampling Methods

Water-level measurements in monitoring wells and piezometers at the landfill site were made using a steel tape calibrated in 0.01-ft increments before the collection of water-quality samples. The tape was rinsed with deionized water before each use. Water-quality samples from monitoring wells and piezometers at the landfill site were obtained using a 2-in. diameter stainless steel submersible pump or bailers. Before 1991 the existing monitoring wells at the site (MW–101, MW–103, MW–104, MW–105, and MW–106) were sampled using disposable polyethylene bailers (MW–102 never contained water and was abandoned). The bailers were lowered slowly to minimize aeration of the water during sampling and avoid disturbing sediments below the screen. After 1991 all monitoring wells and piezometers, except those with 2-in. diameter schedule-80 PVC risers (MW–109, 201–P, 204–P, and 208–P) were sampled with a Grundfos Rediflow stainless steel submersible pump fitted with a polyethylene hose. Monitoring wells and piezometers with 2-in. diameter schedule-80 PVC riser were sampled using dedicated PVC bailers. Wells and piezometers were purged before sampling. During purging, specific conductance, pH, temperature, and dissolved-oxygen concentrations were monitored in a closed beaker, and water-quality samples were not collected until these measurements stabilized. Stabilization criteria were as follows: specific conductance, within 2 percent; pH, within 0.02 unit; temperature, within 0.1 °C; and dissolved oxygen, within 0.05 mg/L. A minimum of two pipe-volumes of water was removed from each well before sampling. Piezometer 2021–P recovered slowly, requiring more than 24 hours, and water-quality samples were collected after purging only one pipe-volume.

The landfill well and domestic wells were sampled from the faucet closest to the well. Water from the

[1] Use of product names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 1. Completion data for landfill wells and piezometers, St. Francois County Landfill site, Missouri

[mp, measuring point; --, not applicable; SH, schedule; PVC, polyvinyl chloride; <, less than]

Well (fig. 5)	Land surface (feet)	Altitude of mp (feet)	Bottom of hole (feet below land surface)	Bottom of well (feet below land surface)	Top of bedrock (feet below land surface)	Top of filter pack (feet below land surface)	Bottom of filter pack (feet below land surface)	Top of screen (feet below land surface)	Casing diameter (inches)	Casing type	Filter type	Top annular seal (feet below land surface)	Surface casing (feet below land surface)
MW-100	782	783.3	71.5	70.0	--	56.5	67.5	[1]59.6	2	SH40 PVC	WB35	54.5	--
MW-101[2]	780	782.03	37.5	36.4	37.5	20.4	37.5	21.4	2	SH40 PVC	WB40	19.4	--
MW-102[2]	784	786	48.5	48.0	--	27	48.5	28	2	SH40 PVC	WB40	26	--
MW-103[2]	796	796.19	29.5	29.5	29.5	3.5	29.5	4.5	2	SH40 PVC	WB40	2.5	--
MW-104[2]	784	785.88	45	43	45	27	45	28	2	SH40 PVC	WB40	26	--
MW-105[2]	768	769.78	29	29	29	16.7	29	19	2	SH40 PVC	WB40	15.7	--
MW-106[2]	683	683.1	10.4	10.1	--	3	10.4	5.1	2	SH40 PVC	WB40	0	--
MW-107	783.96	786.61	103	103	102	87	103	[1]91.8	4	SH40 PVC	WB10-20	85	--
108-P	759.9	762.93	52.5	52.1	52.5	37.2	52.1	[1]41.7	2	SH40 PVC	WB10-20	34	--
MW-109	783.24	786.4	114	107.9	--	94	108.5	97.5	2	SH80 PVC	WB10-20	91	--
201-P	779.34	781.84	84.3	77.9	15	65	80.1	67.5	2	SH80 PVC	WB10-20	63	--
204-P	785.45	788.72	80	78.9	46	65.5	80	68.5	2	SH80 PVC	WB10-20	61	55
205-P	765.7	768.08	74	64.4	17.5	51	69	54	2	SH40 PVC	WB20-40	50	--
208-P	760.91	762.39	71.4	70.8	50.5	58.4	71.4	60.4	2	SH80 PVC	WB10-20	57.2	53
2020-P	781	783.77	95.95	94.4	28.2	81	95.95	84	2	SH40 PVC	WB10-20	76	28
2021-P	791	793.19	86.5	86.0	21	71.5	86.48	75.6	2	SH40 PVC	WB10-20	67.2	29
2022-P	785	788.19	80.7	79.7	4.0	67.3	80.7	69.3	2	SH40 PVC	WB10-20	66	--
2023-P	762	765.05	67.6	65.9	15	51.6	67.6	55.5	2	SH40 PVC	WB10-20	49.15	--
MW-303	796.25	799.25	231	231	23	--	--	--	4	SH40 PVC	--	--	188
Landfill well[3]	788	789.4	215	215	<10	--	--	--	6	SH40 PVC	--	--	80
P-1	760	763	48	37.7	49.0	--	--	32.5	1	SH40 PVC	--	--	--
P-2	779	782.38	61.5	59.3	--	53.0	61.5	54.3	1	SH40 PVC	WB20	35	--

[1] Prepacked screen.
[2] Well installed by Geotechnology, Inc.
[3] Data obtained from Goggins Drilling Company (written commun., 1992).

faucet was allowed to flow freely, and specific conductance, pH, temperature, and dissolved-oxygen concentrations were monitored in a closed beaker. Municipal wells were sampled in a similar manner from a tap at the wellhead.

Discharges of seeps were measured or estimated; measurements of specific conductance, pH, temperature, and dissolved oxygen were made directly at the seep orifice. Seeps were sampled by placing a clean 500-mL (milliliter) polyethylene bottle below the orifice or digging a small hole to form a pool in which the bottle could be immersed. The bottle was filled and contents emptied into a churn splitter until a sufficient volume was collected. Samples for volatile organic compounds (VOC) were collected by filling each 40-mL VOC vial directly from the seep. No seeps were sampled for pesticides.

Discharge and water quality were determined for streams at the landfill site. Stream discharges were measured using a standard AA current meter or a pygmy current meter according to the methods described by Rantz and others (1982). Where streamflow was not sufficient for the above methods, the discharge was estimated. Discharge measurements and water-quality samples were collected from the Big River upstream of the landfill by wading several feet upstream of a low-water crossing referred to locally as the "Bone-hole." Discharge measurements and water-quality samples were collected downstream of the landfill by wading a narrow section of the Big River approximately 100 ft downstream of monitoring well MW–106. Depth integrated water-quality samples were collected using a hand-held DH-48-TM sampler (Ward and Harr, 1990). A minimum of 10 separate subsamples was collected at equal-width intervals across the stream and composited using a churn splitter. Where flow conditions were not sufficient to use a DH-48-TM, grab samples from the centroid of flow were made using a 500-mL polyethylene bottle and composited in a churn splitter. Values of specific conductance, pH, and temperature and dissolved-oxygen concentrations were measured directly in the stream near the centroid of flow and in a subsample from the churn splitter. Samples for VOC were collected from the Big River by filling the vials directly from the centroid of flow. No pesticide samples were collected from the Big River.

The specific conductance of water samples was measured using a portable specific conductance meter with temperature compensation designed to express values in microsiemens per centimeter at 25 °C. The meter was calibrated before each measurement using standards prepared by the USGS Water Quality Laboratory in Ocala, Florida. The pH was measured using a portable pH meter calibrated with standard buffers bracketing the expected sample pH before each measurement. Temperature was measured to the nearest 0.1 °C using a thermistor attached to the pH meter. Dissolved-oxygen concentrations were determined by colorimetry to the nearest 0.05 mg/L using a diethylene glycol and rhodazine-D method. This method was applicable for concentrations of dissolved oxygen ranging from 0.05 to 1.0 mg/L. An indigo carmine method was used for concentrations greater than 1 mg/L. Total alkalinity [$Alk_{(IT)}$] was determined by using incremental titration of 0.16 normal standardized sulfuric acid into 25 mL of sample past the carbonate-bicarbonate inflection point (approximately pH 8.3) and the bicarbonate-carbonic acid inflection point (approximately pH 4.5). Concentrations of carbonate (CO_3), bicarbonate (HCO_3), and CO_3 alkalinity were later computed using a computer program to integrate the rate of pH change to the equivalence of acid added.

Inorganic chemical constituents referred to as "dissolved" were filtered through a disposable capsule filter comprised of a 0.45-µm (micrometer) pore-size polysulfone filter encased in a polycarbonate housing. Samples from monitoring wells and piezometers collected with the submersible pump were filtered by decreasing the pumping rate to less than 500 mL per minute and fitting the filter to the end of the pump hose. Samples from all other locations were filtered after collecting several liters of water in a churn splitter (glass bottle for organic constituents) for transport to a vehicle where aliquots were filtered using a disposable capsule filter and a peristaltic pump. Before 1993, samples were filtered through a 142-mm (millimeter) diameter, 0.45-µm pore size cellulose-nitrate membrane filter placed in a leucite holder. A peristaltic pump was used as the pressure source for filtration. Samples for dissolved cations were collected in acid-washed polyethylene bottles directly from the filter outlet and preserved with nitric acid to a pH less than 2. Samples for dissolved anions were placed into clean polyethylene bottles. Samples for dissolved nutrients [nitrogen (N) and phosphorous (P) species] were placed in amber polyethylene bottles, preserved by adding 1 mL of 10^{-4} molar mercuric chloride, and chilled to 4 °C. Samples for total recoverable cations from monitoring wells and piezometers were collected in acid-rinsed polyethylene bottles directly from the pump outlet, bailer, or churn splitter and acidified to a pH less than 2 with nitric acid. Samples for chemical oxygen demand (COD) were collected in 250-mL glass bottles and preserved with 1 mL sulfuric acid. Total organic carbon (TOC) samples were collected in 250-mL amber glass bottles and preserved by chilling to 4 °C. Samples for tritium determinations were collected in 1-L (liter) glass bottles filled from the bottom using a silicon hose to exclude any contact with the atmosphere. Inorganic constituents and tritium determinations were made according to the methods described by Fishman and Friedman (1989). Concentrations of inorganic constituents and determinations of COD and TOC were made according to the procedures outlined in Fishman and Friedman (1989) and Wershaw and others (1983).

Samples for the determination of VOC were collected in 40-mL amber glass vials with a Teflon septum cap. Each sample consisted of six vials: two vials acidified to pH of 2 with 12 normal organic-free hydrochloric acid (HCl), two vials acidified to pH 5 with 3 normal organic-free HCl, and two vials unpreserved. After preservation the vials were chilled to 4 °C and shipped overnight to the USGS National Water Quality Laboratory in Arvada, Colorado. Concentrations of VOC were determined using purge and trap capillary gas chromatography/mass spectrometry (GC/MS) according to USEPA method 524.2 (U.S. Environmental Protection Agency, 1983). The VOC targeted were those required under assessment monitoring of sanitary landfills (Code of Federal Regulations, 1992), in addition to a number of other VOC. A complete list of the target and nontarget VOC, detection levels, and selected USEPA drinking water regulatory limits is given in table 2.

Samples for total organic halogens (TOX) were collected in baked 1-L amber glass bottles with Teflon septum caps. The samples were acidified to pH 2 with 36 normal sulfuric acid, chilled to 4 °C, and shipped overnight to a contract laboratory in St. Louis, Missouri. Analyses were performed using carbon adsorption with a microcoulometric-titration detector. The method is sensitive to dissolved organic halides containing chlorine, bromine, and iodine that are absorbed by granular activated carbon. Concentrations of TOX are reported as micrograms per liter chlorine.

Samples were collected in September 1993 for analysis of selected pesticides. Pesticide samples were filtered through a 142-mm diameter 0.7-μm pore size baked glass-fiber filter placed in an aluminum holder. A fluid-metering pump was used as the pressure source. The filter holder and all hoses were rinsed with a 10 percent non-phosphate detergent solution, triple rinsed with organic-free water, and rinsed with ultrapure methanol between each site. The filtrate was placed in a 1-L amber, baked-glass bottle and chilled immediately. Pesticide determinations were made by GC/MS using solid-phase extraction techniques described by Thurman and others (1990). The list of target pesticides, detection levels, and selected USEPA drinking water regulatory limits is given in table 2.

Soil and tailings samples were collected using a 2-in. diameter stainless steel split spoon during the installation of monitoring wells MW–100 and MW–107 and piezometer 108–P. Samples were placed into 1-L wide-mouth jars and shipped to the USGS geochemistry laboratory in Denver, Colorado. Bulk mineralogic and chemical analyses were performed according to procedures described in Starkey and others (1984), Taggart and others (1987), and Davis (1988).

Equipment blanks were collected at the conclusion of each sampling trip. Organic- and inorganic-free water was pumped through the submersible pump and hose and processed in a similar manner to groundwater samples. Concentrations of major inorganic constituents were less than 0.5 mg/L, and concentrations of nutrients were less than 0.01 mg/L in all blanks. Several blanks contained detectable concentrations of dissolved Fe (less than 3–5 μg/L), total iron (Fe_t; 20–60 μg/L), Pb_t (3–4 μg/L), and total manganese (Mn_t; less than 1–6 μg/L). Except for one VOC blank collected in April 1993, none of the blanks contained detectable concentrations of VOC. Detections in the April 1993 blank were traced to contaminated HCl used to preserve the blank sample.

GENERAL CHARACTERISTICS OF MUNICIPAL SOLID WASTE AND LEACHATE PRODUCTION

Before regulatory legislation, most municipal solid waste in the United States was contained in open dumps. The exposed waste created public concern, and sanitary landfills became the predominant method of waste disposal. Sanitary landfills require excavating cells of overburden, filling the cell with waste, and covering with soil.

Table 2. Detection levels and drinking water regulatory limits for organic compounds

[µg/L, micrograms per liter; MCLG, maximum contaminant level goal; MCL, maximum contaminant level; DWEL, drinking water equivalent level; <, less than; --, no data]

Chemical family	Organic compound	Detection level (µg/L)	Drinking water regulatory limits[1] MCLG (µg/L)	MCL (µg/L)	DWEL (µg/L)
	Volatile organic compounds				
Substituted methane	Bromomethane	<0.2	--	--	40
	Dibromomethane	<.2	--	--	--
	Bromoform	<.2	0	100	700
	Bromochloromethane	<.2	--	--	--
	Dibromochloromethane	<.2	0	100	700
	Chloromethane	<.2	--	--	100
	Dichloromethane	<.2	0	5	2,000
	Trichloromethane (chloroform)	<.2	0	100	400
	Carbon tetrachloride	<.2	0	5	30
	Chlorofluoromethane[2]	<.2	--	--	--
	Dichlorobromomethane	<.2	0	100	700
	Dichlorofluoromethane[2]	<.2	--	--	--
	Dichlorodifluoromethane	<.2	--	--	5,000
	Trichlorofluoromethane	<.2	--	--	--
	Methyl iodide	<.5	--	--	--
	Carbon disulfide (CS_2)	<.2	--	--	--
Substituted ethane	Chloroethane	<.2	--	--	--
	1,2-Dibromoethane (EDB)	<.2	0	.05	--
	1,1-Dichloroethane (DCA)	<.2	--	--	--
	1,2-Dichloroethane	<.2	0	5	--
	1,1,1-Trichloroethane (TCA)	<.2	200	200	1,000
	1,1,2-Trichloroethane	<.2	3	5	100
	1,1,1,2-Tetrachloroethane	<.2	--	--	1,000
	1,1,2,2-Tetrachloroethane	<.2	--	--	--
	Trichlorotrifluoroethane	<.5	--	--	--
Substituted ethene	Vinyl chloride (VC)	<.2	0	5	--
	1,1-Dichloroethene (1,1-DCE)	<.2	7	7	400
	cis-1,2-Dichloroethene (cis-DCE)	<.2	7	70	400
	trans-1,2-Dichloroethene (trans-DCE)	<.2	100	100	600
	1,1,2-Trichloroethene (TCE)	<.2	0	5	300
	1,1,2,2-Tetrachloroethene (PCE)	<.2	0	5	500
Substituted propane	1,2-Dichloropropane	<.2	0	5	--
	1,2,3-Trichloropropane	<.2	--	--	200
	1,2-Dibromo-3-chloropropane (DBCP)	<1.0	0	.2	--
Substituted propene	cis-1,3-Dichloropropene	<.2	--	--	--
	trans-1,3-Dichloropropene	<.2	--	--	--

Table 2. Detection levels and drinking water regulatory limits for organic compounds—Continued

Chemical family	Organic compound	Detection level (µg/L)	Drinking water regulatory limits[1] MCLG (µg/L)	MCL (µg/L)	DWEL (µg/L)
	Volatile organic compounds—Continued				
Substituted butene	trans-1,4-Dichloro-2-butene	<1.0	--	--	--
Benzene derivitives	Benzene	<.2	0	5	--
	Chlorobenzene	<.2	100	100	700
	1,2-Dichlorobenzene	<.2	600	600	3,000
	1,3-Dichlorobenzene	<.2	600	600	3,000
	1,4-Dichlorobenzene	<.2	75	75	4,000
	Ethylbenzene	<.2	700	700	3,000
	Xylenes (total)	<.2	10,000	10,000	60,000
	Styrene	<.2	100	100	7,000
	Toluene	<.2	1,000	1,000	7,000
	Napthalene[2]	<.2	--	--	100
Ether	2-Chloroethylvinylether	<.2	--	--	--
	Methyltertiarybutyl ether (MTBE)	<.2	--	--	200
	Ethyl ether[2]	<.2	--	--	--
Aldehyde	Acrolein	<20	--	--	--
Ketone	Acetone	<5	--	--	--
	2-Butanone (Methyl ethyl ketone)	<20	--	--	--
	2-Hexanone (Methyl butyl ketone)	<20	--	--	--
	4-Methyl-2-pentanone (MIBK)	<20	--	--	--
Ester	Vinyl acetate	<20	--	--	--
Nitrile	Acrylonitrile	<20	0	--	--
	Pesticides				
Acetanilide	Alachlor	<0.009	0	2	400
Amide	Napropamide	<.01	--	--	--
	Propanil	<.016	--	--	--
Benzamide	Pronamide	<.009	--	--	3,000
Benzenamine	Ethalfluralin	<.013	--	--	--
Carbamate	Butylate	<.008	--	--	2,000
	Carbaryl	<.046	--	--	4,000
	Carbofuran	<.013	40	40	200
	s-Ethyldipropylthiocarbamate (EPTC)	<.005	--	--	--
	Pebulate	<.009	--	--	--
	Thiobencarb	<.008	--	--	--
Carbothioate	Molinate	<.007	--	--	--

Table 2. Detection levels and drinking water regulatory limits for organic compounds—Continued

Chemical family	Organic compound	Detection level (µg/L)	Drinking water regulatory limits[1]		
			MCLG (µg/L)	MCL (µg/L)	DWEL (µg/L)
	Pesticides—Continued				
Chloracetanilide	Metolachlor	<0.009	--	--	5,000
	Propachlor	<.015	--	--	500
Cyclohexane	Alpha benzenehexachloride (BHC)	<.007	--	--	--
	Lindane	<.011	0.2	0.2	10
Dichloroethylene	2,6 Diethylaniline	<.006	--	--	--
	p,p'-Dichlorodiphenyldichlrorethylene (DDE)	<.01	--	--	--
Dinitroaniline	Pendimethalin	<.018	--	--	--
	Trifluralin	<.012	--	--	300
Methyluracil	Terbacil	<.03	--	--	400
Napthalene	Dieldrin	<.008	--	--	2
Organophosphate	Ethoprop	<.012	--	--	--
	Malathion	<.01	--	--	800
	Methyl parathion	<.035	--	--	9
	Parathion	<.022	--	--	--
	Phorate	<.011	--	--	--
	Terbufos	<.012	--	--	5
Organophosphorus	Disulfoton	<.008	--	--	1
	Methyl azinphos	<.038	--	--	--
Phosphonodithioate	Fonofos	<.008	--	--	70
	Dimethoate	<.024	--	--	--
Phosphorothioate	Chlorpyrifos	<.005	--	--	100
	Diazinon	<.008	--	--	--
Pyrethroid	Permethrin	<.016	--	--	--
Substituted urea	Linuron	<.039	--	--	--
	Tebuthiuron	<.015	--	--	2,000
Sulfite ester	Propargite	<.006	--	--	--
Terepthalate/dimethyl	Dimethyl tetrachloroterephtalate (DCPA)	<.004	--	--	4,000
Thiocaramate	Triallate	<.008	--	--	--
Toluidine	Benfluralin	<.013	--	--	--
Triazine	Atrazine	<.017	3	3	200
	Cyanazine	<.013	1	--	70
	Desethyl atrazine	<.007	--	--	200
	Prometon	<.008	--	--	500
	Simazine	<.008	4	4	200
Triazinone	Metribuzin	<.012	--	--	900

[1] U.S. Environmental Protection Agency (1993).
[2] Non-target compound, estimated detection level.

Waste Composition

Tchobanoglous and others (1977) reported the typical composition of municipal solid wastes in percent by weight of the most readily identified components (table 3). Nearly 80 percent of typical solid waste is made of cellulose and will decompose readily. The remaining 20 percent degrades extremely slowly. The rate and degree of initial decomposition depends on the amount of moisture present in the material. Moisture content is important in determining whether the degradation process is predominantly aerobic or anaerobic. The components of the waste also affect the amount of water available for degradation processes. For example, if the waste contains large amounts of food, it has a greater moisture content; with large amounts of paper, moisture is absorbed. Moisture content of typical municipal solid waste is reported in table 3.

Table 3. Typical physical composition of municipal solid waste and moisture content of waste components

[--, no data; modified from Tchobanoglous and others (1977)]

Component	Percent composition (by weight)		Moisture content (percent by weight)	
	Range	Typical	Range	Typical
Food wastes	6-26	15	50-80	70
Paper	25-45	40	4-10	6
Cardboard	3-15	4	4-8	5
Plastics	2-8	3	1-4	2
Textiles	0-4	2	6-15	10
Rubber	0-2	.5	1-4	2
Leather	0-2	.5	8-12	10
Garden trimmings	0-20	12	30-80	60
Wood	1-4	2	15-40	20
Glass	4-16	8	1-4	2
Tin cans	2-8	6	2-4	3
Nonferrous metals	0-1	1	2-4	2
Ferrous metals	1-4	2	2-6	3
Dirt, ashes, and brick	0-10	4	6-12	8
Municipal solid wastes (composite of above components)	--	--	15-40	20

Waste Degradation and Leachate Production

After burial, waste is affected by several processes, including biological decay, dissolution, precipitation and sorption of chemical constituents, leaching of sediments, ion exchange, generation and diffusion of gases, and movement of dissolved materials. Degradation processes depend on the composition of the waste, the degree of sorting and compaction, moisture content, and temperature. The rate of microorganism activity is controlled by temperature, oxygen availability, and type and availability of organic material (Baedecker and Back, 1979). The largest number of microorganisms grow in buried waste when the temperature ranges from 15 to 30 °C (Dobson, 1964). The degradation phases of typical municipal solid waste are delineated by the gas composition in the landfill cell and by the concentrations of chemicals in the landfill leachate (fig. 6).

The easily degradable components of waste, such as food and yard waste, are subject to aerobic decomposition almost immediately after burial. This occurs in an oxidizing environment, represented by phase 1 shown in figure 6. The end products of aerobic degradation are carbon dioxide (CO_2), water, sulfate (SO_4), and ammonia as nitrogen (NH_3; Baedecker and Back, 1979). Aerobic degradation may be complete in a few days or weeks (Tchobanoglous and others, 1977).

Water is produced during aerobic degradation, thereby making a greater amount of moisture available for anaerobic decomposition processes. The anaerobic degradation processes are represented by phases 2, 3, and 4 (fig. 6). Anaerobic degradation produces substantial quantities of methane. The volumes of CO_2, hydrogen (H), volatile fatty acids, NH_3, SO_4, and Zn in leachate peak during these phases. The COD peaks in phase 2, then decreases sharply. The CO_2 derived from aerobic degradation readily dissolves in leachate, increasing the alkalinity of the leachate. During phase 2, pH is at its lowest value and, if calcium carbonate ($CaCO_3$) is present in the fill or cover, it may be dissolved by the acidic leachate. The pH value of leachate begins to increase gradually during phase 3 and stabilizes in phase 4.

Anaerobic degradation processes occur rapidly. Methane production peaks within 2 years then declines for 25 years or more (Tchobanoglous and others, 1977). During phase 5, methane production decreases substantially, and some zones in upper landfill layers may become aerobic. Until this phase, N is

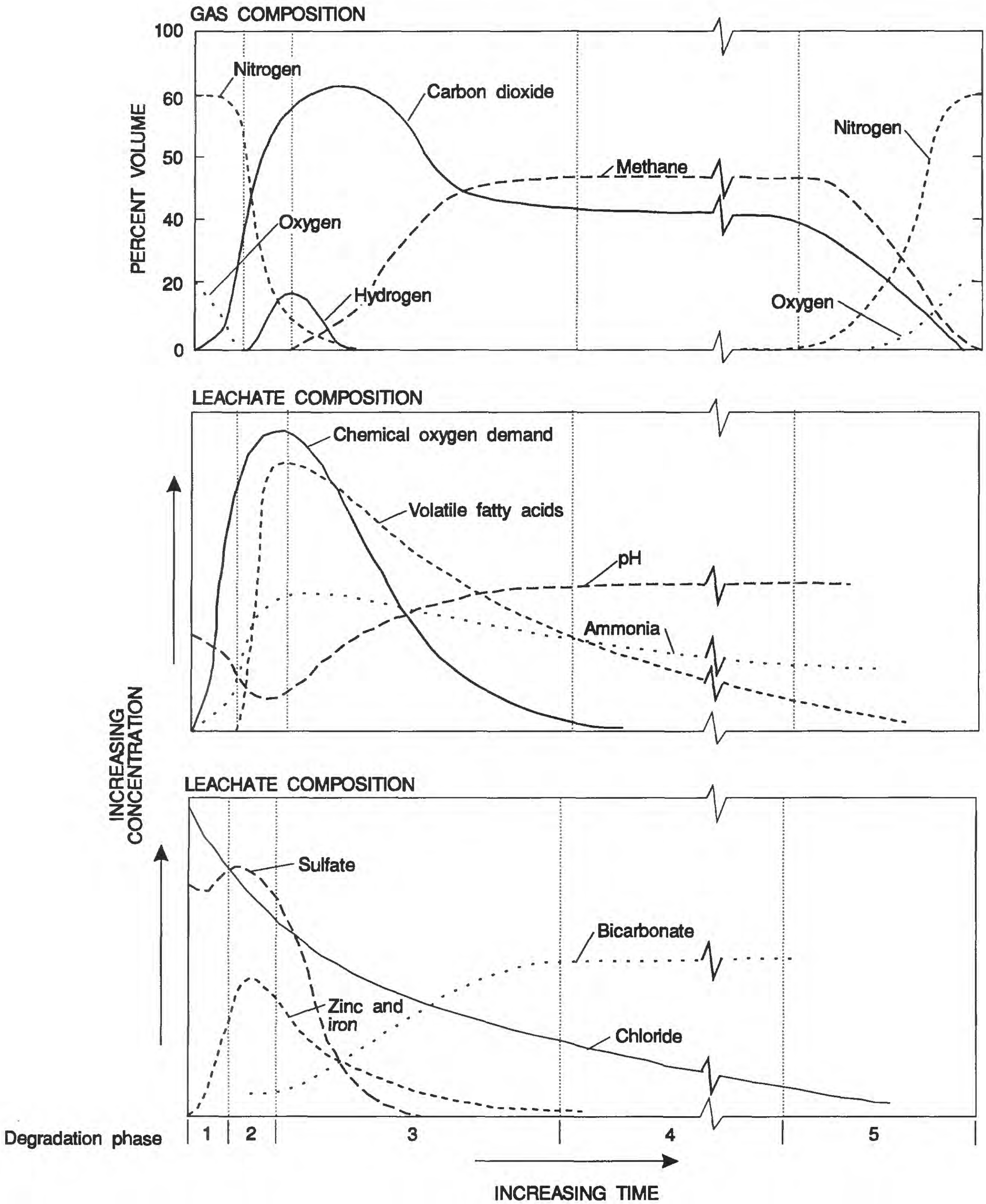


Figure 6. Phases of solid waste degradation and leachate production (modified from Christiansen and others, 1989).

present mainly as NH_3 from anaerobic degradation, but during phase 5 nitrogen gas (N_2) diffuses from the atmosphere into the soil.

Large concentrations of inorganic constituents such as calcium (Ca), Na, Cl, Fe, SO_4, and NH_3 are common in landfill leachate (Uhlman, 1989). The Cl concentration is highest during the initial stages of decomposition and decreases thereafter. Ideally, the products of complete anaerobic degradation of sanitary refuse are methane, water, and CO_2 (Baedecker and Back, 1979). Bicarbonate is a product of anaerobic degradation and is produced when CO_2 dissolves in landfill leachate. Bicarbonate also may come from ash, soil, and rock in the landfill. Sulfate produced by aerobic degradation processes is reduced to sulfide (S^{2-}) during the anaerobic phases. The S^{2-} may be removed by precipitation of insoluble sulfides, such as pyrite (FeS_2), or evolve as hydrogen sulfide (H_2S) gas. The presence of bacterially generated organic acids in leachate increases its capacity to dissolve and transport trace inorganic constituents. Acidic leachate seeping through the waste and earth materials below the landfill may cause some trace constituents to dissolve. Complexes with organic ligands also may increase trace constituent solubility.

The most commonly detected organic compounds are chlorinated solvents, petroleum derived hydrocarbons, and pesticides (Borden and Yanoshak, 1990). Ranges of concentration of the most common constituents of landfill leachate from several studies are shown in table 4. The concentrations of various constituents in landfill leachate vary with the age of the landfill and decrease with time.

SURFACE-WATER HYDROLOGY

The Big River is the principal stream in the region, flowing eastward and northward through the Old Lead Belt (fig. 1). The USGS maintains a continuously recording gaging station on the Big River about 15 mi upstream of the landfill site at Irondale, Missouri. The maximum recorded instantaneous discharge of 49,100 ft^3/s (Reed and others, 1995) at this gage occurred on November 14, 1993, after a series of intense rains. The minimum recorded instantaneous discharge of 2.5 ft^3/s (Reed and others, 1995) occurred on September 15, 1971. The estimated 7-day 2-year low flow of the Big River in the vicinity of the landfill site is about 12 ft^3/s (Skelton, 1976). A seepage run along the Big River during low-flow conditions in September and November of 1989 (Smith and Schumacher, 1993) indicated the discharge of the Big River increased more than 10 percent in the vicinity of the landfill site. Most of this increase was attributed to inflow from the abandoned mines through flowing drill holes and diffuse inflow from ground-water sources. The principal tributary to the Big River is the Flat River, which enters the Big River about 3.5 mi downstream of the landfill site (fig. 1). The Flat River is an intermittent stream that gains flow along some reaches and may lose flow along others.

Surface-water drainage from most of the landfill site flows through a drainage structure near the landfill office and enters Mine-A-Joe Creek near the entrance to the diversion tunnel. Most of the runoff from this area is ponded upstream of the drainage structure to settle most suspended solids before the runoff is released. A small amount of drainage from the southeastern part of the landfill and southern part of the chat pile flows through a small culvert at the southeast corner of the landfill property near piezometer 201–P (figs. 2 and 5). This flow enters Mine-A-Joe Creek about 1,000 ft upstream of the diversion tunnel. Drainage from the northern part of the landfill site and northwest part of the chat pile flows into a flat area southwest of monitoring well MW–101. After intense rain in this area, runoff ponds gradually drain through a small ditch into the Big River west of the landfill. A small closed depression containing piezometer 2021–P collects runoff from about 10 acres of the landfill site and chat pile. This depression holds water for several days after an intense rain, after which the water infiltrates into the tailings or evaporates. Until about 1993, a similar closed depression was immediately east and upslope from monitoring well MW–105.

HYDROGEOLOGY

The St. Francois County Landfill lies within the Old Lead Belt on the northern flank of a positive structure known as the St. Francois Mountains. The St. Francois Mountains are the core of a much larger structural feature called the Ozark Uplift, which dominates the geology of southern Missouri and northern Arkansas. The hydrogeology of the Old Lead Belt region is complex because of the structural framework, varied lithologies, and presence of extensive subsurface mine workings.

Table 4. Common constituents of landfill leachate

[All concentrations in milligrams per liter unless noted otherwise; --, no data; <, less than]

Parameter	Tchobanoglous[1]	Cameron[2]	Salvato[3]	Kunkle[4]
pH, in standard units	5.3-8.5	3.7-8.5	5.6-8.3	5.84-6.16
Biological oxygen demand (BOD)	2,000-30,000	9-55,000	7,050-32,400	13,800-16,800
Chemical oxygen demand (COD)	3,000-45,000	0-9,000	7,130	46,600-52,400
Total organic carbon (TOC)	1,500-20,000	--	--	9,250-10,300
Hardness	300-10,000	0-22,800	500-8,700	12,800
Alkalinity	1,000-10,000	0-20,900	1,290-8,100	7,030-7,820
Total dissolved solids (TDS)	--	0-42,300	2,000-11,254	5,661-6,086
Chloride	100-3,000	34-2,800	220-2,240	1,325-1,375
Ammonia	10-800	0-1,106	141-845	336-340
Nitrate	5-40	--	5-18	<.01
Phosphorus	1-70	0-154	--	.01-.03
Sulfate	100-1,500	1-1,826	24-1,220	265-411
Calcium	200-3,000	5-4,000	--	2,230
Magnesium	50-1,500	16.5-15,600	--	727
Potassium	200-2,000	2.8-3,770	655-1,860	680
Sodium	200-2,000	0-7,700	350-1,805	1,440
Arsenic, in micrograms per liter	--	0-11.6	--	.13
Boron, in micrograms per liter	--	.3-73	--	--
Iron, in micrograms per liter	50-600	.2-5,500	219-336	1,510
Lead, in micrograms per liter	--	0-5.0	--	4.9
Manganese, in micrograms per liter	--	.06-1,400	--	57
Nickel, in micrograms per liter	--	.01-.8	--	.84
Zinc, in micrograms per liter	--	0-1,000	--	7.8

[1] Tchobanoglous and others (1977).
[2] Cameron (1978).
[3] Salvato and others (1971).
[4] Kunkle and Shade (1976).

Geology

The St. Francois Mountains are comprised of Precambrian igneous rocks, mainly rhyolitic porphyries and granites intruded by felsic and diabasic rocks. The porphyries and granites are the oldest rocks in the region. Many of the intrusive structures have been eroded to form knobs, some of which are exposed at the surface about 5 mi south of the landfill site. Other principle structural features in the region include the Simms Mountain Fault System, trending northwest about 5 mi southwest of the site, the Big River Fault System about 4 mi to the northwest, and the Farmington Anticline to the northeast (fig. 7). Numerous steeply dipping faults with displacements of more than 100 ft have been mapped in the Old Lead Belt (Snyder and Gerdemann, 1968); however, no such faults have been mapped within 1 mi of the landfill site.

Drill logs from public-supply wells in Leadwood and Gumbo indicate that about 550 to 700 ft of Paleozoic sedimentary rocks overlie the Precambrian rocks in the vicinity of the landfill site. Paleozoic rocks in the region are the Lamotte Sandstone, Bon-

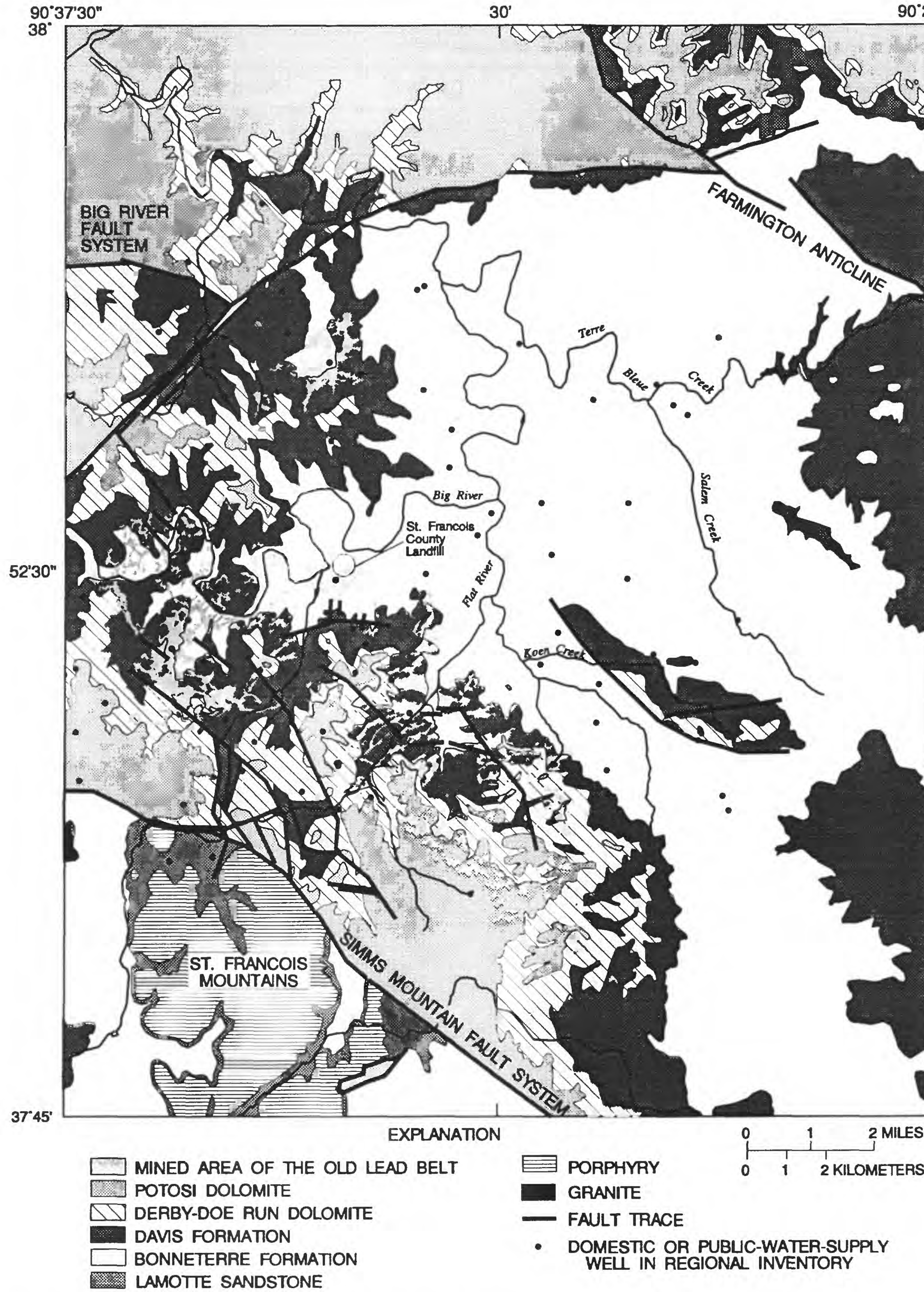


Figure 7. Regional geology in the vicinity of the St. Francois County Landfill site, Missouri (geology modified from Buckley, 1908).

neterre Formation, Davis Formation, Derby-Doe Run Dolomite, and Potosi Dolomite[2] (fig. 8).

The Lamotte Sandstone is the oldest Paleozoic rock in the region and unconformably overlies the Precambrian rocks. The formation crops out along the south side of the Simms Mountain Fault System southwest of the site (fig. 7). The Lamotte Sandstone is a quartzose sandstone with occasional siltstone or dolomitic beds in the upper part (Snyder and Gerdemann, 1968). The unit grades laterally into an arkose and conglomerate near Precambrian knobs, and in some localized areas, the upper part of the unit is mineralized. The thickness of the unit varies considerably in the region but may be as much as 500 ft in depressions between Precambrian knobs. Drill logs from three public-supply wells in Leadwood and Gumbo indicate the Lamotte Sandstone ranges from 120 to 275 ft thick.

The Bonneterre Formation crops out throughout a large part of the Old Lead Belt. It lies directly beneath the Desloge tailings pile and landfill site. This formation was the primary host rock for the vast Pb ore deposits in the Old Lead Belt. In this region, the Bonneterre Formation generally is a light gray, fine- to medium-grained, medium- to thickly bedded dolostone. Typically the Bonneterre Formation is about 375 to 400 ft thick; however, the thickness varies considerably in the Old Lead Belt because of local structure and erosion where the formation crops out. The lower 100 ft contains a variety of depositional structures where the richest ore was concentrated. The middle part of the formation generally is massively bedded with thin shale interbeds. This part of the formation is exposed along the walls of the diversion tunnel and in bluffs along the Big River immediately north of the chat pile. The formation contains well defined joints, most trending about N. 54° W and N. 83° W. Drill logs from public-supply wells in Leadwood and Gumbo indicate a range of thickness from 210 to 415 ft. The contact between the Bonneterre Formation and Lamotte Sandstone is about 280 ft below the surface of the tailings pile, an altitude of about 500 ft.

The Davis Formation unconformably overlies the Bonneterre Formation. The predominant lithology in the Old Lead Belt is shale with interbedded carbonates and glauconitic sandstones and siltstones. A complete section of the Davis Formation is exposed along State Highway 8 about 2 mi west of the landfill site. Thompson and Palmer (1987) described this section in detail and reported the formation to be 170 ft thick. The unit is not present beneath the Desloge tailings pile or the landfill, but is exposed north and west of the Desloge tailings pile across the Big River.

The Derby-Doe Run Dolomite is undifferentiated in the region. The upper part is a massive oolitic dolostone or algal reef dolostone and the lower part is a thin-bedded, argillaceous dolostone with glauconite. The thickness of the Derby-Doe Run Dolomite ranges from 0 to 200 ft, but commonly is about 150 ft thick.

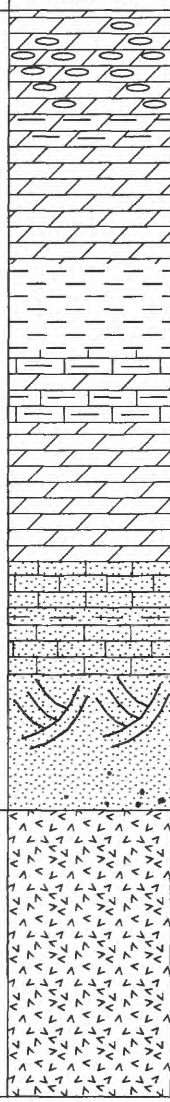
The Potosi Dolomite is the youngest formation exposed in the region. The formation is a brown, massively bedded, siliceous dolostone containing quartz druse, and averages about 200 ft thick. The Potosi Dolomite contains abundant karst features, such as solution channels, caves, and sinkholes.

Regional Hydrogeology

Hydrogeologic units have been defined in the Old Lead Belt (fig. 8). This definition was made as part of the USGS Central Midwest Regional Aquifer-System Analysis (Jorgenson and Signor, 1981), which was conducted to gain information on the flow regime and geohydrologic properties of regional aquifer systems in the Midwest.

The Lamotte Sandstone and Bonneterre Formation comprise the St. Francois aquifer in eastern Missouri (Imes, 1990a). The St. Francois aquifer is the lowermost aquifer in the Ozark Plateaus aquifer system. It is underlain by the basement confining unit that is composed of Precambrian rocks. The St. Francois County Landfill lies within the recharge area for the St. Francois aquifer. The aquifer is used extensively for domestic and public-water supply throughout the outcrop area in and around the St. Francois Mountains. The hydraulic conductivity of the aquifer was computed from specific capacity data by Imes (1990a) and ranges from 10^{-6} to 10^{-4} ft/s with a general decrease in values with distance from the St. Francois Mountains. Most public-supply wells are completed in the Lamotte Sandstone and lower Bonneterre Formation, and wells with an appreciable thickness of Lamotte Sandstone typically yield 100 to 500 gal/min (gallons per minute). Generally only domestic wells are completed in the Bonneterre Formation, and these wells yield about 1 to 10 gal/min.

[2] Nomenclature follows usage of the Missouri Department of Natural Resources, Division of Geology and Land Survey.



ERATHEM	SYSTEM	GEOLOGIC UNIT	TYPICAL THICKNESS, IN FEET	LITHOLOGY	HYDROGEOLOGIC UNIT
Paleozoic	Cambrian	Potosi Dolomite	75-300	Massively bedded dolostone with algal reefs, recrystalized dolomite, and quartz druse	Ozark aquifer
		Derby-Doe Run Dolomite	0-200	Massive dolostone and thin-bedded argillaceous dolostone	St. Francois confining unit
		Davis Formation	0-225	Calcareous shale with dolostone, limestone conglomerate, and limestone	
		Bonneterre Formation	375-400	Fine- to medium-grained, medium- to thickly bedded dolostone	St. Francois aquifer
		Lamotte Sandstone	0-500	Sandstone with occasional siltstone or dolomitic beds	
Precambrian		St. Francois Mountains (intrusive and volcanic rocks)	Greater than 4,000	Granite and volcanic rocks, including porphyry	Basement confining unit

Figure 8. Generalized stratigraphic column for the Old Lead Belt area, southeastern Missouri (modified from Smith and Imes, 1991).

The Davis Formation and the Derby-Doe Run Dolomite comprise the St. Francois confining unit. This is the lowermost confining unit in the Ozark Plateaus aquifer system. Quantitative measurements of lateral hydraulic conductivity of the confining unit are not available; however, vertical hydraulic conductivity of the confining unit derived from ground-water simulations is about 10^{-8} ft/s (Imes and Emmett, 1994). The confining unit crops out throughout most of the western part of the Old Lead Belt; however, it is not present at the landfill site or throughout most of the central part of the region (fig. 7), where the St. Francois aquifer crops out.

Water levels in the Old Lead Belt have changed dramatically as the result of past mining activities. Before 1972, the mines and much of the adjacent St. Francois aquifer were dewatered. Just before the mine pumps were shut off in 1972, an estimated 14 Mgal/d (million gallons per day) were pumped from the mines (Ron Warren, Park Hills Water Department, written commun., 1993). This rate is comparable to a city with a population of about 150,000. Pumpage from the mines produced a large cone of depression around the Old Lead Belt (fig. 9). The effect of dewatering the mines on water levels in public-supply wells completed in the Lamotte Sandstone is shown in figure 9, but this interpretation probably overestimates the radius of influence of this pumpage. Between 1968 and 1970, four public-supply wells were drilled into the Lamotte Sandstone beneath the mined areas in the cities of Leadwood (Leadwood No. 1 and No. 2), Gumbo (Gumbo well), and Park Hills (Park Hills Desloge well, hereinafter referred to as the Desloge well). The static water levels in the Leadwood No. 1 and No. 2 wells (wells 15 and 74, table 5 and fig. 10) and Gumbo well (well 80, table 5 and fig. 10) at the time of drilling were between an altitude of 393 and 414 ft. The Desloge well (well 31, table 5 and fig. 10) is located immediately outside the mined areas and the altitude of water at the time of drilling (altitude 700 ft) was much higher than those altitudes in the Leadwood and Gumbo wells. After the mine pumps were shut off in 1972, the water level in the Leadwood and Gumbo wells has increased more than 200 ft, whereas the water level in the Desloge well has increased only 3 ft, indicating the effect of dewatering the mines was restricted to a relatively small distance from the mine cavities.

By 1976 water-level measurements in 13 mine shafts made by the St. Joseph Lead Company indicated that water levels in mines south of the Big River were identical (Ron Warren, written commun., 1993). The identical water levels in these mines reflect the fact that all the mines south of the Big River were connected. Water levels in the mines generally stabilized in 1979.

Regional ground-water flow in the lower part of the St. Francois aquifer generally is toward the north with the Big River as the primary ground-water drain (fig. 10). The predominant recharge areas are to the south and southwest where the Precambrian rocks and Lamotte Sandstone are exposed and to the east where the Bonneterre Formations crops out extensively (fig. 7). Ground-water flow in the region is complicated by: the absence of the St. Francois confining unit throughout much of the region, the different hydrologic properties of the Bonneterre Formation and Lamotte Sandstone, and the presence of the abandoned mine cavities.

On a localized scale the St. Francois aquifer can be separated into two distinct units based on the much larger hydraulic conductivity of the Lamotte Sandstone as compared to that of the Bonneterre Formation. Where the Lamotte Sandstone is overlain by the Bonneterre Formation and younger units, water levels in wells completed in the Lamotte Sandstone generally are higher than the top of the unit. For example, public-supply wells completed in the Lamotte Sandstone in Leadwood, Gumbo, and Desloge have water levels more than 300 ft above the top of the unit. Water flowed from exploration drill holes completed in the Lamotte Sandstone along the lower reaches of the Flat River in the late 1800's (Buckley, 1908), indicating the Bonneterre Formation is a leaky confining unit to the underlying Lamotte Sandstone. Many of these drill holes in the Big River and Flat River valleys currently (1994) have flowing water. The Bonneterre Formation also impedes the upward movement of water in discharge areas along the Big River, where hydraulic heads in the Lamotte Sandstone are about 15 ft higher than the altitude of the river near the junction of the Big and Flat Rivers.

The relatively flat hydraulic gradient within the mined area is an effect of the water-filled abandoned mine cavities on regional water levels. Wells completed in mine cavities south of the Big River have similar water levels regardless of their depth or location. Wells adjacent to mine cavities have water levels similar to that of the mines if the altitude of the bottom of the well is not substantially above the mines.

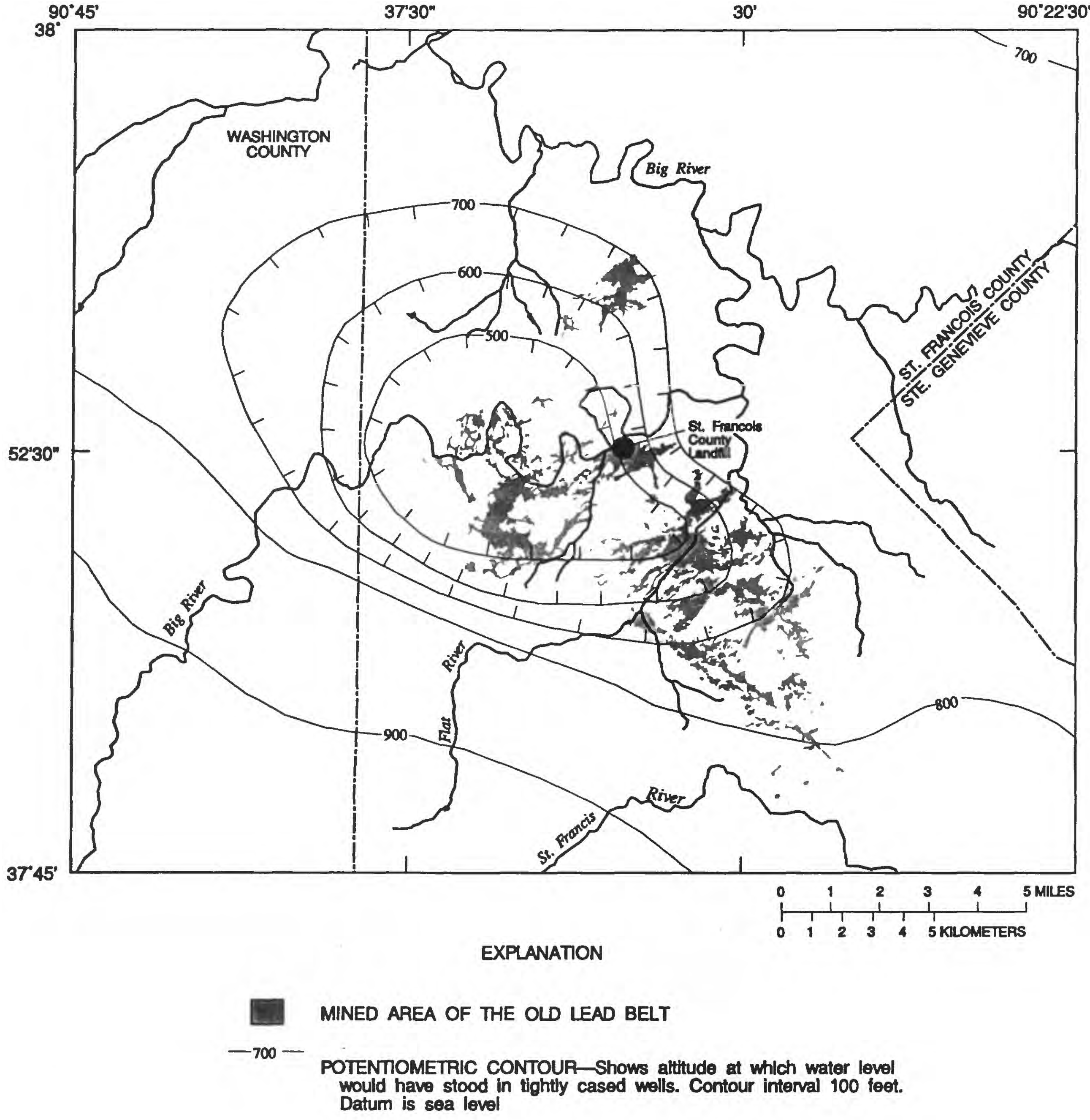


Figure 9. Pre-1972 potentiometric surface of the St. Francois aquifer in the vicinity of the St. Francois County Landfill site, Missouri (modified from Wright and Endicott, 1987).

Table 5. Well inventory data for selected domestic and public-supply wells in the vicinity of the St. Francois County Landfill site, Missouri

[ATD, at time of drilling; µS/cm, microsiemens per centimeter at 25 degrees Celsius; --, no data; Bt, Bonneterre Formation; Lm, Lamotte Sandstone; DD, Derby-Doe Run Dolomite; Dv, Davis Formation; P, Potosi Dolomite; >, greater than]

Well no. (fig. 10)	Latitude	Longitude	Date drilled	Well depth (feet below land surface)	Casing depth (feet below land surface)	Land surface (feet)	Geologic unit	Static water level ATD (feet below land surface)	Date inventoried	Water level (feet below land surface)	Water level (feet)	Specific conductance (µS/cm)
1	374941	0903456	--	--	--	960	Bt-Lm[1]	--	09-16-92	222.5	737.5	675
6	374804	0903028	--	705	507	1,030	Bt-Lm[1]	329	09-16-92	280	750	--
7	374914	0903245	12-03-87	287	--	790	Bt	--	09-16-92	70.6	719.4	1,450
10	374953	0903245	--	--	--	880	Bt[1]	--	09-14-92	144	736	--
12[2]	374927	0902804	--	--	--	970	Bt[1]	--	09-15-94	49	921	1,105
13	375150	0902550	1983	300	--	850	Lm	--	09-15-94	64.5	785.5	435
14	375058	0902814	05-05-40	100	--	820	Lm	25	07-15-92	77	743	491
15	375127	0903540	08-23-68	790	605	865.82	Lm	473	09-14-92	153.5	712.32	1,020
									04-20-94	139.9	725.92	--
16	375418	0903254	--	--	--	895	Bt	--	09-15-92	152.7	742.3	920
20	375034	0903132	07-73	410	--	762.04	Bt[3]	--	09-14-92	49.15	712.89	1,304
									04-20-94	35.8	726.24	--
24	375148	0903429	07-09-77	780	--	830	Bt[3]	--	09-16-92	117.2	712.8	984
25	375523	0903256	--	--	--	800	Bt[3]	--	09-14-92	91.55	708.45	--
27	375157	0903259	--	--	--	740	Bt	--	09-15-92	18.2	721.8	898
28	375224	0903249	--	--	--	789.4	Bt[3]	--	09-15-92	76.5	712.9	930
31	375229	0903115	--	765	385	809.4	Lm	109	09-15-92	[4]135	674.4	596
32	375623	0903124	09-05-80	260	--	730	Bt	--	09-14-92	25.3	704.7	749
33	375626	0903117	06-24-69	566	283	710	Lm[1]	--	09-14-92	53.45	656.55	450
34	375548	0903554	11-01-89	348	--	870	Lm	--	09-14-92	171.1	698.9	419
35	375529	0903458	08-01-90	>300	--	820	Lm	--	09-14-92	136.9	683.1	462
36	375459	0903351	07-11-92	310	80	950	DD-Dv	--	09-15-92	162	788	848
37	375513	0903224	--	--	--	750	Lm[1]	--	09-15-92	53	697	554
38	375500	0903118	--	--	--	780	Bt-Lm[1]	--	09-15-92	57.5	722.5	--
39	375427	0903049	--	--	--	760	Bt-Lm[1]	--	09-15-92	37.7	722.3	--
40	375218	0903453	--	--	--	775	Bt	--	09-15-92	52	723	843
41	375439	0902642	1979	320	--	860	P[1]	--	09-15-92	148.8	711.2	497
42	375622	0903346	1978	220	--	825	Bt	--	09-15-92	119.9	705.1	728
43[2]	375734	0903407	--	--	--	800	Bt-Lm[1]	--	09-15-92	147.3	652.7	397

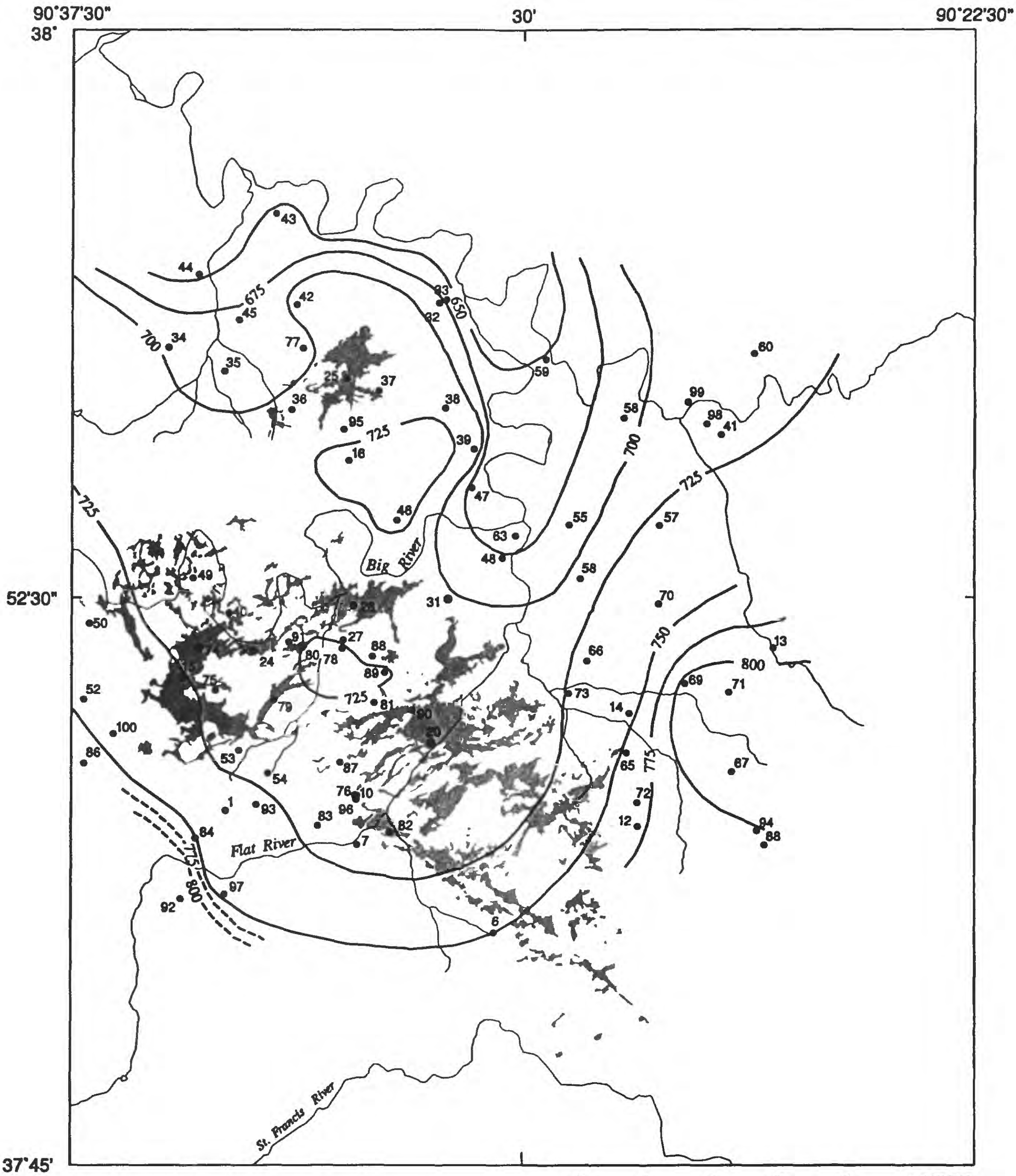
Table 5. Well inventory data for selected domestic and public-supply wells in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Well no. (fig. 10)	Latitude	Longitude	Date drilled	Well depth (feet below land surface)	Casing depth (feet below land surface)	Land surface (feet)	Geologic unit	Static water level ATD (feet below land surface)	Date inventoried	Water level (feet below land surface)	Water level (feet)	Specific conductance (µS/cm)
44	375646	0903524	--	--	--	760	P-Bt[1]	--	09-15-92	110.7	649.3	557
45	375610	0903444	1972	--	--	780	Bt	--	09-15-92	97.2	682.8	712
46	375331	0903206	--	--	--	800	Bt	--	09-15-92	59.5	740.5	792
47	375356	0903051	--	--	--	745	Lm[1]	--	09-16-92	73.5	671.5	620
48	375301	0903021	--	220	--	730	Bt-Lm[1]	--	09-16-92	54.5	675.5	707
49	375246	0903529	1991	--	--	780	Bt	--	09-16-92	34	746	797
50	375210	0903712	1930	--	--	760	Bt	--	09-16-92	18.4	741.6	763
51	375134	0904001	--	--	--	890	Unknown	--	09-16-92	16	874	727
52	375110	0903718	--	240	100	910	Bt	--	09-16-92	168	742	790
53	375029	0903443	--	--	--	840	Bt	--	09-17-92	129	711	1,553
54	375010	0903414	1989	--	--	900	Bt	--	09-17-92	184	716	1,593
55	375327	0902914	--	270	--	760	Lm[1]	--	09-14-92	69.8	690.2	452
56	375245	0902903	1970	--	--	785	Lm[1]	--	09-14-92	78.8	706.2	466
57	375327	0902744	1984	266	--	870	Lm[1]	--	09-14-92	135.3	734.7	413
58	375452	0902820	--	--	--	795	Lm[1]	--	09-14-92	100	695	510
59	375538	0902938	1986	246	--	720	Lm	--	09-15-92	69.5	650.5	477
60	375543	0902610	1975	--	--	790	Lm	--	09-15-92	80	710	612
63	375319	0903007	04-23-92	225	--	710	Lm	--	09-15-92	26	684	601
65	375026	0902817	--	--	--	850	Lm[1]	--	09-15-92	96.5	753.5	429
66	375140	0902856	1992	325	--	815	Lm	--	09-16-92	79	736	514
67	375011	0902631	1980	--	--	905	Lm[1]	--	09-16-92	73	832	685
68[2]	371413	0902559	1982	102	--	950	Lm	--	09-16-92	23.5	926.5	479
69	371522	0902717	1991	369	--	855	Lm	--	09-16-92	47	808	522
70	375225	0902745	1989	282	--	825	Lm	--	09-16-92	96	729	491
71	375115	0902634	1991	348	--	917	Lm	--	09-16-92	112	805	659
72	374947	0902806	1985	320	--	925	Lm	--	09-16-92	164	761	504
73	375114	0902915	--	--	--	785	Lm[1]	--	09-17-92	58.5	726.5	496
74	375151	0903523	01-70	750	--	805	Lm	391	09-14-92	149	656	1,102
75	375117	0903507'	--	--	--	825	Bt[3]	--	09-14-92	101.8	723.2	--

Table 5. Well inventory data for selected domestic and public-supply wells in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Well no. (fig. 10)	Latitude	Longitude	Date drilled	Well depth (feet below land surface)	Casing depth (feet below land surface)	Land surface (feet)	Geologic unit	Static water level ATD (feet below land surface)	Date inventoried	Water level (feet below land surface)	Water level (feet)	Specific conductance (μS/cm)
76	374953	0903247	--	--	--	900	Bt-Lm	--	09-14-92	185.5	714.5	--
77	375547	0903340	11-09-89	750	--	875	Lm	--	09-15-92	210	665	--
78	375150	0903300	--	415	--	790	Bt	--	09-15-92	45	745	800
79	375109	0903408	--	--	--	840	Bt	--	09-15-92	121.3	718.7	1,540
80	375151	0903340	12-01-69	565	400	815	Lm	406	09-15-92	109.1	705.9	735
81	375107	0903228	12-06-88	574	80	905	Lm	--	09-15-92	184.6	721.6	--
82	374924	0903212	--	--	--	820	Bt[3]	--	09-15-92	111.6	708.4	1,415
83	374929	0903324	06-23-92	410	80	895	Bt	--	09-15-92	175.8	719.2	1,014
84[2]	374918	0903527	--	102	--	1,010	P	--	09-15-92	80	930	565
85[2]	374938	0903714	01-23-86	225	105	1,010	P	--	09-15-92	71.3	938.7	600
86[2]	375018	0903718	--	--	--	950	P	--	09-15-92	77	873	643
87	375019	0903302	--	--	>400	1,010	Lm	--	09-15-92	279.6	760.4	555
88	375144	0903230	1978-79	--	--	850	Bt	--	09-16-92	135.5	714.5	1,330
89	375131	0903218	--	--	--	890	Bt	--	09-16-92	162.8	727.2	1,150
90	375101	0903151	06-29-87	285	80	880	Bt[1, 2]	--	09-16-92	168	710	1,000
91	375155	0903354	--	--	--	815	Lm	--	09-16-92	64.4	751.6	--
92	374831	0903541	--	164	--	935	Bt	--	09-16-92	56	879	--
93	374946	0903426	1986	[5]500	--	960	Lm	--	09-17-92	229.2	730.8	570
94	374925	0902606	09-92	328	--	960	Lm	--	09-17-92	160.8	799.2	--
95	375443	0903259	--	--	--	875	Bt	--	11-23-93	162.13	712.87	--
96	374950	0903246	--	615	--	880	Bt	--	11-23-93	149.75	730.25	1,193
97	374834	0903457	--	--	--	950	Lm	--	11-23-93	200.75	749.25	672
98	375447	0902658	--	--	--	762	Bt-Lm[1]	--	12-20-93	31.5	730.5	704
99	375504	0902716	10-11-93	185	80	760	Bt-Lm[1]	--	12-21-93	40.2	719.8	--
100	375042	0903648	08-88	950	--	1,020	Lm	375	01-06-94	276.3	743.7	--

[1] Geologic unit information is uncertain.
[2] Water level in this well was not used to prepare the regional potentiometric surface map (fig. 10).
[3] Well completed in abandoned mine cavity within the Bonneterre Formation.
[4] Static water level of 106 feet (measured during March 1989 after well was shut down for several weeks for repairs) was used to prepare the regional potentiometric surface map (fig. 10).
[5] Well depth is approximate.



EXPLANATION

MINED AREA OF THE OLD LEAD BELT

—725— POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 25 feet. Datum is sea level

•72 DOMESTIC OR PUBLIC-SUPPLY WELL AND NUMBER

Figure 10. Potentiometric surface of the lower part of the St. Francois aquifer (1992–93) in the vicinity of the St. Francois County Landfill site, Missouri.

Because the mine cavities extend for several miles, the hydraulic head in the mine cavities probably is an average of hydraulic heads across the region. In effect, as mine cavities filled with water and the water levels stabilized, the natural gradient was leveled by averaging the higher hydraulic heads in the south with the lower hydraulic heads near the Big River. Hydraulic heads in mined areas near the Big River probably are higher than they were before mining took place. This may explain why the hydraulic heads in mined areas near the landfill site are 25 to 35 ft higher than the altitude of the Big River as compared to hydraulic heads only about 15 ft higher than the altitude of the Big River downstream of the mined areas.

In mined areas near the Big River, hydraulic heads in the mine cavities probably are higher than the hydraulic heads in the underlying Lamotte Sandstone. During March 1989, the water-level altitude in the Desloge well (703.4 ft; well 31, fig. 10) was nearly 17 ft lower than the water-level altitude in the Park Hills River Mines well, hereafter referred to as the River Mines well (720.29 ft; well 20, fig. 10), indicating the potential for downward flow of mine water in the Lamotte Sandstone. The 1989 water level in the Desloge well was used in preparation of the potentiometric surface map because the well had been inactive for several weeks before this measurement (Ron Warren, written commun., 1994). In localized areas, such as the city of Leadwood, water levels in the mines and Lamotte Sandstone were nearly identical, indicating hydraulic connection between the abandoned mines and the Lamotte Sandstone. The water-level altitude in the Leadwood No. 1 well (well 15, table 5) was 0.32 ft and 0.57 ft below the water-level altitude of the River Mines well (well 20, table 5) in September 1992 and April 1994.

Water levels in the mine cavities exhibit seasonal variation, decreasing in the summer and increasing in the fall and winter (fig. 11). This variation is probably caused by increased recharge during wet seasons. Pumpage from domestic and public-supply wells is unlikely to be large enough to affect water levels in the mine cavities.

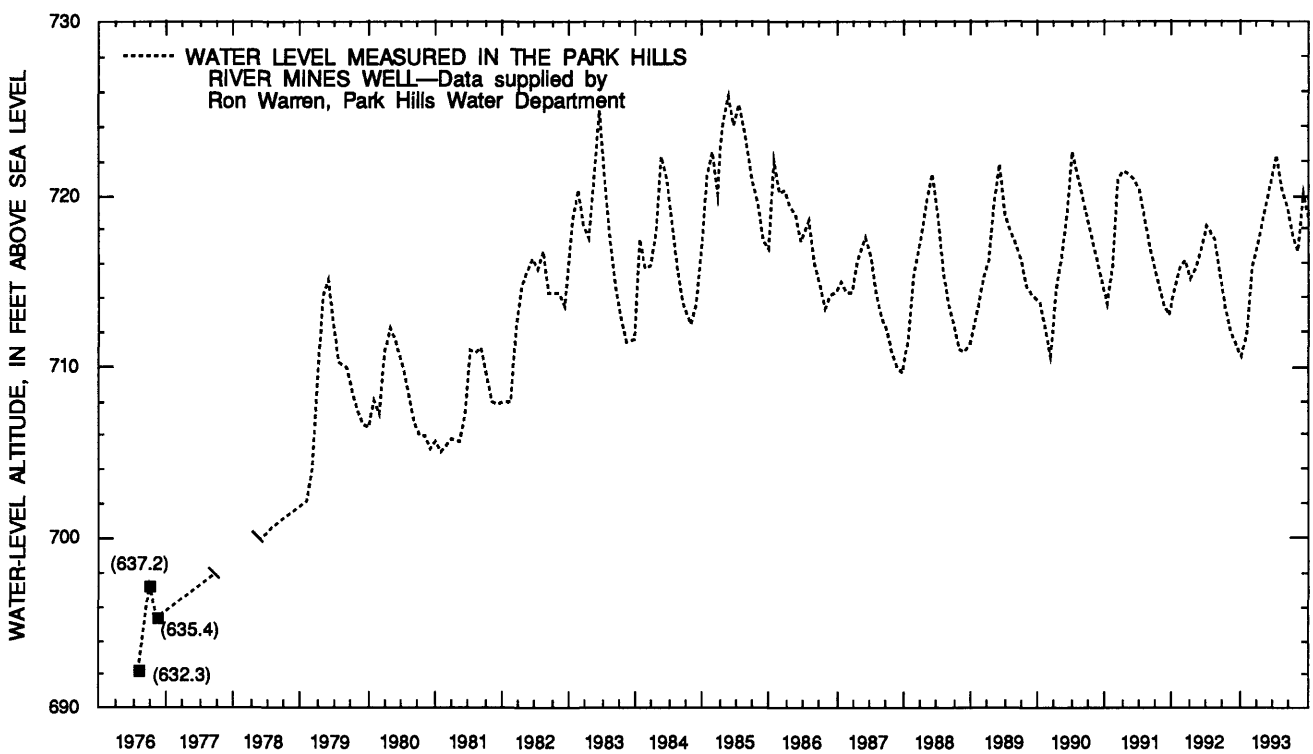


Figure 11. Seasonal variation of mine water levels in the vicinity of the St. Francois County Landfill site, Missouri.

Hydrogeology of the St. Francois County Landfill Site

The tailings are composed mainly of variable quantities of silt-size (11.5–98 percent by weight) and sand-size material (0.8–87.5 percent by weight) with small (2 percent or less by weight) quantities of clay-size material (table 6). In contrast, a sample of the overburden (organic-rich top soil and gravelly clay) beneath the tailings (MW–100, 69.5–71.5 ft) contained more than 14 percent by weight clay-size material and only about 10 percent sand-size material. The organic carbon contents of the tailings and overburden were small, averaging less than 0.2 percent by weight. Analyses of three tailings samples indicated they are comprised mainly of dolomite with associated ankerite (more than 70 percent by weight), quartz (9–12 percent by weight), calcite (4–7 percent by weight), and smaller quantities of feldspar and mica and trace quantities of sulfide minerals, such as pyrite. Chemical analyses of the coarse (greater than 0.063 mm) and fine (less than 0.063 mm) fractions of the tailings indicate both fractions are chemically similar except for concentrations of several trace elements. Concentrations of trace elements in both fractions generally were less than 100 mg/kg (milligrams per kilogram) except for concentrations of Fe (3.2–4.1 percent by weight), Pb (910–3,400 mg/kg), Mn (3,700–5,100 mg/kg), and Zn (190–1,900 mg/kg). The sample of the overburden beneath the tailings contained the largest concentrations of barium (Ba; 460 and 490 mg/kg) and chromium (Cr; 78 and 68 mg/kg) in the coarse and fine fractions and among the smallest concentrations of Pb (49 and 51 mg/kg), Mn (1,600 and 1,000 mg/kg), and Zn (73 and 76 mg/kg).

Ground-water flow at the landfill site is affected by the altitude of the original land surface beneath the tailings, the difference between the hydraulic conductivity of the tailings and bedrock, the presence of solution enlarged fractures and joints in the bedrock, the location of exploration drill holes beneath the tailings pile and landfill, and the proximity of the site to the Big River. Water-level measurements indicate a ground-water mound in the tailings and shallow bedrock beneath the landfill site. The mound forms a shallow ground-water divide that trends generally eastward from the middle of the site (fig. 12). Ground water in the northeastern part of the site flows north toward the Big River, and ground water in the southeastern part flows toward Mine-A-Joe Creek. Flow in the western one-half of the site generally is toward the southwest or west toward the Big River. The diversion tunnel in the southwest corner of the site may be a drain and limit the movement of shallow ground water from the landfill site to the southwest.

The nose of the ground-water mound coincides with part of the buried Mine-A-Joe Creek valley beneath the tailings (fig. 13). The original land surface of the buried valley generally slopes northward toward the Big River, where the tailings are more than 100 ft thick. The original land surface closely approximates the top of bedrock as drill logs indicated usually less than 1 or 2 ft of overburden between the tailings and the bedrock. More than 50 ft of saturated tailings exist within the buried creek valley, and the base of the landfill is within 15 ft of the potentiometric surface (fig. 14). The thickness of saturated tailings decreases where the altitude of the original land surface increases, and tailings along the east and west boundaries of the site generally are unsaturated (fig. 14). Four of the original monitoring wells (MW–102, MW–103, MW–104, and MW–105) installed in 1987 probably intersected perched water because these wells have subsequently gone dry. Bedrock piezometers installed near the perimeter of the site (201–P, 204–P, 205–P, 2020–P, 2021–P, and 2022–P) did not encounter appreciable quantities of water above the bedrock; however, minor quantities of perched water were encountered during the installation of piezometers 204–P and 205–P.

The hydraulic conductivity values determined from slug tests in tailings monitoring wells MW–100 and MW–101 were 6.1×10^{-6} and 5.4×10^{-6} ft/s. These values are somewhat larger than the range of laboratory derived values (2.5×10^{-9} to 2.5×10^{-7} ft/s) reported by Gastreich (1974). A probable explanation for the differences is that the slug tests evaluated a mixture of the silt- and fine sand-size layers under natural densities, conditions difficult to replicate in the laboratory. Slug tests in bedrock piezometers 204–P, 2020–P, 2022–P, and 2023–P indicate the hydraulic conductivity of the bedrock (1.0×10^{-7} to 5.0×10^{-6} ft/s) tends to be slightly smaller than the hydraulic conductivity of the tailings. Because of the layered nature of the tailings, the slope of the original buried land surface, and the slightly smaller hydraulic conductivity of the bedrock as compared to that of the tailings, recharge in the northeastern part of the landfill site probably moves downward through the refuse and tailings to the ground-water surface, then down the buried Mine-A-Joe Creek valley toward the Big River.

Table 6. Grain size, bulk mineralogy, and selected chemical composition of tailings and overburden samples, St. Francois County Landfill site, Missouri

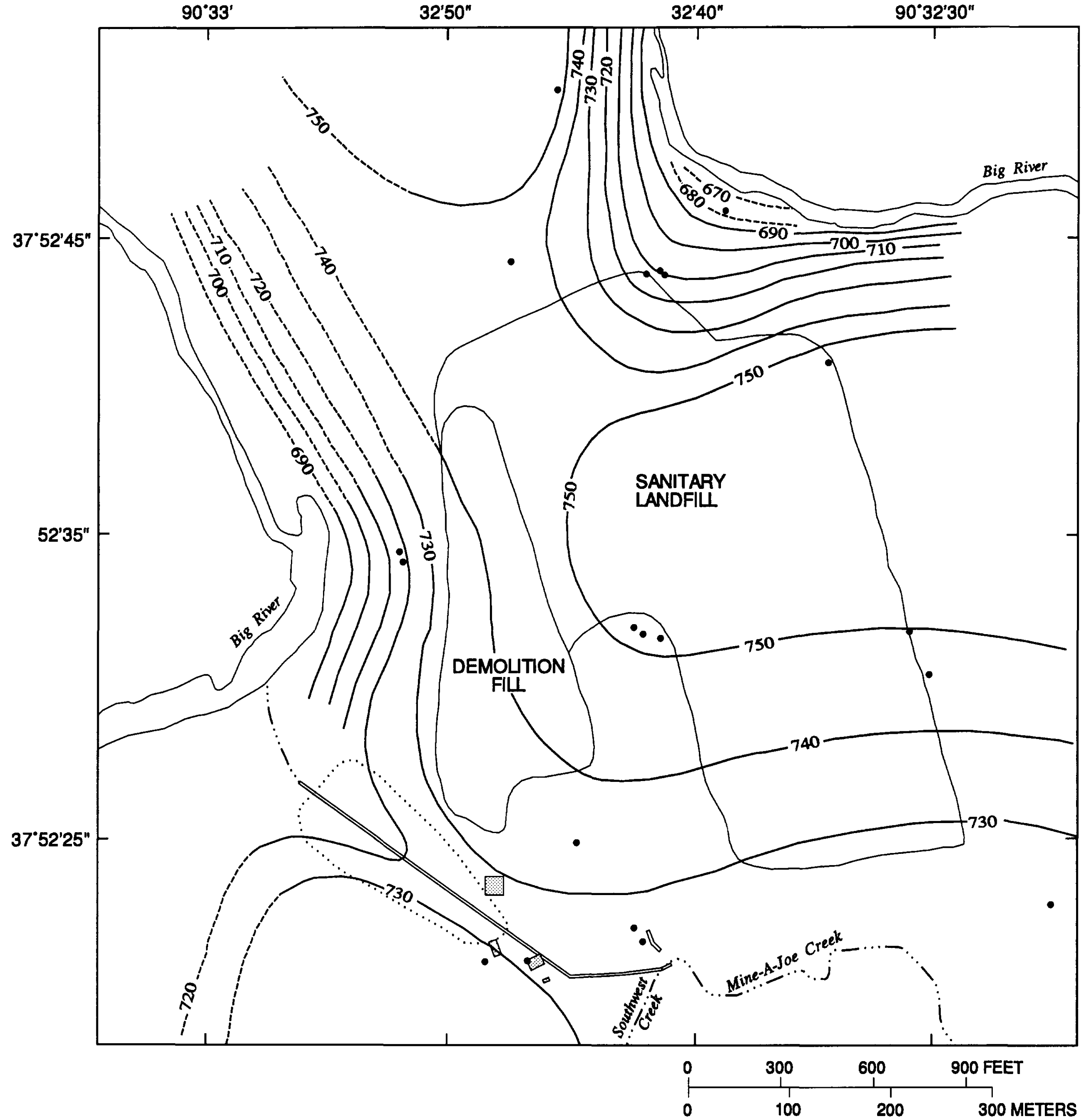
[All concentrations in percent by weight unless noted otherwise; --, not detected; t, trace; <, less than; coarse, greater than 0.063 millimeter; fine, less than 0.063 millimeter; mg/kg, milligrams per kilogram]

Well (fig. 5)	Depth (feet below land surface)	Grain size			Carbon			Bulk mineralogy					
		Sand	Silt	Clay	Total	Organic	Carbonate	Dolomite and ankerite	Quartz	Calcite	Potassium feldspar	Mica	Pyrite and hematite
MW-100	9.5-11.5	58.2	40.8	1.0	11.8	0.20	11.6	--	--	--	--	--	--
	19.5-21.5	81.5	17.6	.9	11.9	.10	11.8	78	9	7	3	t	t
	29.5-31.5	57.2	41.8	1.0	11.4	.10	11.3	--	--	--	--	--	--
	39.5-41.5	22.2	76.8	1.0	10.7	<.1	10.9	--	--	--	--	--	--
	49.5-51.5	57.5	40.5	2.0	11.7	.10	11.6	--	--	--	--	--	--
(overburden)	69.5-71.5	10.2	75.6	14.2	.32	.20	.12	--	--	--	--	--	--
MW-107	55.0-60.0	87.5	11.5	1.0	11.7	.20	11.5	78	9	7	3	t	t
108-P	19.5-21.5	22.8	75.9	1.3	11.0	.20	10.8	--	--	--	--	--	--
	29.5-31.5	41.1	57.7	1.2	10.1	.17	9.93	--	--	--	--	--	--
	39.5-40.5	.8	98.0	1.2	11.2	<.1	11.3	--	--	--	--	--	--
	49.5-51.5	50.5	48.7	.8	11.5	.30	11.2	73	12	4	5	2	t

Well (fig. 5)	Depth (feet below land surface)	Calcium		Magnesium		Iron		Arsenic (mg/kg)		Barium (mg/kg)		Cadmium (mg/kg)	
		Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
MW-100	9.5-11.5	21	19	11	10	3.5	3.4	<10	10	47	65	30	26
	19.5-21.5	22	19	11	11	3.4	3.5	<10	10	39	57	26	26
	29.5-31.5	21	18	11	10	4.0	4.1	<10	13	61	76	12	13
	39.5-41.5	20	18	10	10	3.6	3.7	<10	11	80	88	5	5
	49.5-51.5	21	19	11	9.4	4.0	4.0	<10	<10	39	55	11	10
(overburden)	69.5-71.5	.5	.5	.58	.62	4.0	4.0	14	15	460	490	<2	<2
MW-107	55.0-60.0	21	18	8.3	9.9	3.4	3.7	<10	13	38	77	17	22
108-P	19.5-21.5	20	18	10	10	3.5	3.5	<10	10	79	87	33	33
	29.5-31.5	19	19	9	10	3.4	3.5	10	10	110	72	24	15
	39.5-40.5	21	17	9.3	9.2	3.5	3.4	<10	<10	64	110	13	23
	49.5-51.5	21	18	10	9.1	3.2	3.3	<10	13	56	80	11	9

Table 6. Grain size, bulk mineralogy, and selected chemical composition of tailings and overburden samples, St. Francois County Landfill site, Missouri—Continued

Well (fig. 5)	Depth (feet below land surface)	Chromium (mg/kg)		Cobalt (mg/kg)		Copper (mg/kg)		Lead (mg/kg)		Manganese (mg/kg)		Zinc (mg/kg)	
		Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
MW-100	9.5-11.5	6	9	31	44	31	42	1,400	2,200	4,700	4,500	1,400	1,200
	19.5-21.5	5	9	29	49	32	47	910	1,900	4,500	4,300	1,200	1,300
	29.5-31.5	8	11	46	70	240	340	1,900	3,400	4,800	4,500	570	690
	39.5-41.5	10	12	30	33	49	55	1,700	2,000	4,400	4,300	190	210
	49.5-51.5	5	8	22	27	13	17	980	1,500	5,100	4,800	550	500
(overburden)	69.5-71.5	78	68	18	18	26	25	49	51	1,600	1,000	73	76
MW-107	55.0-60.0	5	13	28	53	6	15	1,100	2,900	4,800	4,300	870	1,200
108-P	19.5-21.5	10	11	23	24	7	7	1,800	2,100	4,500	4,300	1,800	1,900
	29.5-31.5	16	11	22	30	7	8	3,000	1,700	4,200	4,300	1,300	780
	39.5-40.5	8	17	26	23	6	8	1,300	3,100	4,500	4,200	670	1,300
	49.5-51.5	8	13	39	50	34	57	1,200	2,000	4,100	3,700	600	500



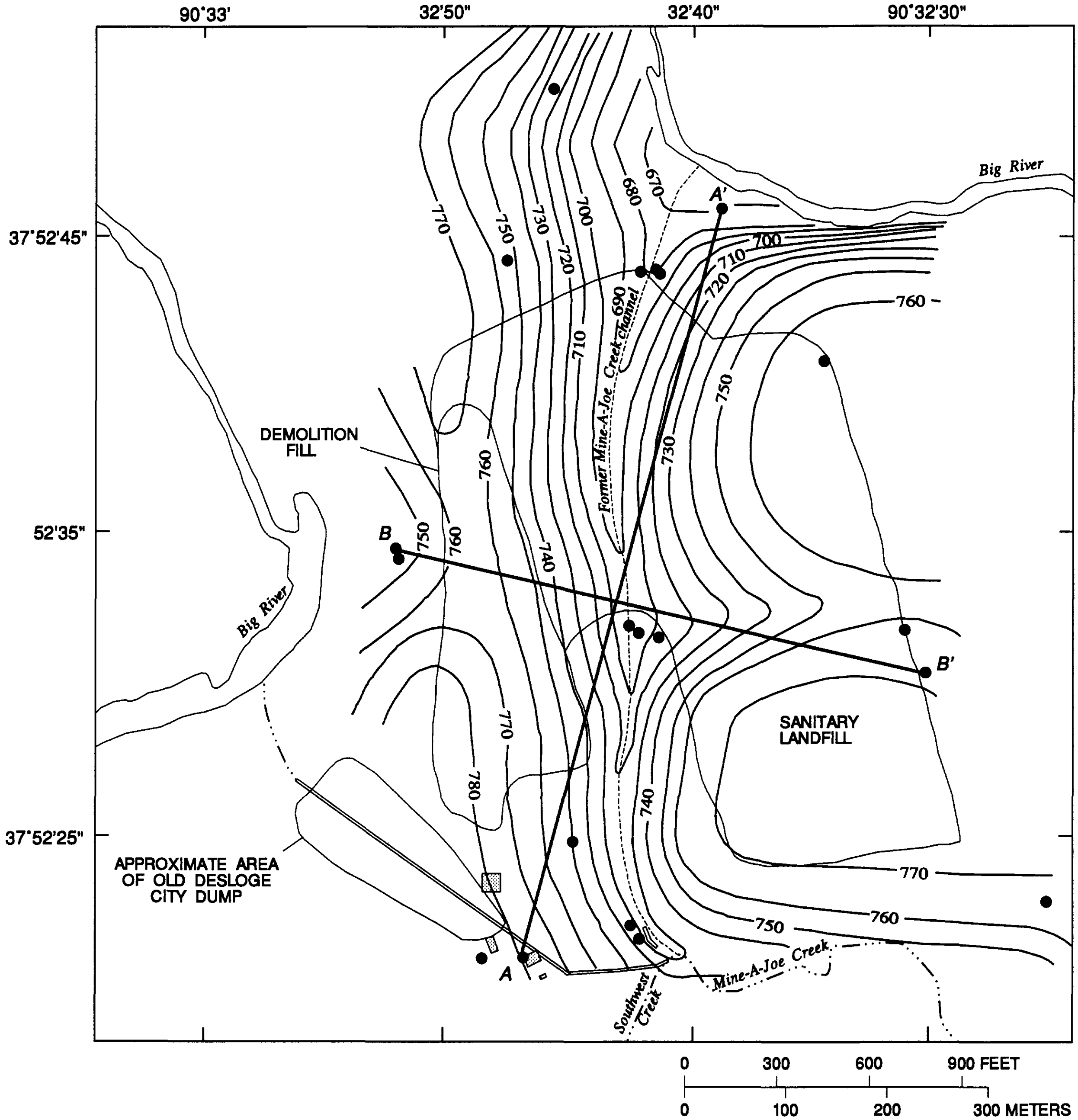
EXPLANATION

·················· APPROXIMATE BOUNDARY OF THE OLD DESLOGE CITY DUMP

—— 720 —— POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 10 feet. Datum is sea level

• DOMESTIC OR MONITORING WELL OR PIEZOMETER

Figure 12. Potentiometric surface in the tailings and shallow bedrock at the St. Francois County Landfill site, Missouri, in November 1993.



EXPLANATION

—720— LINE OF EQUAL ALTITUDE OF ORIGINAL LAND SURFACE—Contour interval 10 feet

A——A' TRACE OF GEOHYDROLOGIC SECTION

● DOMESTIC OR MONITORING WELL OR PIEZOMETER

Figure 13. Altitude of original land surface beneath the St. Francois County Landfill site, Missouri.

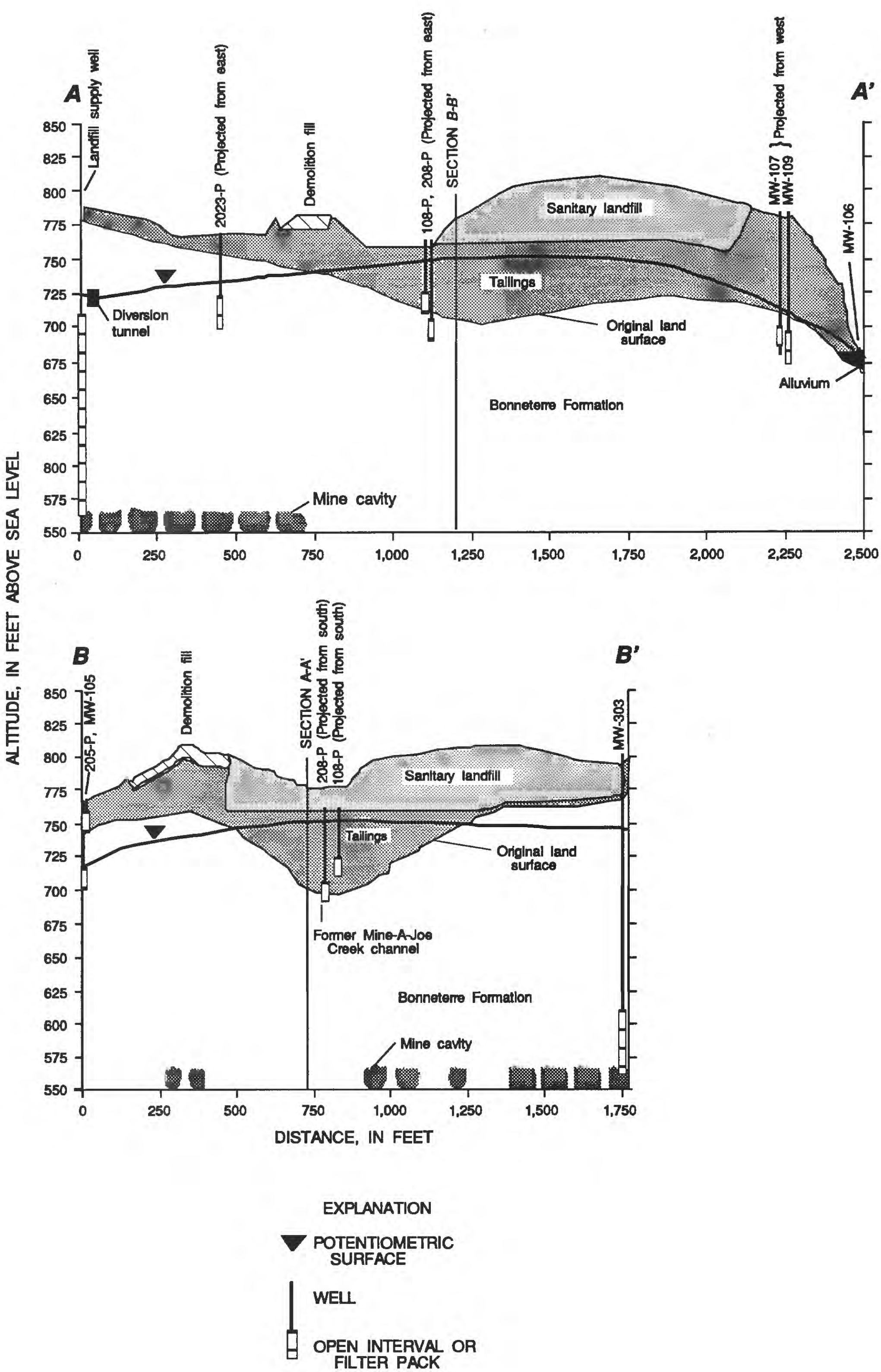


Figure 14. Hydrogeologic sections at the St. Francois County Landfill site, Missouri.

Although most recharge at the landfill is expected to move through the tailings down the buried Mine-A-Joe Creek valley, some recharge moves vertically through the tailings into the shallow bedrock. Except for measurements made on September 9, 1993, the water-level altitude in tailings piezometer 108–P was between 0.14 and 2.43 ft higher than the altitude of water in bedrock piezometer 208–P, indicating a downward gradient between the tailings and bedrock in the vicinity of these wells. Because of the proximity of the site to the Big River and a regional ground-water drain, recharge entering the shallow bedrock from the tailings will travel along relatively shallow flow paths and discharge into the Big River.

The presence of solution-enlarged fractures and joints within the bedrock and numerous exploration drill holes beneath the tailings pile create the potential for some recharge from the tailings pile to move deeper into the bedrock and possibly into the abandoned mines. A number of mines in the Old Lead Belt received substantial surface inflow through fractures and solution channels (Buckley, 1908). Three incidents of tailings ponds partially or completely draining into the underlying mines through such channels were reported (Buckley, 1908). Two such incidents occurred when water in the National Lead Company's mill pond drained through a bedrock channel into the National No. 2 mine located about 2 mi southeast of the landfill site. Surface water carrying debris and several hundred cubic yards of chat entered the Desloge No. 3 mine (beneath the Desloge tailings pile and landfill site) through fractures and solution channels intersecting Mine-A-Joe Creek. Buckley (1908) reported these channels were grouted at the surface; a reconnaissance of Mine-A-Joe Creek upstream of the landfill site failed to locate these grouted channels, indicating they may be buried beneath the tailings pile and landfill. More than 1,200 exploration drill holes are beneath the landfill site—247 lie beneath the sanitary landfill and demolition fill (fig. 15). Most of these drill holes were installed in the 1950's after most of the Desloge tailings pile was in place. Many of the drill holes probably are completed in the abandoned mine cavities and possibly in the underlying Lamotte Sandstone. Several severely corroded iron pipes thought to be surface casing remnants from these drill holes were exposed during excavation activities at the landfill; however, attempts to obtain water-level measurements in these pipes were unsuccessful because they were bent or plugged several feet below the land surface.

Hydraulic properties of the tailings can be used to estimate the time required for landfill contaminants to travel from the most recently disposed refuse (about 300 ft north of piezometer 108–P) downgradient to monitoring well MW–106. The macroscopic linear velocity is calculated using hydraulic conductivity, the slope of the potentiometric surface, and a representative value of tailings porosity. The tailings are primarily silt-size, for which porosity typically ranges from 35 to 50 percent (Fetter, 1988), averaging 42.5 percent. The hydraulic conductivity values determined from slug tests in wells completed in the tailings are 6.1×10^{-6} ft/s (monitoring well MW–100) and 5.4×10^{-6} ft/s (monitoring well MW–101). The total distance from the area north of piezometer 108–P to monitoring well MW–106 is about 1,050 ft over which the altitude of the potentiometric surface decreases 70 ft, indicating an average hydraulic gradient of -0.067. Based on the two values of hydraulic conductivity, the time required for leachate to travel from this area of landfill to monitoring well MW–106 could be between 35 and 40 years. Using the same technique and hydraulic conductivity values, it would take between 10 and 12 years for leachate to travel from a deep hole filled with refuse near piezometer 2021–P to monitoring well MW–106. The tailings were emplaced in layers and range in composition from silt- to sand-size particles. Because of the complexities of the media and because only two slug tests were performed in wells completed in the tailings, travel time calculations can only give a general indication of the actual time required for leachate to travel to monitoring well MW–106. Estimating travel time to piezometers completed in bedrock is equivocal, because of flow from tailings into bedrock and multiple flow paths (exploration drill holes, fractures, and bedding planes) within the Bonneterre Formation.

WATER QUALITY

Ground- and surface-water quality in the region varies due to the presence of varied lithology types and the presence of sulfide mineralization. Human activities, such as mining, agriculture, industry, and refuse disposal, also may affect water quality.

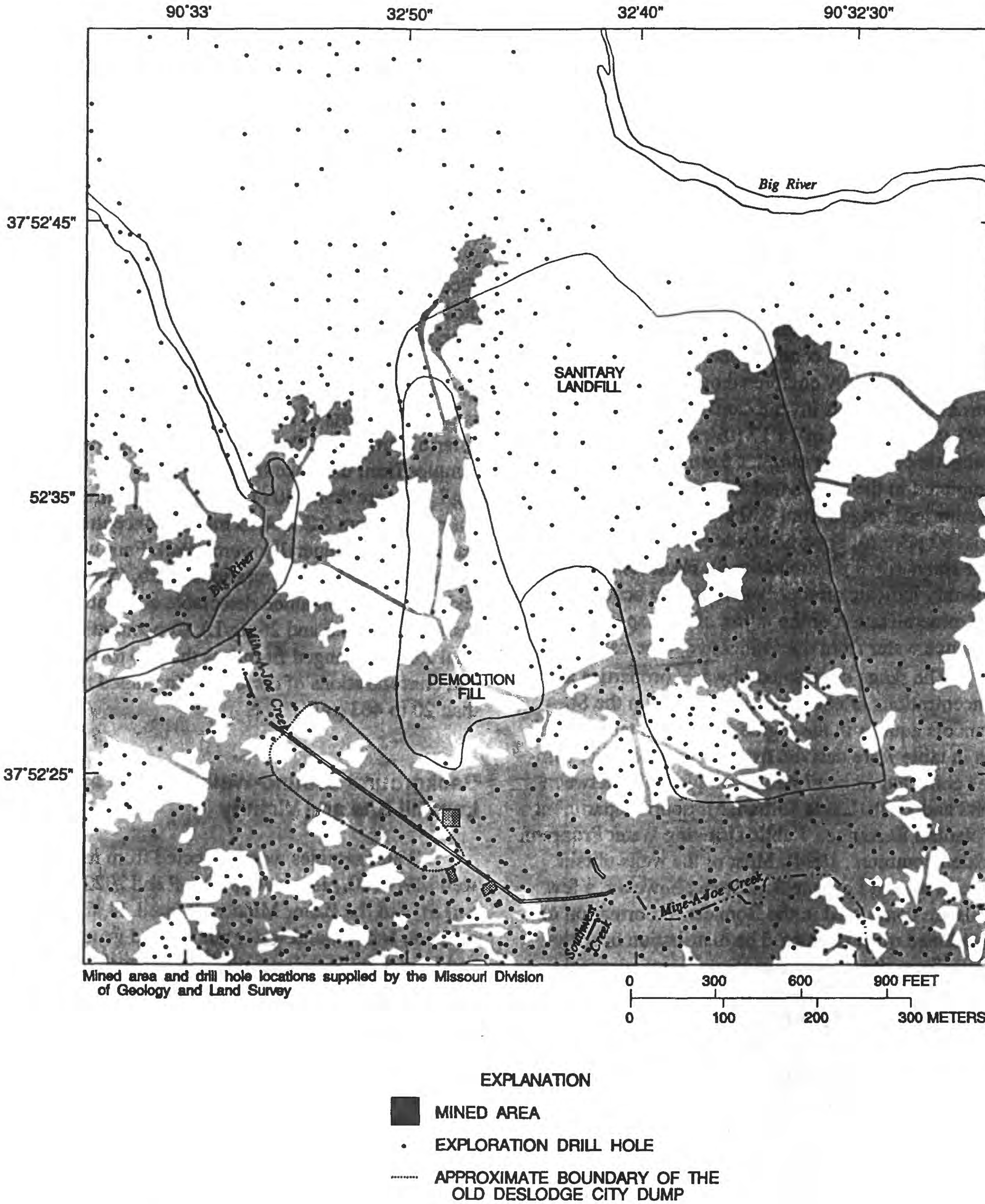


Figure 15. Extent of underground mine workings and location of abandoned exploration drill holes beneath the St. Francois County Landfill site, Missouri.

Regional Ground-Water Quality

The quality of water in wells completed in the St. Francois aquifer is related to the location of the well, proximity to mineralized areas, and whether the well is completed in the Lamotte Sandstone, Bonneterre Formation, or abandoned mine cavities. The specific conductance of water samples from wells completed primarily in the Lamotte Sandstone (35 wells inventoried) ranged from 413 to 735 μS/cm (mean of 566 μS/cm), except for samples from the two public-supply wells in the city of Leadwood where the specific conductance values were greater than 1,000 μS/cm. The specific conductance of water samples from wells probably completed only in the Bonneterre Formation (21 wells inventoried) ranged from 712 to 1,593 μS/cm (mean of 1,017 μS/cm). The specific conductance of water samples from wells known to be completed in the abandoned mine cavities (4 wells inventoried) ranged from 930 to 1,415 μS/cm (mean of 1,160 μS/cm). Specific conductance values larger than about 1,000 μS/cm in the St. Francois aquifer probably indicate effects from naturally occurring sulfide mineralization or the influx of high specific conductance water from the abandoned mine cavities.

The range of selected physical properties and concentrations of chemical constituents in the St. Francois aquifer in the region is given in table 7. Values in table 7 are derived from 47 water-quality samples collected from 17 public-supply wells between 1988 and 1991 (Linda Killian, Missouri Department of Natural Resources, Public Drinking Water Program, written commun., 1994). Most of the wells obtain water from the Lamotte Sandstone; however, a few wells are completed in the Bonneterre Formation or abandoned mine cavities. The distribution of major ions reflects the dissolution of carbonate material within the aquifer. Water in the wells ranges from a Ca-Magnesium (Mg)-HCO_3 to a Mg-HCO_3 type, with water from the Bonneterre Formation generally harder than water from the Lamotte Sandstone. Water from the abandoned mine cavities ranges from a Ca-Mg-HCO_3 to a Ca-Mg-SO_4-HCO_3 water. Concentrations of dissolved Na in the St. Francois aquifer generally are less than about 10 mg/L, but concentrations in excess of 30 mg/L have been reported in areas northwest of the Old Lead Belt where the water type can be Na-HCO_3 (Imes and Davis, 1991). Concentrations of SO_4 in the aquifer outside of the mined areas usually are less than 150 mg/L. Concentrations of SO_4 larger than 250 mg/L are associated with mineralized areas, such as in the vicinity of the abandoned mine cavities or near Precambrian basement rock exposures along the Simms Mountain Fault System. Concentrations of dissolved trace elements, except for copper (Cu), Fe, Mn, and Zn, were less than the detection level (table 7).

The USEPA sampled 42 domestic wells in the vicinity of the Desloge tailings pile (including the landfill well) for physical properties, dissolved major constituents, and dissolved and total trace elements (Ecology and Environment, 1992). The formations these wells are completed in were not furnished; however, specific conductance values ranged from 370 to 1,300 μS/cm, indicating that the wells were completed in the Lamotte Sandstone, the abandoned mines, or mineralized parts of the Lamotte Sandstone or Bonneterre Formation. Concentrations of Ca and Mg in samples from these wells ranged from 42.1 and 19 mg/L to more than 140 mg/L, and concentrations of Na ranged from 2.2 to 45.5 mg/L. Concentrations of trace elements generally were small. Four wells contained detectable concentrations of Pb_t (5.9–33 μg/L), and two wells contained detectable concentrations of dissolved Pb (6.6 and 26 μg/L). Concentrations of total Zn (Zn_t) ranged from less than 20 to 467 μg/L, and concentrations of dissolved Zn ranged from less than 20 to 463 μg/L.

Background Ground-Water Quality at the Landfill Site and Vicinity

Water samples were collected from monitoring well MW–100, piezometers 201–P and 2022–P (figs. 2 and 5), and the Baker Mine well (well 24, fig. 10) to evaluate background water quality and geochemical conditions in the tailings, shallow bedrock, and mine cavities. Analytical data for the flowing drill hole west of the landfill site (Smith and Schumacher, 1991) were also used to characterize background conditions in the mine cavities. In addition, samples were collected from public-supply wells in Desloge, Gumbo, and Leadwood. Usage of the term background refers to ambient water quality and geochemical conditions existing in the respective media in areas not affected by the landfill. Monitoring well MW–100 is located about 2,500 ft north of a east-west trending ground-water trough located between monitoring well MW–101 and piezometer 2020–P. The selection of piezometers 201–P and 2022–P as background monitoring points is somewhat equivocal because ground

Table 7. Range of selected physical properties and chemical constituents in samples from selected public-supply wells completed in the St. Francois aquifer, Missouri

[Data are summarized from the results of water-quality samples collected between 1988 and 1991 by the Missouri Department of Natural Resources, Public Drinking Water Program (Linda Killian, Missouri Department of Natural Resources, Public Drinking Water Program, written commun., 1994); <, less than]

Physical property or constituent	Minimum	Maximum	Mean
pH, in standard units	7.3	7.9	7.5
Calcium, in milligrams per liter	34	163	82
Magnesium, in milligrams per liter	35	105	53
Sodium, in milligrams per liter	2.5	30	9.2
Potassium, in milligrams per liter	.8	4.3	2.0
Hardness, in milligrams per liter as $CaCO_3$	236	840	421
Sulfate, in milligrams per liter	11	531	154
Chloride, in milligrams per liter	2	20	8.8
Fluoride, in milligrams per liter	.1	1	.4
Bicarbonate, in milligrams per liter	294	420	347
Total dissolved solids, in milligrams per liter	258	1,128	532
Nitrite plus nitrate as nitrogen, in milligrams per liter	<.05	3.36	1.00
Arsenic, in micrograms per liter	<5	<5	<5
Barium, in micrograms per liter	<200	<200	<200
Cadmium, in micrograms per liter	<5	<5	<5
Chromium, in micrograms per liter	<25	<25	<25
Copper, in micrograms per liter	<10	50	<18
Iron, in micrograms per liter	<100	480	<210
Lead, in micrograms per liter	<10	<10	<10
Manganese, in micrograms per liter	<20	50	<33
Mercury, in micrograms per liter	<.5	<.5	<.5
Selenium, in micrograms per liter	<5	<5	<5
Silver, in micrograms per liter	<10	<10	<10
Zinc, in micrograms per liter	<100	500	<210

water from the southern part of the landfill flows to the south (fig. 12). However, ground water from the southeast part of the landfill flows to the west of piezometer 201–P, and shallow ground water from the southwest part of the landfill probably flows toward the west or southwest to the Big River or is intercepted by the diversion tunnel. Piezometers 201–P and 2022–P did not contain increased concentrations of constituents commonly associated with landfill leachate (table 4) during sampling in 1993. The Baker Mine well (well 24, fig. 10) is located several miles southwest of the landfill site and probably upgradient of the landfill in the regional flow system. The flowing drill hole west of the landfill site also lies somewhat upgradient of the landfill in the regional flow system.

Physical Properties and Inorganic Constituents

Ground-water samples from the background sites in the tailings, shallow bedrock, and mine cavities in the vicinity of the landfill site had specific conductivity values ranging from 921 to 1,500 µS/cm; near neutral pH values; and Ca, Mg, SO_4, and HCO_3 as the predominant ions (table 8). These samples plot

ABBREVIATIONS AND REPORTING UNITS FOR CHEMICAL CONSTITUENTS AND NOTATIONS USED IN TABLE 8

SC	Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
pH	In standard units
DO	Dissolved oxygen, in milligrams per liter
COD	Chemical oxygen demand, in milligrams per liter
Ca	Calcium, dissolved, in milligrams per liter
Ca_t	Calcium, total, in milligrams per liter
Mg	Magnesium, dissolved, in milligrams per liter
Mg_t	Magnesium, total, in milligrams per liter
Na	Sodium, dissolved, in milligrams per liter
Na_t	Sodium, total, in milligrams per liter
K	Potassium, dissolved, in milligrams per liter
$Alk_{(IT)}$	Alkalinity, total, in milligrams per liter as $CaCO_3$, by incremental titration
$HCO_{3(IT)}$	Bicarbonate, in milligrams per liter, by incremental titration
SO_4	Sulfate, dissolved, in milligrams per liter
Cl	Chloride, dissolved, in milligrams per liter
F	Fluoride, dissolved, in milligrams per liter
TDS	Dissolved solids, sum of constituents, in milligrams per liter
Hard	Hardness, total, in milligrams per liter as $CaCO_3$
TOC	Organic carbon, total, in milligrams per liter
NO_2+NO_{3t}	Nitrite plus nitrate, total as nitrogen, in milligrams per liter
NH_{3t}	Ammonia, total as nitrogen, in milligrams per liter
P_t	Phosphorous, total, in milligrams per liter
Sb_t	Antimony, total, in micrograms per liter
As	Arsenic, dissolved, in micrograms per liter
As_t	Arsenic, total, in micrograms per liter
Ba	Barium, dissolved, in micrograms per liter
Ba_t	Barium, total, in micrograms per liter
B	Boron, dissolved, in micrograms per liter
B_t	Boron, total, in micrograms per liter
Cd	Cadmium, dissolved, in micrograms per liter
Cd_t	Cadmium, total, in micrograms per liter
Cr	Chromium, dissolved, in micrograms per liter
Cr_t	Chromium, total, in micrograms per liter
Co	Cobalt, dissolved, in micrograms per liter
Co_t	Cobalt, total, in micrograms per liter
Cu	Copper, dissolved, in micrograms per liter
Cu_t	Copper, total, in micrograms per liter
Fe	Iron, dissolved, in micrograms per liter
Fe_t	Iron, total, in micrograms per liter
Pb	Lead, dissolved, in micrograms per liter
Pb_t	Lead, total, in micrograms per liter
Li	Lithium, dissolved, in micrograms per liter
Mn	Manganese, dissolved, in micrograms per liter
Mn_t	Manganese, total, in micrograms per liter
Hg	Mercury, dissolved, in micrograms per liter
Hg_t	Mercury, total, in micrograms per liter
Mo	Molybdenum, dissolved, in micrograms per liter
Ni	Nickel, dissolved, in micrograms per liter
Ni_t	Nickel, total, in micrograms per liter
Se	Selenium, dissolved, in micrograms per liter
Se_t	Selenium, total, in micrograms per liter
Ag	Silver, dissolved, in micrograms per liter
Ag_t	Silver, total, in micrograms per liter
Sr	Strontium, dissolved, in micrograms per liter
Tl	Thallium, dissolved, in micrograms per liter
V	Vanadium, dissolved, in micrograms per liter
V_t	Vanadium, total, in micrograms per liter
Zn	Zinc, dissolved, in micrograms per liter
Zn_t	Zinc, total, in micrograms per liter
<	Less than
--	No data

Table 8. Range of selected physical properties and chemical constituents from background sites in the tailings, shallow bedrock, and mine cavities in the vicinity of the St. Francois County Landfill site, Missouri

Physical property or chemical constituent	Tailings (MW-100) (fig. 5)	Shallow bedrock (201-P, 2022-P) (fig. 5)	Mine cavity (Baker Mine well and drill hole) (figs. 5 and 10)
SC	1,110-1,340	955-1,500	921-1,220
pH	7.5-7.7	6.9-7.3	6.2-7.5
DO	<.5	<.5	<.5
COD	<10-26	<10	<10-18
Ca	71-95	100-180	110-130
Ca_t	85-189	180-200	120-130
Mg	110-120	72-110	58-74
Mg_t	120-150	100-120	63-73
Na	5.9-9.4	10-14	6.1-11
Na_t	3.1-9.2	13-15	8.4-8.8
K	11-11.9	.73-2.5	2.7-5.1
$Alk_{(IT)}$	288-303	238-414	258-516
$HCO_{3(IT)}$	328-370	290-505	314-630
SO_4	450-500	240-520	250-420
Cl	2.3-3.3	6.2-9.7	9.3-14
F	.5-.6	<.1	<.1-.2
TDS	808-887	645-1,090	622-902
Hard	630-1,090	550-900	520-630
TOC	.9-14.8	.8-6.5	.6-1.9
NO_2+NO_{3t}	<.02-.28	<.02-.19	<.02-.71
NH_{3t}	.43-.52	<.01-.09	.01-.04
P_t	<.02-1.2	<.02-.06	.01-.03
Sb_t	<1-1	<1-4	<1
As	--	--	<1
As_t	11-30	2-4	<1-3
Ba	41-55	20-39	20-28
Ba_t	50	20-80	20-30
B	562-610	30-230	60-90
B_t	560-640	210-230	<230
Cd	<1	<1	<1-2
Cd_t	<1-7	<1-6	<1
Cr	<5	<5	<5
Cr_t	<5-11	<5	<5
Co	<3	3-30	<3-30
Co_t	<3-43	20	6-10
Cu	<10	<10	<10
Cu_t	<10-34	<10-15	<10-11
Fe	41-250	14-160	<3-2,400
Fe_t	530-28,900	310-4,900	2,000-3,000

Table 8. Range of selected physical properties and chemical constituents from background sites in the tailings, shallow bedrock, and mine cavities in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Physical property or chemical constituent	Tailings (MW-100) (fig. 5)	Shallow bedrock (201-P, 2022-P) (fig. 5)	Mine cavity (Baker Mine well and drill hole) (figs. 5 and 10)
Pb	<10	<10-50	<10-30
Pb_t	28-2,360	110-1,200	5-21
Li	24-29	<4-10	4-17
Mn	240-270	21-720	17-160
Mn_t	290-3,620	690-1,200	52-73
Hg	--	--	<.1
Hg_t	<.2	<.1	<.1
Mo	<10-20	<10	<10
Ni	<10	10-20	10-80
Ni_t	<10	20-30	10-30
Se	<1	<1	<1
Se_t	<5	<1	<1
Ag	<1-2	<1	<1
Ag_t	<5	<1	<1
Sr	290-360	110-130	94-120
Tl	<1	<1	<1
V	<6	<6	<6
V_t	<1-3	<6	<6
Zn	<4-8	10-140	22-310
Zn_t	7-424	110-240	90-220

within a narrow band on a trilinear diagram between the Ca plus Mg-CO_3 vertex and the Ca plus Mg-SO_4 plus Cl vertex (fig. 16).

Concentrations of COD (less than 10–26 mg/L), Na (5.9–14 mg/L), Cl (2.3–14 mg/L), NO_2+NO_{3t} (less than 0.02–0.71 mg/L), and NH_{3t} (less than 0.01–0.52 mg/L) were relatively small in samples from the background sites. Concentrations of SO_4 (240–520 mg/L) and Fe (less than 3–2,400 µg/L) were, however, moderately large.

Concentrations of Ca (170–180 mg/L), Mg (93–110 mg/L), SO_4 (480–520 mg/L), and several trace elements in samples from piezometer 201–P (table 9, at the back of this report) generally were larger than concentrations in samples from public-supply wells in the region (table 7) and the Baker Mine well (table 9). The large concentrations of various constituents in samples from piezometer 201–P are attributed to naturally occurring sulfide mineralization in the bedrock in this area. Abundant pyrite and marcasite (FeS_2) and galena (PbS) were observed in drill cuttings during the installation of this piezometer. A sample from piezometer 2022–P, located in a relatively non-mineralized part of the bedrock, had smaller concentrations of Ca (100 mg/L), Mg (72 mg/L), and SO_4 (240 mg/L) than those in samples from piezometer 201–P, and the concentrations were comparable to those detected in samples from public-supply wells (table 7).

Except for boron (B), total boron (B_t), Fe, Fe_t, Pb_t, Mn, Mn_t, strontium (Sr), Zn, and Zn_t, concentrations of most trace elements ranged from less than the detection level to a few tens of micrograms per liter. Ground-water samples from the tailings tended to have the largest concentrations of total trace elements, whereas samples from the mines and bedrock tended to have the largest concentrations of dissolved trace elements (table 8). Samples from the tailings, however, tended to have larger concentrations of Sr in addition to large concentrations of total arsenic (As_t), Ba, B, B_t, and lithium (Li). The large concentrations of B and B_t are anomalous, because B-rich minerals have not been identified in the tailings or sedimentary rocks in the region. Appreciable quantities of B are contained within P ore and phosphate (PO_4) reagents,

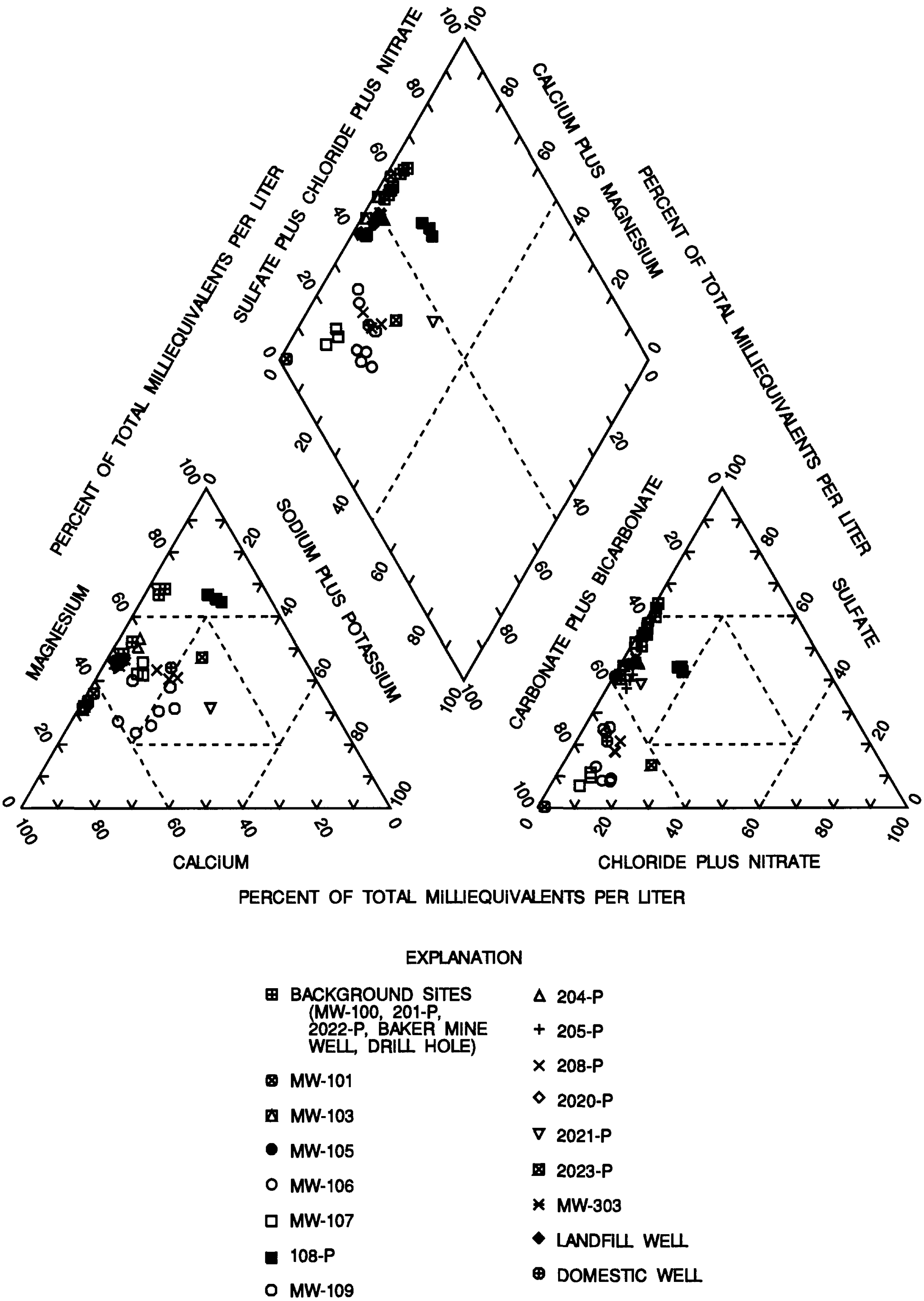


Figure 16. Trilinear diagram of major constituents in ground-water samples from the St. Francois County Landfill site and vicinity, Missouri.

such as detergents. A potential source of B could be reagents used in the milling process. Taggart (1945) indicated that PO_4 was used in the flotation process to precipitate Ca, Mg, and trace elements and to depress the formation of non-silicate salts of these ions.

Molar ratios of Ca to Mg in the tailings are small (0.39–0.48; table 10) as compared to a nearly 1:1 ratio in the bedrock (0.84–1.11) and mines (1.03–1.26). The molar ratios of Ca to Mg indicate the predominant source of Ca and Mg in water from the tailings, bedrock, and mine cavities is dissolution of dolomite [$(Ca, Mg)(CO_3)_2$]. The small molar ratio of Ca to Mg in the tailings indicates the dissolution of dolomite and subsequent precipitation of nearly pure calcite.

Mineral saturation indices (SI) calculated using the computer code WATEQ4F (Ball and others, 1987) indicate probable solubility controls on aqueous concentrations of several major ions (Ca, Mg, and HCO_3). A thorough discussion of this concept is given in Ball and others (1987). A SI of zero indicates the solution is at equilibrium with a given mineral phase; values larger than zero indicate super saturation, and values less than zero indicate the solution is undersaturated with a given mineral phase. An error of ± 0.5 in the SI often is used for common minerals phases, such as calcite ($CaCO_3$), whereas errors for most trace element mineral phases (such as galena) may be much larger. Aqueous concentrations of Ca and HCO_3 in the tailings, bedrock, and mines probably are controlled by the dissolution of dolomite or calcite and precipitation of aragonite, a metastable form of calcite. Aqueous concentrations of Mg in the tailings may be controlled by the precipitation of magnesite ($MgCO_3$) because

Table 10. Molar ratios of calcium to magnesium and saturation indices for selected mineral phases in water samples from background sites in the vicinity of the St. Francois County Landfill site, Missouri

[Ca, calcium; Mg, magnesium; --, no data]

Well (figs. 5 and 10)	Date	Ca/Mg ratio	Saturation index				
			Aragonite	Calcite	Dolomite	Gypsum	Magnesite
MW-100 (tailings)	03-30-93	0.42	0.11	0.26	0.82	-1.10	0.08
	06-22-93	.39	.08	.23	.80	-1.11	.09
	[1]09-28-93	.48	.01	.26	.75	--	.01
	10-27-93	.44	.14	.29	.87	-1.06	.09
201-P (bedrock)	03-29-93	1.07	.13	.28	.48	-.80	-.30
	06-22-93	.99	.03	.18	.30	-.77	-.36
	[1]09-28-93	1.11	-.24	-.08	-.28	--	-.69
	10-27-93	1.09	.05	.20	.29	-.78	-.40
2020-P (bedrock)	12-21-93	.84	.01	.16	.32	-1.21	-.32
Baker Mine well (mine)	04-25-90	1.07	.08	.23	.39	-1.00	-.32
	04-01-93	1.14	.05	.21	.29	-1.03	-.40
	06-24-93	1.14	-.19	-.04	-.19	-.91	-.64
	[1]09-29-93	1.26	.12	.27	.38	--	-.38
	10-29-93	1.14	-.01	.15	.18	-.98	-.46
Drill hole (mine)	02-24-88	1.14	-.09	.07	-.02	-1.10	-.57
	05-17-88	1.12	.23	.38	.65	-1.09	-.22
	09-27-88	1.04	-.03	.13	.17	-1.12	-.44
	11-30-88	1.03	-.22	-.07	-.24	-1.13	-.66
	03-02-89	1.08	-.30	-.15	-.42	-1.14	-.75
	05-04-89	1.09	-.20	-.05	-.22	-1.13	-.65
	09-14-89	1.11	-1.09	-.93	-1.98	-1.14	-1.53

[1] Sulfate concentrations are not available for this sample, and saturation indices for minerals are estimated.

the SI values (0.01–0.09) indicate near saturation with this mineral phase (table 10). Dolomite is slightly supersaturated in the tailings (0.75–0.87) and slightly undersaturated or near equilibrium in the bedrock (-0.28–0.48) and mine cavities (-1.98–0.65). Reaction kinetics of dolomite dissolution are slow, which probably explains the slight supersaturation in the tailings.

The distribution of trace elements in ground water at the landfill site reflects their solid-phase abundances in the tailings and bedrock and geochemical controls on their solubilities. For example, Fe, Pb, and Mn are abundant in the bedrock and tailings; however, only Fe and Mn were detected in substantial quantities in ground-water samples from these media. Concentrations of Pb probably are limited by the formation of Pb-oxides, Pb-carbonate (cerussite), and sorption onto clay minerals (Smith and Schumacher, 1991). Iron, Pb, and Zn are mainly derived from sulfide minerals, such as FeS_2, PbS, and sphalerite (ZnS). The predominant sources of Li, Mn, and Sr are carbonate minerals (calcite and dolomite) within the tailings and bedrock.

Pesticides and Volatile Organic Compounds

Background concentrations of pesticides and VOC were determined in samples from monitoring well MW–100, piezometer 201–P, piezometer 2022–P (VOC only), the Baker Mine well, and the River Mines well (wells 20 and 24, fig. 10). The flowing drill hole west of the landfill site was not accessible during the time samples for background pesticide and VOC concentrations were collected. The Leadwood wells No. 1 and No. 2 (wells 15 and 74, fig. 10), the Gumbo well (well 80, fig. 10), and the Desloge well (well 31, fig. 10) also were sampled to provide additional background concentrations of VOC in the Lamotte Sandstone beneath mined (Leadwood wells) and unmined (Gumbo and Desloge wells) areas. A VOC sample also was collected from the Elvins tailings pile seep, previously sampled (Smith and Schumacher, 1991), to provide an additional tailings background sample. All pesticide and VOC samples were analyzed for the entire list of compounds in table 2.

Diazinon, a commonly used lawn and garden insecticide, was detected in several background sites in the tailings, bedrock, and mine cavities. Diazinon was detected at 17 ng/L (nanograms per liter) in the sample from monitoring well MW–100 and at 4 ng/L in piezometer 201–P (table 11). The presence of diazinon in monitoring well MW–100 cannot be attributed to documented usage around the tailings ponds. Diazinon in the sample from monitoring well MW–100 could be derived from runoff from an old brush and yard waste disposal area 600 ft west of this well. The source of the small (4 ng/L) concentration of diazinon

Table 11. Concentrations of pesticides detected in water samples from monitoring and public-supply wells in the vicinity of the St. Francois County Landfill site, Missouri

[ng/L, nanograms per liter; <, less than; --, no data]

Well (figs. 5 and 10)	Date	Time	Diazinon, dissolved (ng/L)	Prometon, dissolved (ng/L)	Terbacil, water filtered (ng/L)	Total pesticides detected (ng/L)
MW-100	09-28-93	1335	17	<8	<30	17
MW-106	09-29-93	0900	<8	<8	<30	--
MW-107	09-29-93	0930	24	<8	<30	24
108-P	09-28-93	1735	11	<8	54	65
MW-109	09-29-93	1030	<8	<8	<30	--
201-P	09-28-93	1030	4	<8	<30	4
204-P	09-28-93	1500	3	<8	<30	3
205-P	09-28-93	1600	<8	<8	<30	--
208-P	09-28-93	1840	2	<8	<30	2
MW-303	09-28-93	0825	6	57	<30	63
Landfill well	11-24-93	0915	<8	65	<30	65
Baker Mine well	09-29-93	1330	<8	8	<30	8
Park Hills River Mines well	11-24-93	1612	<8	17	<30	17

in piezometer 201–P could be the landfill or nonpoint sources from residential areas less than 0.5 mi to the east.

Prometon (the active ingredient in the nonselective herbicide Pramitrol) was detected at 8 ng/L in the sample from the Baker Mine well and at 17 ng/L in the sample from the River Mines well. The occurrence of prometon in both the Baker Mine well and River Mines well (more than 3 mi apart) may indicate the presence of widespread low-level contamination of the mine cavities. Extensive use of prometon has not been documented in the region; however, the occurrence indicates a nonpoint source or multiple localized sources, such as usage around mill buildings during operation of the mines.

Small concentrations of benzene (0.2–0.3 µg/L, table 12, at the back of this report) were detected in the background tailings well (MW–100). No VOC were detected in the background bedrock piezometers (201–P and 2022–P); however, concentrations of several VOC were detected in the mine cavities. Small concentrations of methyltertiarybutylether (MTBE) were detected in samples from the Baker Mine well (0.2–0.4 µg/L) and in the River Mines well (0.3 µg/L). Concentrations of 1,1,2,2-tetrachloroethene (PCE) at the detection level (0.1 µg/L) were detected in samples from the Baker Mine well and the River Mines well. No VOC were detected in the Leadwood No. 1 well, Gumbo well, or Desloge well; however, 0.74 µg/L of benzene was detected in the sample from the Leadwood No. 2 well. Benzene commonly is in fuels, such as gasoline, many lubricants, hydraulic fluids, and solvents, and is used in the manufacture of a variety of chemicals from pharmaceuticals to pesticides. The small concentrations of benzene in monitoring well MW–100 could be contamination introduced during drilling or residual contamination from the use of creosote in the ore flotation process (Taggart, 1945). The predominant use of MTBE is as an additive in gasoline and other fuels. Because of its nonflammability, PCE is a commonly used industrial solvent. The most likely source of the small concentrations of PCE and MTBE in the mine cavities is old unsalvageable equipment and supplies left underground when the mines were closed. Equipment used in the mines was electric (such as locomotives) or air powered (such as the shovel used to load shot rock into ore cars) and was serviced in underground maintenance shops. The source of benzene in the Leadwood No. 2 well could be related to mining activities or other sources near the wellhead.

Distribution of Contaminants in Ground Water

The physical properties and chemical constituents judged to be the best indicators of landfill leachate effects at the landfill site were specific conductance, Ca, Na, $Alk_{(IT)}$, Cl, NH_{3t}, Ba, Fe, pesticides other than prometon, and VOC other than MTBE and carbon disulfide (CS_2). Although large Ca concentrations are not unique to landfill leachate, anomalously large Ca values may indicate the dissolution of carbonate minerals within the tailings during the neutralization of organic acids present in landfill leachate. Anomalously large concentrations of $Alk_{(IT)}$ also may indicate the presence of landfill leachate. Large concentrations of $Alk_{(IT)}$ can be the result of: (1) analytical errors in the titration method caused by the presence of organic acid anions such as acetate ($C_2H_3O_2^{1-}$) or oxygen-containing organic compounds that are weak bases; (2) additional HCO_3 present from the neutralization of acidic leachate by carbonate minerals; and (3) additional HCO_3 present from the bacterial production of CO_2 gas and subsequent formation of carbonic acid and HCO_3. Large concentrations of Na, Cl, and NH_{3t} typically characterize landfill leachate, and the small background concentrations of these constituents makes them useful tracers of leachate effects from the landfill.

The large concentrations of trace elements commonly reported in landfill leachate predominantly are derived from refuse within the landfill. Leachate generated within the St. Francois County Landfill, however, may also contain SO_4 and trace elements derived from the dissolution of ore minerals within the tailings. Minerals such as PbS, ZnS, chalcopyrite ($CuFeS_2$), sieginite [$(Co,Ni)_3S_4$], FeS_2, and bravoite [$(Ni,Fe)S_2$] present in the Old Lead Belt (Snyder and Gerdemann, 1968) can contain abundant quantities of a variety of trace elements, including cadmium (Cd), cobalt (Co), Cr, Cu, Fe, Pb, nickel (Ni), and Zn. Increased concentrations of SO_4 and these elements have been detected in seeps emerging from tailings piles in the region (Smith and Schumacher, 1991). The presence of naturally occurring trace elements in ground water from the tailings, bedrock, and mine cavities in the region makes an identification of landfill leachate based solely on SO_4 and trace element distributions equivocal. Concentrations of Ba, however, in the water samples from background sites generally were small (55 µg/L or less). In addition, concentrations of Fe in water samples from the background tailings and bedrock sites (MW–100, 201–P, and 2022–P) were small (less than 250 µg/L) as compared to concentrations commonly detected (0.2–5,500 µg/L) in landfill leachate (table 4). Background concentrations of Fe in the mine cavities, however, were much larger (as much as 2,400 µg/L) than concentrations from background tailings and bedrock sites.

Small concentrations of the pesticide prometon and the VOC MTBE were detected in samples from the background mine cavity site (Baker Mine well, tables 11 and 12) and in samples from several public-supply wells in the region. The occurrence of these two compounds in the mine-cavity system makes their use as indicators of landfill leachate equivocal. A common degradation product of the xanthates used in the ore processing is CS_2, limiting its usefulness as an indicator of landfill leachate.

To determine if the water quality of samples from monitoring wells, piezometers, and seeps at the landfill site was affected by the landfill, values of physical properties and concentrations of chemical constituents in samples from various sites at the landfill were compared to background concentrations reported in the previous section (table 8). Data from tailings monitoring wells, piezometer 108–P, and seeps G, H, and K were compared to background values represented by data from monitoring well MW–100. Data from piezometers, wells, and seeps in the bedrock (seep 10+07) were compared to background values represented by data from piezometers 201–P and 2022–P. Water-quality data from monitoring points in the mine cavities were compared to background values characteristic of the mine cavities represented by data from the Baker Mine well and the drill hole west of the landfill site.

Physical Properties and Major Inorganic Constituents

Sample results from monitoring wells MW–106, MW–107, and MW–109 and piezometers 108–P, 208–P, 2021–P, and 2023–P, and the domestic well south of the landfill site (fig. 2) plot outside the range for background sites on a trilinear diagram (fig. 16). Water in these wells and piezometers tends to be a Ca-Mg-HCO_3 type, compared to the mixed Ca-Mg-SO_4-HCO_3 type typical of ground water in the tailings, bedrock, and mine cavities in the region. Values of specific conductance and various physical properties and concentrations of major constituents in samples from these sites commonly exceeded the background values determined for the tailings or bedrock.

The largest constituent concentrations were detected in samples from tailings monitoring wells MW–106, MW–107, and MW–109 and piezometer 108–P. Samples from monitoring well MW–303 and piezometer 208–P contained generally the largest concentrations of major constituents in samples from bedrock and mine cavity monitoring points, and samples from piezometer 205–P contained among the smallest. Concentrations of total major constituents compared favorably with dissolved concentrations, with the total concentrations usually equal to or slightly larger than the dissolved concentrations (table 9).

Specific conductance values in monitoring well and piezometer samples collected at the landfill site ranged from 473 µS/cm in a sample from monitoring well MW–105 to 2,260 µS/cm in samples from monitoring well MW–106 (table 9; values of 330 and 3,000 µS/cm in samples from monitoring wells MW–106 and MW–103 were considered suspect). Samples from monitoring well MW–106 also contained among the largest concentrations of COD (7–150 mg/L), Ca (160–356 mg/L), Na (28–96 mg/L), potassium (K; 25–39 mg/L), $Alk_{(IT)}$ (840–1,040 mg/L), Cl (44–157 mg/L), TOC (4.6–71.6 mg/L), NO_2+NO_3 (less than 0.05–5.9 mg/L as N), and NH_{3t} (13–28 mg/L as N). These concentrations were larger than background concentrations for tailings (table 8) in most sampling rounds. A strong smell of H_2S was detected during the sampling of this well. Water-quality samples from seep K, located about 25 ft downslope of monitoring well MW–106, also contained specific conductance values and concentrations of COD, Ca, Na, K, $Alk_{(IT)}$, Cl, NH_3, and NH_{3t} larger than background (table 13, at the back of this report). The discharge of this seep was estimated at less than 0.01 ft^3/s. Monitoring well MW–106 and seep K are submerged occasionally during high flow on the Big River and constantly are being covered by wind-blown tailings and small slumps at the base of the pile that may, in part, explain the variable water quality observed in MW–106.

Samples from monitoring wells MW–101, MW–103, MW–104, MW–107, and MW–109, and piezometers 108–P, 204–P, 208–P, 2020–P, 2021–P, and 2023–P also had specific conductance values or concentrations of COD, Ca, Mg, Na, K, $Alk_{(IT)}$, SO_4, Cl, NO_2+NO_{3t}, NH_{3t}, and TOC larger than background. Samples from three of these sites (MW–103, 204–P, and 2020–P), however, plotted within the range of background sites on a trilinear diagram (fig. 16), indicating the distribution of major constituents in these samples was not substantially different from that of the background sites. Insufficient data were available to plot samples from monitoring well MW–104. None of the samples from bedrock piezometers had larger than background specific conductance values or concentrations of Ca, Mg, or SO_4.

Concentrations of Na larger than background (9.4 mg/L tailings, 14 mg/L bedrock) also were detected in samples from monitoring wells (table 9) MW–107 (29–33 mg/L) and MW–109 (28–150 mg/L) and piezometers 108–P (63–69 mg/L), 204–P (14–16 mg/L), 208–P (35–46 mg/L), 2021–P (130 mg/L), and 2023–P (46 mg/L). Between March and October 1993, concentrations of Na in samples from monitoring well MW–109 decreased with time (150–28 mg/L), whereas concentrations of Ca (110–150 mg/L) and Mg (64–73 mg/L) increased. Concentrations of other indicator constituents such as Cl and NH_{3t} had no such trends. The molar equivalent decrease in the Na charge (about 5 millimoles per liter) was almost balanced by the increase in equivalences of Ca plus Mg (about 3 millimoles per liter), indicating ion exchange may be affecting the concentrations of major cations in samples from this well. The most likely cause is the exchange of Ca or Mg for Na in the Na-bentonite used as the annular seal. Exchange reactions typically occur rapidly, and the concentrations of Ca, Mg, and Na stabilized by October 1993.

Larger than background concentrations of $Alk_{(IT)}$ (303 mg/L) also were detected in samples from tailings monitoring wells MW–101 (321 and 333 mg/L), MW–103 (346 and 381 mg/L), MW–107 (582–623 mg/L), and MW–109 (528–676 mg/L), piezometer 108–P (328–349 mg/L), and bedrock piezometer 2021–P (439 mg/L, background bedrock concentration of 414 mg/L). Larger than background concentrations of Cl (3.3 mg/L tailings, 9.7 mg/L bedrock) were detected in samples from monitoring wells MW–101 (less than 1–66 mg/L), MW–103 (less than 1–46 mg/L), MW–104 (4–64 mg/L), MW–107 (38–51 mg/L), and MW–109 (32–40 mg/L) and piezometers 108–P (95–110 mg/L), 204–P (17–20 mg/L), 208–P (44–45 mg/L), 2021–P (44 mg/L), and 2023–P (78 mg/L). Concentrations of Cl in samples from piezometer 205–P (7.5–11 mg/L) were only slightly above background.

The largest concentrations of NH_3 or NH_{3t} in the tailings or bedrock (excluding samples from monitoring well MW–106) were detected in samples from monitoring wells MW–107 (2.1–3.62 mg/L) and MW–109 (2–3.02 mg/L) and piezometers 108–P (2.3–4.8 mg/L) and 2023–P (2.5 mg/L; table 9). An NH_3 concentration of 8.5 mg/L in a sample from monitoring well MW–105 (January 18, 1988; table 9) was more than 10 times larger than any other concentration from this well and is suspect.

Several samples from two seeps (seep G and H) emerging from the base of the tailings and a bedding plane in the bedrock near monitoring well MW–104 had specific conductance values or concentrations of COD, Ca, Na, K, $Alk_{(IT)}$, SO_4, and Cl (table 13) larger than background for tailings. Seep G is the seep near the drainage tower that was sampled by the Missouri DGLS and Missouri DEQ in 1980 and 1988. Between 1980 and 1989, specific conductance values and concentrations of most constituents in samples from this seep increased. However, except for slightly increased concentrations of Ca (96 and 99 mg/L, background of 95 mg/L) and Cl (3.5 and 3.6 mg/L, background of 3.3 mg/L), concentrations of major constituents in samples from seep G decreased to less than background in samples collected on June 7, 1990. Specific conductance values and concentrations of most major constituents in two samples from seep H (about 25 ft east of seep G) collected in April and June 1990 were larger than concentrations in samples from seep G. Both seeps have been dry between mid-1991 and the present (1994).

A number of bedding plane seeps were observed during a reconnaissance of the diversion tunnel in April 1990. Small seeps (flowing less than 25 mL per minute) were observed along a pronounced bedding plane along the entire 1,500 ft length of the tunnel. Between the tunnel entrance and the bend that underlies the landfill office, seep orifices on the north side of the tunnel tended to be encrusted with orange and black Fe and Mn oxy-hydroxides. Seep orifices on the south side of the tunnel along this same reach were clear and had no Fe or Mn staining. Seep 10+07, the largest of the Fe-stained seeps, is about 150 ft past the bend on the north side of the tunnel. Concentrations of Na, K, Cl, NO_2+NO_{3t}, and NH_{3t} in samples from this seep have increased to larger than background bedrock concentrations since the initial sampling in June 1990. Concentrations of Na and NH_3 or NH_{3t} increased an order of magnitude from 2.9 and 0.36 mg/L to 30 and

4.8 mg/L; concentrations of K doubled (4.1–8.5 mg/L), and concentrations of Cl increased from 6.1 to 44 mg/L.

Trace Elements

The potential for landfill leachate to mobilize large quantities of trace elements from the tailings was evaluated through a series of laboratory leaching experiments. Fine (less than 0.063 mm) and coarse (greater than 0.063 mm) tailings from the landfill site were leached under batch conditions with leachate obtained from a leachate collection system at a municipal sanitary landfill in Topeka, Kansas. Leachate from the St. Francois County Landfill was not used because of the difficulty in obtaining leachate that had not contacted tailings. Experiments were carried out under oxygen-rich and oxygen-poor conditions over 5 days. Concentrations of dissolved trace elements in the initial leachate were Cd (less than 3 μg/L), Cr (less than 5 μg/L), Co (14 μg/L), Cu (less than 10 μg/L), Pb (56 μg/L), and Zn (48 μg/L). A detailed description of the experimental conditions and analytical results is given by Dixon (1994).

The results of the laboratory experiments indicate that landfill leachate can mobilize measurable quantities of trace elements from the mine tailings at the landfill site. Under near-neutral pH conditions, experimental results indicated variable increases in the dissolved concentrations of Co (271–957 percent), Cu (0–2,350 percent), Pb (0–650 percent), and Zn (608–1,168 percent). The coarse tailings contributed the largest concentrations of Co, Cu, and Zn to the leachate solution (maximum solution concentrations of 169, 336, and 620 μg/L), whereas the fine tailings contributed the largest concentrations of Pb (maximum solution concentration of 939 μg/L). Concentrations of Cd and Cr did not increase substantially in the experiments. In anoxic experiments, solution concentrations of Cu and Pb actually decreased, indicating possible precipitation of reduced phases. The landfill leachate extracted 5 times more Pb and 30 times more Zn than similar experiments using rainwater (Dixon, 1994). Based on the laboratory experiments, leachate generated at the St. Francois County Landfill may contain increased concentrations of Co, Cu, Pb, and Zn derived from interaction of organic acids with mineral phases in the tailings.

Samples from several monitoring wells, piezometers, and seeps in the tailings and bedrock contained detectable concentrations of trace elements indicative of landfill leachate (Ba and Fe) and several trace elements (Co, Cu, Pb, and Zn) mobilized in the laboratory experiments (tables 9 and 13). Concentrations of most trace elements in samples from the landfill site generally were smaller than those detected in the laboratory experiments, indicating that dilution or geochemical reactions may restrict trace element mobility as leachate mixes with ambient ground water and migrates farther from the landfill. Concentrations of most other trace elements, except arsenic (As), As_t, Ni, total nickel (Ni_t), and Sr, were small and near the background concentrations for the various media (table 8). Occasional outliers in the results indicate possible laboratory error, sampling error, or heterogeneity in the solid-phase composition of the tailings and bedrock. Total concentrations of most trace elements, especially Fe_t, Pb_t, Mn_t, and Zn_t, in several samples from tailings monitoring points were much larger than dissolved concentrations, which indicates small quantities of aquifer particulates were disturbed during sampling. Because of this potential problem, dissolved concentrations of trace elements generally were used to interpret water quality and identify contaminant migration from the landfill.

Concentrations of trace elements were largest in samples from tailings monitoring wells and piezometers. Samples from monitoring well MW–106 (table 9), in addition to having among the largest concentrations of major constituents, also contained among the largest concentrations of As (4–49 μg/L), Ba (80–371 μg/L), Cu (6–27 μg/L), Fe (9–29,100 μg/L), Pb (less than 10–68 μg/L), Ni (less than 30–50 μg/L), and Zn (5–1,300 μg/L)—larger than background concentrations for tailings. Concentrations of As_t larger than the background tailings concentration of 30 μg/L (table 8) were detected in one or more samples from monitoring wells MW–107 (26–41 μg/L; table 9), MW–109 (21–41 μg/L), and piezometer 108–P (13–35 μg/L). Concentrations of As_t in samples from piezometers 204–P (less than 1–7 μg/L) and 208–P (less than 1–5 μg/L) were only slightly larger than the background bedrock concentration of 4 μg/L (table 8). No As_t data were available for piezometers 2020–P, 2021–P, 2022–P, or 2023–P.

Concentrations of Ba exceeded the background tailings concentration of 55 μg/L (table 8) in one or more samples from monitoring wells MW–101, MW–103, MW–105, MW–106, and MW–107, piezometer 108–P, and seeps G and K. Excluding samples from monitoring well MW–106, the largest Ba concentrations were detected in samples from seep K (130–240 µg/L; table 13) and monitoring wells MW–101 (19–180 µg/L; table 9) and MW–107 (110–120 µg/L). Concentrations of Ba larger than the background bedrock concentration of 39 µg/L (table 8) were detected in bedrock piezometers 204–P (26–46 µg/L), 208–P (29–55 µg/L), 2020–P (56 µg/L), 2021–P (100 µg/L), and 2023–P (81 µg/L) and the domestic well (58 µg/L; table 9). Concentrations of Ba in monitoring well MW–303 (25–30 µg/L; table 9) were only slightly larger than the background mine cavity concentration of 28 µg/L (table 8) and are within analytical error.

Samples from monitoring wells MW–101, MW–103, MW–106, MW–107, and MW–109, piezometers 108–P and 2020–P, and seeps G and K contained Fe concentrations larger than the background concentration for the various media. Excluding samples from monitoring well MW–106, the largest Fe concentrations detected were in samples from monitoring wells MW–103 (40–8,900 µg/L) and MW–107 (1,400–2,500 µg/L) and seep K (7–6,100 µg/L). By comparison the largest Fe concentration detected in the bedrock was 330 µg/L in a sample from piezometer 2020–P (table 9).

Larger than background concentrations of Pb, Ni, and Zn were detected in samples from monitoring wells MW–103, MW–105, MW–106, MW–107, and MW–109 and seeps G and H. The largest concentrations of Pb tended to be in samples from seeps G (less than 10–80 µg/L) and H (20 and 170 µg/L). Concentrations in the tailings monitoring wells generally were less than 50 µg/L except in several samples collected during early 1989 from MW–101 (72 µg/L), MW–103 (88 µg/L), MW–106 (68 µg/L), and one sample collected in June 1990 from MW–105 (70 µg/L). A Pb concentration of 420 µg/L in a sample from MW–106 (May 1992; table 9) is suspect. One sample from monitoring well MW–303 contained a Pb concentration of 40 µg/L (table 9) slightly larger than the background concentration of 30 µg/L for mine cavities (table 8). Concentrations of Ni in the tailings monitoring wells generally were less than 50 µg/L except in one sample from monitoring well MW–103 (70 µg/L).

Samples from all tailings monitoring wells and seeps G, H, and K contained concentrations of Co and Zn larger than those detected in the background tailings well (MW–100; table 8). Concentrations of Co (less than 3 µg/L) and Zn (less than 3–8 µg/L) detected in samples from monitoring well MW–100 probably are not representative of the background variability within the tailings. The distribution of Co- and Zn-rich minerals in the ore bodies within the Old Lead Belt was erratic—consequently the distribution of these minerals within the tailings piles is erratic. The small Co and Zn concentrations in samples from monitoring well MW–100 probably indicate that the tailings in the vicinity of this well were derived from Co- and Zn-poor host rock. The concentrations of Co and Zn detected in tailings samples from the landfill site generally were less than the concentrations of Co (310–610 µg/L) and Zn (11,000–18,000 µg/L) detected in samples from the Elvins tailings pile seep (table 13) and probably within the range of background concentrations in mine tailings.

Pesticides and Volatile Organic Compounds

Monitoring wells MW–100, MW–106, MW–107, MW–109, and MW–303, piezometers 108–P, 204–P, 205–P, and 208–P, the landfill well, Baker Mine well, and River Mines well were sampled once between September and November 1993 for 47 selected pesticides (table 2). Samples for VOC determinations were collected quarterly between March and November 1993 from the above sites (excluding the River Mines well). Synoptic samples were collected from piezometer 2022–P, seep 10+07, the domestic well south of the landfill site, the Elvins tailings pile seep, public-supply wells in the cities of Leadwood (Leadwood No. 1 and No. 2), Gumbo (Gumbo well), and Park Hills (Desloge well and River Mines well), and the Big River upstream (Big River at Bone-hole) and downstream (Big River downstream) of the landfill site (table 12). The VOC samples were analyzed for the constituents listed in table 2. A graphical representation of the distribution of pesticides and VOC in well samples collected in October 1993 from the landfill site and vicinity is given in figure 17.

Concentrations of diazinon were detected in samples from monitoring wells MW–107 (24 ng/L; table 11) and MW–303 (6 ng/L) and piezometers 108–P (11 ng/L), 204–P (3 ng/L), and 208–P (2 ng/L). In addition to diazinon, the sample from piezometer 108–P contained a large concentration of the selective herbicide terbacil (54 ng/L). Terbacil is a relatively uncommon herbicide and is used on fruit crops, such as apples, peaches, and blueberries, and on alfalfa. The detection of the nonselective herbicide prometon was confined to monitoring points in the abandoned mines. Concentrations of prometon in samples from monitoring well MW–303 (57 ng/L) and the landfill well (65

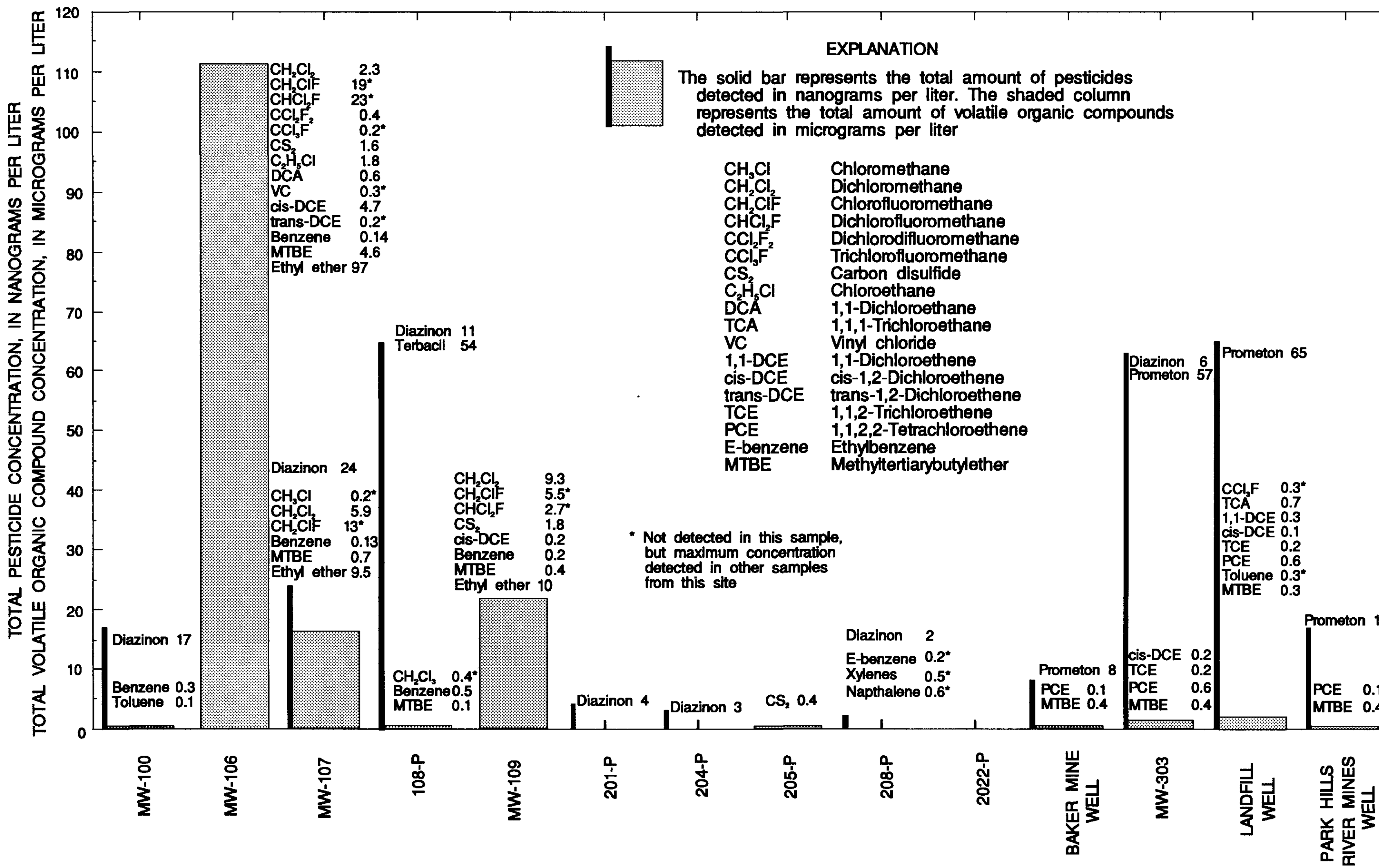


Figure 17. Total mass of pesticides and volatile organic compounds detected in ground-water samples collected in October 1993, St. Francois County Landfill site, Missouri.

ng/L) were larger than the concentrations detected in the background mine sites at the Baker Mine well (8 ng/L) and River Mines well (17 ng/L).

Samples from monitoring wells MW–106, MW–107, MW–109, and MW–303, piezometers 108–P, 205–P, and 208–P, and the landfill well contained detectable concentrations of VOC (table 12). More than 20 VOC were detected in ground-water samples from the landfill site, with the largest frequency of detections and concentrations in samples from monitoring wells MW–106, MW–107, and MW–109. Samples from monitoring well MW–106 contained detectable concentrations of dichloromethane (0.3–2.3 µg/L), chlorofluoromethane (less than 0.2–38 µg/L), dichlorofluoromethane (less than 0.2–23 µg/L), dichlorodifluoromethane (less than 0.2–0.4 µg/L), trichlorofluoromethane (less than or equal to 0.2 µg/L), CS_2 (less than 0.2–1.6 µg/L), chloroethane (0.2–1.8 µg/L), 1,1-dichloroethane (DCA; 0.6–1 µg/L), vinyl chloride (VC; less than 0.2–0.3 µg/L), cis-1,2-dichloroethene (cis-DCE; 4.7–16 µg/L), trans-1,2-dichloroethene (trans-DCE; less than or equal 0.2 µg/L), benzene (0.14–0.2 µg/L), MTBE (2–4.6 µg/L), and ethyl ether (18–97 µg/L).

Concentrations of dichloromethane in samples from monitoring wells MW–107 (5.4–11 µg/L) and MW–109 (9–11 µg/L) and CS_2 (1.8 µg/L) in the October 1993 sample from monitoring well MW–109 were the largest concentrations detected. Samples from these monitoring wells also contained detectable concentrations of chlorofluoromethane, dichlorofluoromethane, benzene, MTBE, and ethyl ether. Monitoring wells MW–106, MW–107, and MW–109 are located immediately north of an older (about 1973 to 1980) part of the sanitary landfill. According to the landfill operator, wastes from a shoe manufacturing plant were placed in this area during the early years of landfill operation, and the probable source of the VOC detected in these three monitoring wells are solvents and other materials contained in these wastes.

The only VOC detected in samples from piezometer 205–P was CS_2 (0.4 µg/L). The small concentrations (less than 1 µg/L) of ethylbenzene, xylenes, napthalene, and several nontarget VOC detected in the March 1993 sample from piezometer 208–P may be the result of down-hole contamination from a hydraulic line break during piezometer installation.

Samples from the landfill well contained trichlorofluoromethane (0.3 µg/L in one sample), 1,1,1-trichloroethane (TCA; less than 0.2–0.7 µg/L), 1,1-dichloroethene (1,1-DCE; less than 0.2–0.3 µg/L), cis-DCE (less than 0.2 µg/L), 1,1,2-trichloroethene (TCE; 0.2 µg/L or less), PCE (0.4–0.6 µg/L), toluene (0.3 µg/L in two samples), and MTBE (0.2–0.4 µg/L). A sample collected from this well on January 26, 1994, was the only sample in which acetone (9.7 µg/L) and 2-butanone (6.1 µg/L) were detected. A probable source of these compounds is PVC cements used in the installation of a new pump and discharge line several days before the January samples were collected. Samples from monitoring well MW–303 contained concentrations of cis-DCE (less than or equal to 0.2 µg/L), TCE (0.2 µg/L in the October 1993 sample), PCE (0.5–0.6 µg/L), and MTBE (0.4 µg/L) similar to those detected in samples from the landfill well.

The compound DCA (detected in samples from MW–106) commonly is used as a solvent for varnishes and paints and in some ore flotation processes. Vinyl chloride is used in the plastics industry and occasionally as a refrigerant. In anaerobic environments, such as within a sanitary landfill, cis-DCE and VC can be derived from the microbial decomposition of TCE. Trans-DCE commonly is used as a solvent for fats, phenol, and camphor (Budavari and others, 1989). Trichlorofluoromethane (Freon 11), dichlorodifluoromethane (Freon 12), and chloroethane commonly are used as refrigerants and aerosol propellants.

Dichloromethane is a common solvent in paint removers and degreasing agents. Benzene is widely used in the manufacture of a variety of industrial chemicals and used as a solvent for paints and varnishes. Benzene also is a component of most fuels (such as diesel and gasoline) and lubricating oils. The presence of chlorofluoromethane (Freon 31) and dichlorofluoromethane (Freon 21) in samples from monitoring wells MW–106, MW–107, and MW–109 is somewhat anomalous because these compounds have not been widely used for more than 20 years (Angila Menton, Dupont Chemical Corporation, written commun., 1994). Chlorofluoromethane and dichlorofluoromethane may have been used as degreasers. Their relatively high boiling points (about -9 and 9 °C) would not make them effective refrigerants or aerosol propellants. These compounds possibly also may be reductive-dechlorination decomposition products of more chlorinated molecules such as trichlorofluoromethane or dichlorodifluoromethane. Ethyl ether is widely used as a solvent in the manufacture of explosives and as a gasoline engine primer (Budavari and others, 1989).

Surface-Water Quality

Although surface-water quality was not a major focus of this investigation, a limited number of samples were collected from streams in the vicinity of the landfill. During October 1993, water-quality samples were collected from the Big River at the Bone-hole (Big River at Bone-hole; fig. 5) and downstream of the landfill about 150 ft downstream of monitoring well MW–106 (Big River downstream; fig. 5).

During the October 1993 sample collection, the discharge and specific conductance values at the upstream site were 119 ft^3/s and 510 μS/cm as compared to 122 ft^3/s and 468 μS/cm measured at the downstream site (table 13). Except for a slight increase in the concentration of SO_4 (49–54 mg/L) and NO_2+NO_{3t} (0.05–0.09 mg/L) and decrease in the concentration of total phosphorous (P_t; 0.13–0.02 mg/L), concentrations of major constituents at the upstream and downstream site were similar. Concentrations of Fe_t, Pb_t, and Mn_t were smaller at the downstream site, whereas concentrations of B, Zn, and Zn_t were larger downstream. Small concentrations of xylenes and toluene were detected in samples from the upstream (0.2 and 0.14 μg/L) and downstream (0.3 and 0.2 μg/L) sites (table 12). Concentrations of most inorganic constituents in these samples were smaller than concentrations in base flow samples collected on November 7, 1989 (table 13). The smaller concentrations detected in this study probably are the result of dilution by runoff, because the discharges during the 1993 sampling were about three times larger than those during the 1989 sampling.

Samples from Mine-A-Joe Creek downstream of the diversion tunnel (tunnel seep; fig. 5) had the largest values of specific conductance and concentrations of chemical constituents as compared to samples from the Big River and Mine-A-Joe Creek upstream of the tunnel (table 13). Although several samples have been collected from Mine-A-Joe Creek upstream and downstream of the diversion tunnel, the upstream and downstream samples were collected by various agencies on different dates using different sample collection and analytical methods and, therefore, are not directly comparable. Despite these inconsistencies, the concentrations of Co (less than 3–88 μg/L), Ni (20–60 μg/L), and Zn (72–740 μg/L) in samples downstream of the diversion tunnel were larger than the maximum concentrations detected in samples upstream of the tunnel (Co, less than 3 μg/L; Ni, less than 10 μg/L; and Zn, 9nd 63 μg/L), suggesting the source of these constituents is within the tunnel, probably the numerous small seeps emerging from fractures and bedding planes along the tunnel walls.

EFFECTS OF THE LANDFILL ON WATER QUALITY

The analytical results of water-quality sampling indicate a complex distribution of inorganic and organic constituents within the tailings, bedrock, and mine cavities at the landfill site and vicinity. Evaluation of the data indicates that ground water at the landfill site has been affected by contaminants originating from the landfill and relic contamination from mining activities. Because detailed water-quality samples have been collected for less than a year at most sites and pesticide and VOC data are not available for several of the newer piezometers (2020–P, 2021–P, and 2023–P), a comprehensive interpretation of how constituent concentrations vary through time is not possible.

Samples from several monitoring wells and piezometers in the tailings and bedrock contained concentrations of inorganic constituents larger than the respective background values established for these media. A one-way analysis of variance (ANOVA) and Tukey's honest significant difference (HSD) multiple-comparison tests (Helsel and Hirsch, 1992) were performed on ranked data from background sites (MW–100, 201–P, 2022–P, Baker Mine, and drill hole) and monitoring wells and piezometers at the landfill site. The ANOVA and HSD tests were used to compare water-quality data from monitoring wells and piezometers within each media (tailings, bedrock, and mine cavities). Data from piezometer 2022–P were grouped with data from piezometer 201–P to represent background conditions within the bedrock. Because water-quality data tend to be non-normally distributed, the data were transformed by a joint ranking procedure. Values flagged as questionable in table 9 were not used in the ANOVA and HSD tests. Data from monitoring wells MW–103, MW–104, and MW–105 and piezometers 2020–P, 2021–P, and 2023–P were not included in the ANOVA because of insufficient sample size.

A students t-test [alpha level (α-level) of 0.05] was used to compare physical property and major constituent data collected previously by the landfill to data collected during this investigation. Most physical property and major constituent data were comparable, with the exception of specific conductance, Na, and Cl concentrations in samples from monitoring well MW–106, which indicated significant differences. Because of differences in sampling protocols previously used and the methods used in this investigation and known sensitivity in trace element data to sampling technique, only trace element data collected during this investigation were used in the ANOVA and HSD tests.

An α-level of 0.05 was used for ANOVA procedures, and the null hypothesis, which states that all sites within a group (tailings, bedrock, and mine cavities) have equal mean ranks for a given constituent, was rejected for analyses with probability values (p-values) less than 0.05. The α-level is the significance level of the test and is established before reviewing the data. The p-value is the attained significance level and is determined by the data (Inman and Conover, 1983). The multiple-comparison test was used to determine significant differences in values of physical properties or constituent concentrations between sites within each group. Usage of the Tukey's HSD procedure allowed the overall error rate to be controlled at 0.05 (Snedecor and Cochran, 1980).

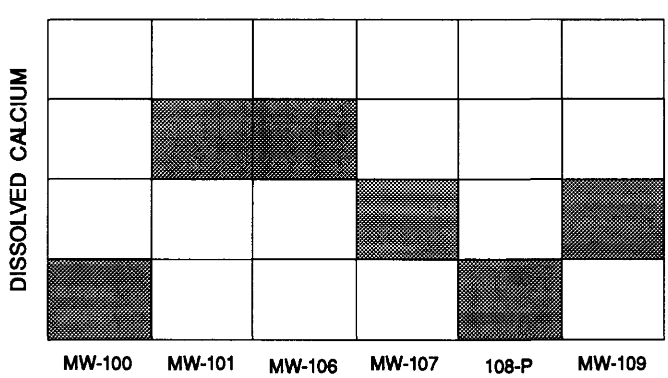
The ANOVA indicated significant differences between the mean ranks of several constituents in samples from monitoring wells and piezometers in the tailings, bedrock, and mine cavities. In general, the differences were detected between the mean ranks of physical properties and constituents determined previously to be indicative of landfill leachate effects (specific conductance, Ca, Na, $Alk_{(IT)}$, Cl, NH_{3t}, Ba, and Fe) at tailings and bedrock monitoring points. Few significant differences were detected between mean ranks of most trace elements, especially total trace elements. An example of the ANOVA and HSD tests is graphically summarized in figure 18, and the results are in figures 19, 20, and 21.

EXPLANATION

MEAN CONSTITUENT RANK

NV NO VARIANCE

Shaded boxes graphically summarize the results of a one-way analysis of variance (ANOVA) and all possible pairwise multiple-comparison tests. Shaded boxes in each column represent the relative mean constituent rank for each site. The absence of a shaded box in a column indicates that insufficient data were available for analysis. Sites with boxes shaded in the lowermost rows have among the smallest mean constituent ranks. Those sites with boxes shaded in the uppermost rows have among the largest mean constituent ranks. Two or more sites with boxes shaded in the same row indicate their respective mean constituent ranks are not significantly different at an alpha level of 0.05. Two shaded boxes in the same column indicate that the mean constituent rank of the site is not significantly different at an alpha level of 0.05 from mean ranks of two or more sites that have shaded boxes in the same rows. However, the mean constituent ranks of the other sites that are not in the same row are significantly different.



For example, monitoring well MW-100 and piezometer 108-P have boxes shaded in the lowermost row indicating that their mean constituent ranks are among the smallest detected in the tailings. The boxes for these two sites are shaded on the same row indicating that their mean ranks of dissolved calcium are not significantly different at an alpha level of 0.05. The mean ranks of dissolved calcium in samples from MW-107 and MW-109 also were not significantly different; however, their mean ranks were significantly larger than those of samples from monitoring well MW-100 and piezometer 108-P. Mean ranks of dissolved calcium in samples from monitoring well MW-101 and MW-106 were not significantly different; however, mean ranks of dissolved calcium in samples from these two wells were significantly larger than those from the other tailings sites.

Figure 18. Example of results from analysis of variance and multiple-comparison tests.

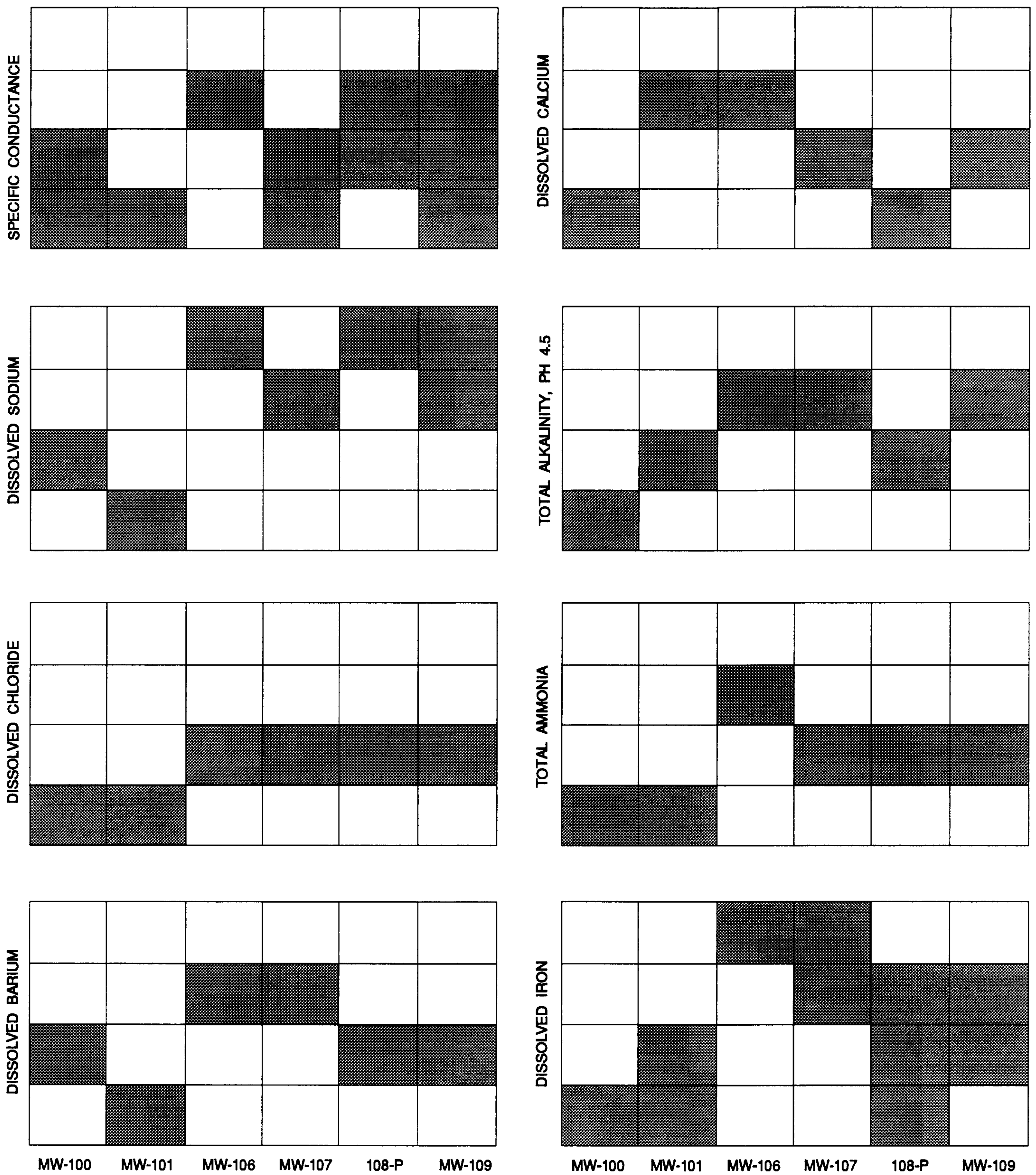


Figure 19. Results of analysis of variance and multiple-comparison tests on ranked data for selected physical properties and chemical constituents from tailings monitoring wells and piezometers at the St. Francois County Landfill site, Missouri.

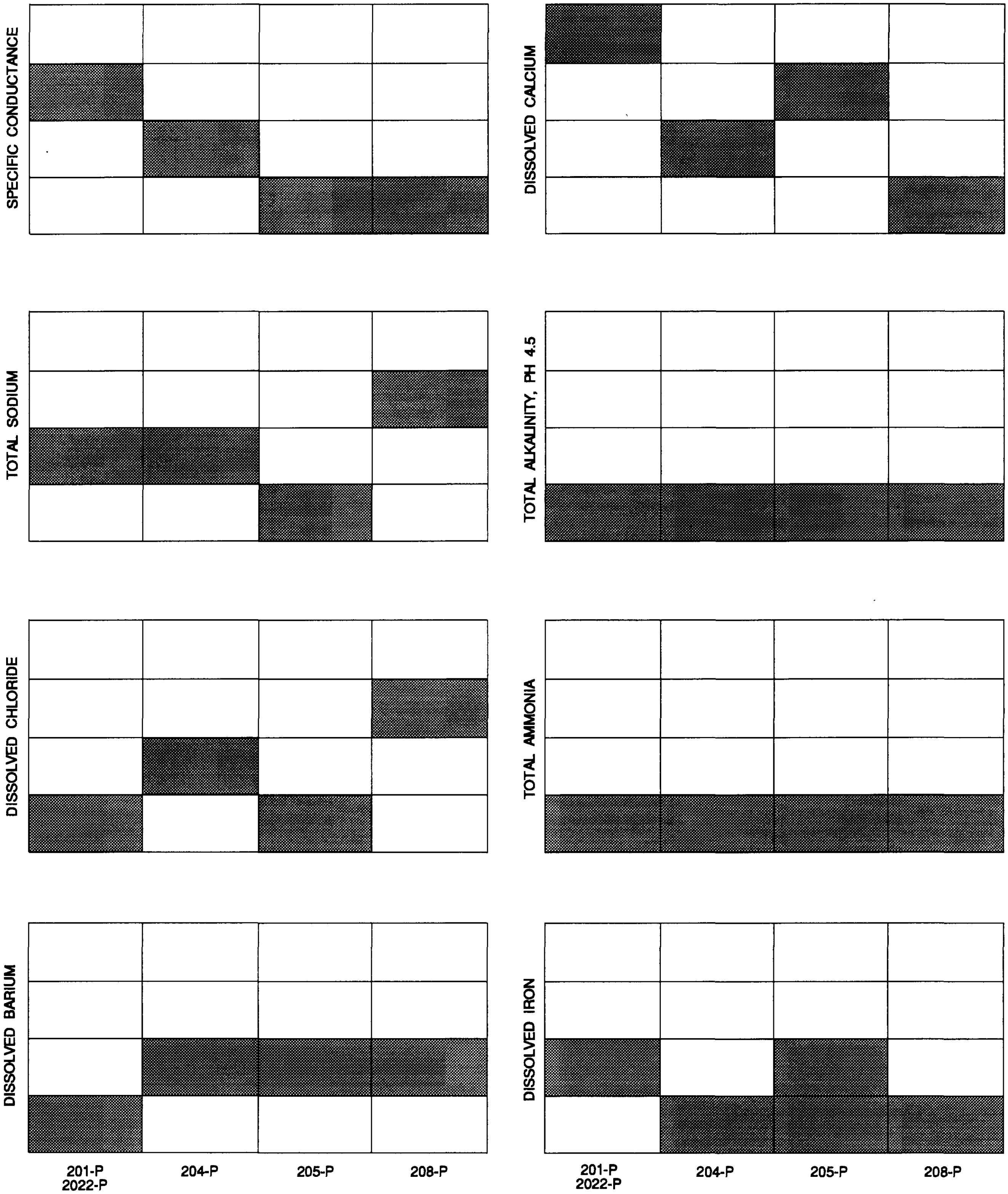


Figure 20. Results of analysis of variance and multiple-comparison tests on ranked data for selected physical properties and chemical constituents from bedrock piezometers at the St. Francois County Landfill site, Missouri.

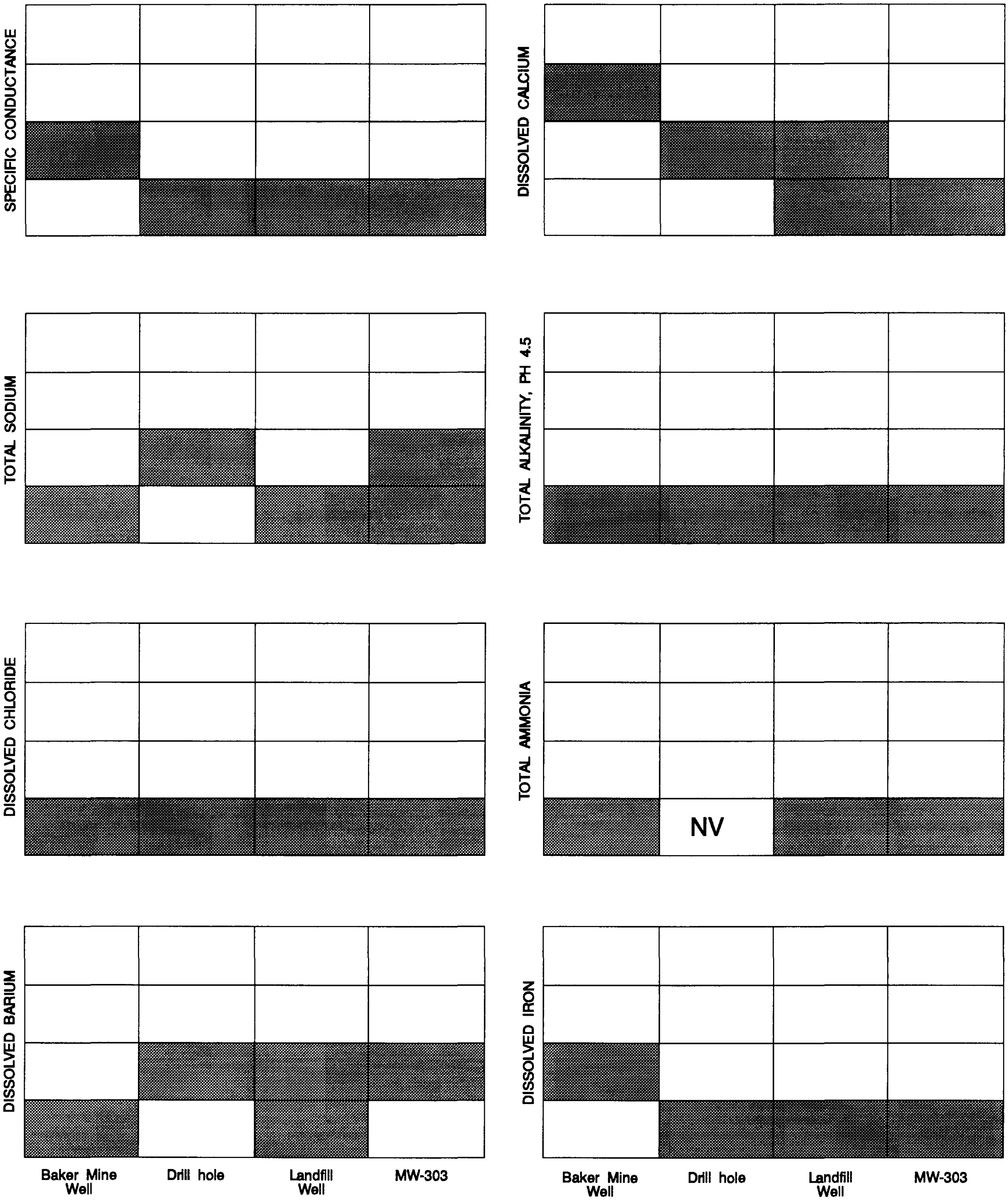


Figure 21. Results of analysis of variance and multiple-comparison tests on ranked data for selected physical properties and chemical constituents from wells completed in mine cavities in the vicinity of the St. Francois County Landfill site, Missouri.

Tailings

The water quality near monitoring wells (MW–106, MW–107, and MW–109) and seep K has been affected by the landfill. These wells and seep K are downgradient from most of the sanitary landfill, near the lower end of the buried creek valley (fig. 13). The detection of landfill contaminants in this area indicates leachate from the landfill is migrating down the buried creek valley toward the Big River. A predominant pathway for leachate migration is through the tailings down this buried creek valley. Mean ranks of specific conductance, Ca, Na, $Alk_{(IT)}$, Cl, NH_{3t}, Ba, and Fe in samples from monitoring well MW–106 were significantly larger than those in the background tailings well (MW–100) and among the largest detected in the tailings (fig. 19). Except for specific conductance and Ba, the mean ranks of these constituents in samples from monitoring wells MW–107 and MW–109 also were significantly larger than background mean ranks for the tailings. Concentrations of trace elements in samples from monitoring wells MW–107 and MW–109 were much smaller than the maximum concentrations detected in the laboratory leaching experiments. If leachate from the St. Francois County Landfill is mobilizing trace elements from the tailings, the smaller trace element concentrations detected in ground-water samples may be related to dilution of landfill leachate, sorption, or re-precipitation of trace elements as they migrate farther from the landfill. In addition to the significantly larger concentrations of indicator constituents, samples from monitoring wells MW–106, MW–107, and MW–109 contained the largest concentrations of diazinon (24 ng/L in the sample from MW–107) and VOC detected at the landfill site and vicinity.

The water quality in tailings near the center of the site also has been affected by the migration of leachate from the landfill as evidenced by the large concentrations of indicator constituents and pesticides in samples from piezometer 108–P. Mean ranks of Na, $Alk_{(IT)}$, Cl, and NH_{3t} in samples from this piezometer were significantly larger than background (fig. 19) and indicate the presence of landfill leachate. Although VOC concentrations were small (0.5 µg/L) in samples from this piezometer (possibly because it is adjacent to the most recent fill), concentrations of pesticides (diazinon, 11 ng/L; terbacil, 54 ng/L) were large. A sample from this piezometer contained a tritium concentration of 16.0 pCi/L (picocuries per liter; table 9), indicating a measurable component of post-1952 water in this well.

Samples from monitoring wells MW–103, MW–104, and MW–105 also may be affected by leachate from the landfill. These wells probably monitor perched water in the tailings, and samples from them may not represent actual ground-water quality conditions within the tailings. Monitoring well MW–103 was located within a drainage ditch, and surface runoff may have entered the well during storm events. In addition, the filter pack extended to within 5 ft of the land surface, which also may have allowed surface contaminants to enter the well. Monitoring well MW–104 is located adjacent to the old drainage tower (originally clogged with trash and debris) and settling pond behind the new drainage structure, both of which may affect the water quality in this well. Although MW–105 is downgradient from the landfill, the number of samples is not sufficient to conclude if leachate affects this well.

Although samples from monitoring well MW–101 contained mean ranks of Ca and $Alk_{(IT)}$ larger than background (fig. 19), mean ranks of other indicator constituents (Na, Cl, NH_{3t}, Ba, and Fe) were not significantly larger than those in monitoring well MW–100 and, in the case of Na and Ba, were significantly smaller than those in MW–100. A ground-water trough lies between this well and the sanitary landfill (fig. 12), and the water quality of this well probably has not been affected by contaminants migrating through the saturated zone from the landfill. The variable water quality of this well may be related to the infiltration of pooled runoff from the northern part of the sanitary landfill or complex flow within perched zones in the tailings.

The water quality of samples from seeps G and H has been affected indirectly by the landfill. Specific conductance values and concentrations of indicator constituents in samples from seep G decreased with time (table 13) after demolition and removal of trash and other debris from the area around the original drainage tower adjacent to monitoring well MW–104 in 1989. This decrease indicates the source of at least part of the contaminants in the original samples from this seep collected by the Missouri DGLS and Missouri DEQ was the trash and debris around the drainage tower. After the new drainage structure was installed and the tailings excavated to bedrock behind the tailings dam in this area, both seeps have gone dry. However, several small orange seeps along bedding planes inside the diversion tunnel, including seep 10+07, continue to flow.

Bedrock and Mines

Data collected during this investigation indicate that landfill leachate has affected water quality in the upper bedrock. Results of the ANOVA indicate mean ranks of Na, Cl, and Ba in samples from piezometer 208–P are significantly larger than those from the background piezometers completed in bedrock (fig. 20). The presence of increased Na and Cl concentrations indicates leachate from the landfill has affected the bedrock water quality in this area. The magnitude of the effect, however, is smaller than the effect in the overlying tailings. For example, the concentration of Cl and diazinon in samples from piezometer 208–P (44–45 mg/L and 2 ng/L) are less than one-half of those concentrations in samples from piezometer 108–P (95–110 mg/L and 11 ng/L; tables 9 and 11). The lack of detectable tritium (less than 5.7 pCi/L) in a sample from piezometer 208–P indicates that the component of recent (post-1952) water that contains landfill contaminants near this well is small.

Water-quality data from piezometer 2023–P probably indicate the effects of landfill leachate. This piezometer lies downgradient of part of the sanitary landfill and south of the demolition fill (fig. 5). A sample from this piezometer contained larger than background concentrations of several indicator constituents (Na, Cl, NH_{3t}, and Ba), and small specific conductance (818 µS/cm) and concentrations of Ca (46 mg/L) and $Alk_{(IT)}$ (286 mg/L; table 9). The small specific conductance value indicates most of this water is not derived from the mines or the tailings. The small concentrations of Ca may indicate the precipitation of $CaCO_3$ as CO_2-rich landfill leachate mixes with ambient ground water. Although this piezometer lies downgradient of the septic tank and drain field immediately north of the landfill office, the most likely source of contamination is landfill leachate. The concentrations of Cl and NH_{3t} in samples from piezometer 2023–P were larger than those in samples from piezometer 208–P even though piezometer 2023–P is 600 ft farther downgradient. A measurable landfill leachate effect at piezometer 2023–P indicates preferential lateral transport along bedding planes or horizontal fractures in the bedrock. The available water-level and water-quality data indicate that landfill leachate detected at piezometer 2023–P could eventually discharge to the diversion tunnel or the mines in the vicinity of piezometer 2023–P and the landfill well before reaching domestic wells southwest of the landfill site (fig. 14). Leachate contaminants entering the mine could affect the water quality of the landfill well.

Samples from piezometer 204–P (fig. 5) contained mean ranks of Cl and Ba significantly larger than background and detectable concentrations of diazinon (3 ng/L); however, no VOC were detected in samples from this piezometer. Probable sources of the increased constituent concentrations include leachate migrating from the sanitary landfill southward through the bedrock, infiltration of contaminated water ponded behind the south tailings dam and original discharge into the bedrock, or effluent from the septic tank and drain field migrating down the original land surface to the water table north of piezometer 204–P. The most probable source is migration of leachate from the landfill to the south.

The larger than background concentrations of Na (40 mg/L), Cl (16 mg/L), and NO_2+NO_{3t} (4.8 mg/L) in the sample from the domestic well south of the landfill office are anomalous. The small specific conductance value (862 µS/cm) indicates the well is not completed in the abandoned mines. The wellhead is buried and is in the vicinity of at least one septic tank and drain field, and the increased Na, Cl, and NO_2+NO_{3t} concentrations probably are related to effluent from this source and not landfill leachate.

Concentrations of Na, K, Cl, NH_{3t}, Ba, and B in samples from seep 10+07 increased dramatically between 1990 and 1993 while concentrations of Ca, Mn, SO_4, and Zn decreased. Although the potentiometric surface map (fig. 12) indicates the potential for flow from the landfill toward the southwest where this seep is located, the increased concentrations probably are the result of effluent from the septic tank and drain field behind the landfill office that lie directly above the diversion tunnel and seep 10+07. The increase in constituent concentrations coincides with the installation of a septic tank and drain field in 1992. This seep is more than 1,000 ft from the sanitary landfill and more than 500 ft from the demolition fill.

The migration of leachate from the landfill also has affected the water quality in the bedrock northeast of the landfill between the sanitary landfill and the Big River. The larger than background concentrations of several indicator constituents (Na, $Alk_{(IT)}$, Cl, NH_{3t}, and Ba) and increased concentrations of K, NO_2+NO_{3t}, Li, and Sr in the sample from piezometer

2021–P indicate the movement of landfill leachate into the bedrock in this area. The altitude of the bottom of the screened interval and filter pack in this piezometer (704.52 ft) is more than 30 ft above the Big River, and landfill contaminants in this area are expected to move toward the Big River. Although concentrations of K, NH_{3t}, Ba, and Fe in the sample from piezometer 2020–P were larger than background, the small concentrations of Na (2.7 mg/L) and Cl (3.5 mg/L) indicate that substantial effects from the landfill are unlikely in this area.

No direct effects from the landfill on the water quality of the abandoned mines were detected during this investigation. However, the presence of a ground-water mound within the tailings and shallow bedrock beneath the landfill, the occurrence of landfill leachate effects within the tailings and shallow bedrock, the presence of relatively recent (post-1952) recharge in the mine cavities as evidenced by detectable tritium (29 pCi/L) in the landfill well, and the presence of potentially open abandoned exploration drill holes beneath the tailings pile and landfill indicate some downward movement of water and contaminants from the landfill into the mine cavities is possible. The mean ranks of Ba in samples from monitoring well MW–303 were significantly larger than those at the background mine cavity site at the Baker Mine (fig. 21). Also, the mean ranks of B in samples from monitoring well MW–303 were significantly larger than the background mine cavity site at the Baker Mine (not shown in fig. 21; no data were available from the drill hole). The increased B concentrations could indicate B-rich water in the tailings is migrating into the mine cavities. In addition, the small concentration of diazinon (6 ng/L) detected in a sample from monitoring well MW–303 may indicate the migration of landfill contaminants into the mines; however, additional data are needed to confirm this hypothesis. Contaminants migrating from the landfill probably would not affect the water quality of the abandoned mines in the vicinity of the River Mines well or the water quality of the Desloge well. Once in the mine cavities, contaminants would enter the regional flow system and migrate to the north away from the River Mines well. The lack of a well-developed connection between the Desloge well and the mine cavities, as evidenced by the large differences in water levels in this well and the abandoned mine cavities during installation of this well in 1972, indicates the water quality of this well is not likely to be affected by the landfill.

The concentrations of TCA, 1,1-DCE, cis-DCE, TCE, PCE, and MTBE detected in samples from monitoring well MW–303 and the landfill well are anomalous. Potential sources include landfill leachate, spent solvents used in the landfill maintenance shop adjacent to the landfill well, and localized sources (underground maintenance facilities and abandoned equipment) within the mines. Except for trichlorofluoromethane, cis-DCE, and MTBE, the distribution of VOC in samples from monitoring well MW–303, the landfill well, and tailings monitoring wells and piezometers contaminated by landfill leachate (MW–106, MW–107, 108–P, and MW–109) are different, indicating some sources other than landfill leachate. Underground sources within the mines probably are responsible for at least part of these compounds, because background samples from the Baker Mine well and samples from the River Mines well contained detectable concentrations of PCE and MTBE. Based on the available data, however, sources from the landfill cannot be ruled out. If the landfill is the source for part of the VOC contamination in the mines cavities at the landfill site, the general lack of detection of these compounds in the bedrock may indicate discrete paths of migration, such as through the exploration drill holes.

Surface Water

The available data indicate that the landfill probably has not substantially affected the water quality of the Big River; however, additional data at low-base flow would be needed for further evaluation. Samples collected from the Big River upstream and downstream of the landfill in October 1993 did not contain substantial differences in concentrations of indicator constituents. However, discharges during this sampling event were about 10 times the estimated 7-day 2-year low flow of about 12 ft^3/s (Skelton, 1976), and landfill effects would have been minimized by dilution. Although the sample downstream of the landfill contained larger concentrations of SO_4, NO_2+NO_{3t}, B, Zn, and Zn_t than the upstream sample, the differences generally are within the range of analytical error. Increased concentrations of constituents at the downstream site also could be caused by inflow from the abandoned mines, seeps from the tailings pile unrelated to the landfill, or inflow from tributaries between the upstream and downstream sampling sites. Increased concentrations of SO_4 and Zn are common in seeps from tailings piles and the abandoned mines in the region. Smith and Schumacher (1991) concluded that increases in SO_4 and Zn concentrations in the Big River downstream of the Desloge tailings pile were caused by inflow from the abandoned mines. Trace element concentrations in samples from Mine-A-Joe Creek downstream of the landfill tended to be larger than in upstream samples; however, no paired upstream and downstream samples were collected during this investigation because the creek was either dry or flowing at discharges too large to obtain samples safely. Data collected by Smith and Schumacher (1991) downstream of the landfill indicate constituent concentrations were within the range expected for seeps from tailings and mined areas.

SUMMARY AND CONCLUSIONS

A multi-phased investigation of the hydrogeology and water quality in the vicinity of the St. Francois County Landfill was conducted by the U.S. Geological Survey in cooperation with the St. Francois County Environmental Corporation. The landfill is located within an abandoned lead-mine tailings pile and was operated from 1973 to 1993. Two temporary piezometers and 13 monitoring wells and piezometers were installed at the landfill site to determine the direction of ground-water flow and ground-water quality at the landfill site. A regional potentiometric map of the St. Francois aquifer was prepared to determine the relation between shallow ground-water flow at the landfill site and the regional ground-water flow system. In addition to onsite studies, a laboratory investigation was conducted to determine the quantity of trace elements mobilized from the tailings by landfill leachate.

The youngest bedrock unit beneath the landfill and tailings pile is the Bonneterre Formation, consisting primarily of dolostone, which was host to the vast lead deposits of the Old Lead Belt of southeastern Missouri. In southeastern Missouri, the Bonneterre Formation and underlying Lamotte Sandstone comprise the St. Francois aquifer, which is used extensively for domestic and public-water supplies in the region. The Bonneterre Formation crops out extensively throughout the Old Lead Belt region and locally is a leaky confining unit impeding the downward movement of water into the underlying Lamotte Sandstone. Water levels in the lower Bonneterre Formation and Lamotte Sandstone indicate ground-water flow in the region generally is toward the north with the Big River as the primary drain. About 8 square miles of the region are underlain by abandoned, water-filled mine cavities. The abandoned mines generally are less than several hundred feet below the surface and are used locally for domestic and occasionally as public-water supply.

The mine cavities and Lamotte Sandstone are well connected through fractures, joints, and tens of thousands of exploration drill holes, and in some areas ground water probably is flowing from the mines into the Lamotte Sandstone. More than 1,200 exploration drill holes were drilled before 1970 on what would later become the landfill site—247 lie beneath the sanitary landfill and demolition fill. The water type in the St. Francois aquifer in the region ranges from a calcium-magnesium-bicarbonate to a magnesium-bicarbonate water, and water from the Bonneterre Formation generally is harder than that from the Lamotte Sandstone. Based on measurements made during a regional well inventory, the mean specific conductance value of water from the Lamotte Sandstone was 566 microsiemens per centimeter at 25 degrees Celsius as compared to 1,017 and 1,160 for the Bonneterre Formation and mine cavities. Concentrations of trace elements in samples from public-supply wells in the region generally were less than detection levels.

Water-level measurements from monitoring wells and piezometers at the landfill site indicate the presence of a ground-water mound within the tailings and upper bedrock near the center of the site. The ground-water mound trends east-west across most of the site, the nose of which coincides with the part of the buried Mine-A-Joe Creek valley beneath the tailings. In the lower part of the buried valley, the tailings are more than 100 feet thick. Within the middle buried creek valley, the tailings are saturated to a thickness of more than 50 feet. In the northeastern part of the landfill site, recharge moves downward through the refuse and tailings to the water table, then down the buried Mine-A-Joe Creek valley toward the Big River and the abandoned mine cavities about 200 feet below the tailings surface.

Ground water in the tailings, shallow bedrock, and mine cavities in the vicinity of the landfill generally has near neutral pH values; specific conductance values ranging from 921 to 1,500 microsiemens per centimeter; and calcium, magnesium, sulfate, and bicarbonate as the predominant dissolved ions. Concentrations of most trace elements generally were less than a few tens of micrograms per liter. The distribution of trace elements commonly associated with ore minerals in the Old Lead Belt, such as cadmium, cobalt, lead, nickel, and zinc, in ground water reflects the abundance of ore minerals within the tailings and bedrock and geochemical reactions that limit their aqueous solubilities. Laboratory experiments performed during this investigation indicate that landfill leachate, however, may mobilize substantial quantities—as much as several hundred micrograms per liter—of cobalt, copper, lead, and zinc.

Water-quality data indicate the landfill has affected the quality of water in the tailings and shallow bedrock beneath the site. Landfill leachate has migrated from the landfill into the tailings and shallow bedrock as evidenced by increased values of specific conductance and increased concentrations of calcium, sodium, alkalinity, chloride, total ammonia, barium, iron, pesticides (diazinon and terbacil), and volatile organic compounds (dichloromethane, chlorofluoromethane, dichlorofluoromethane, dichlorodifluoromethane, trichlorofluoromethane, chloroethane, 1,1-dichloroethane, vinyl chloride, cis-1,2-dichloroethene, trans-1,2,-dichloroethene, and ethyl ether). Although laboratory experiments indicated landfill leachate could mobilize measurable quantities of trace elements from the mine tailings at the landfill site, concentrations of most trace elements in water samples from sites affected by landfill leachate were not significantly larger than background concentrations. Ground water in monitoring wells and piezometers affected by the landfill was predominantly a calcium-magnesium-bicarbonate type, compared to the calcium-magnesium-sulfate-bicarbonate type typical of ground water in the tailings, bedrock, and mine cavities in the region. In general, the effects of the landfill were greatest in the tailings and Big River alluvium northeast of the landfill.

Samples from monitoring wells MW–106, MW–107, and MW–109 generally had the largest values of specific conductance (1,150–2,260 microsiemens per centimeter) and concentrations of the following chemical constituents (concentrations in milligrams per liter unless noted): calcium (110–356), sodium (28–150), total alkalinity (528–1,040), chloride (32–157), total ammonia as nitrogen (2–28), barium (40–371 micrograms per liter), and iron (9–29,100 micrograms per liter). Samples from these wells also contained the largest concentrations of volatile organic compounds (all concentrations in micrograms per liter), such as dichloromethane (0.3–11), chlorofluoromethane (less than 0.2–38), dichlorofluoromethane (less than 0.2–23), dichlorodifluoromethane (less than 0.2–0.4), trichlorofluoromethane (less than or equal to 0.2), carbon disulfide (less than 0.2–1.8), chloroethane (less than 0.2–1.8), vinyl chloride (less than 0.2–0.3), cis-1,2-dichloroethene (less than 0.2–16), trans-1,2-dichloroethene (less than or equal to 0.2), benzene (less than or equal to 0.2), methyltertiarybutylether (0.3–4.6), and ethyl ether (1.6–97). A sample from monitoring well MW–107 contained the largest concentration of the pesticide diazinon (24 nanograms per liter) detected at the landfill site. These monitoring wells are completed in the tailings (MW–107), Big River alluvium (MW–106), or tailings-Big River alluvium contact (MW–109) near the end of the buried creek valley. A predominant pathway for leachate migration from the landfill is flow through the tailings down this buried valley. Except for this area, the available data indicate that contaminants from the landfill have not migrated off-site.

Landfill leachate also has entered the shallow bedrock beneath the site and seems to be migrating through the shallow bedrock toward the Big River northeast of the site and southwest toward the landfill well. Increased concentrations of sodium, chloride, total ammonia, and barium were detected in samples from bedrock piezometers 208–P, 2021–P, and 2023–P. Except for carbon disulfide (probable degradation of xanthates used in the ore flotation process) and drill fluid contaminants detected in the initial sample from piezometer 208–P (ethylbenzene, xylene, and napthalene), none of the volatile organic compounds detected in the tailings were detected in the bedrock.

Although water in the abandoned mine cavities beneath the landfill contained detectable concentrations of tritium, indicating a component of recent (post-1952) recharge, no direct effects from landfill leachate were detected in the mine cavities beneath the landfill site. Samples from monitoring well MW–303 and the landfill well (both completed in the abandoned mines), however, contained detectable concentrations of several volatile organic compounds (cis-1,2-dichloroethene; 1,1,2-trichloroethene; 1,1,2,2-tetrachloroethene; and methyltertiarybutylether). Samples from the landfill well also contained detectable concentrations of 1,1,1-trichloroethane and 1,1-dichloroethane. Samples from these wells also contained detectable concentrations of the herbicide prometon (57 and 65 nanograms per liter), and a sample from monitoring well MW–303 contained a small concentration of diazinon (6 nanograms per liter). Methyltertiarybutylether, 1,1,2,2-tetrachloroethene, and prometon were present in background mine water samples from sites upgradient of the landfill (Baker Mine and River Mines wells). The widespread occurrence of these compounds throughout the mine cavities indicates a source other than the landfill, such as a nonpoint source or multiple localized sources within the mines, such as abandoned machinery and supplies. The small concentration of diazinon detected in a sample from monitoring well MW–303 may indicate the migration of landfill contaminants into the mines; however, the differences between the distribution of volatile organic compounds in samples from this well and the landfill well and the tailings wells contaminated by landfill leachate (such as monitoring wells MW–106, MW–107, and MW–109) indicate some sources for the volatile organic compounds in the mines other than landfill leachate. Additional monitoring is needed, however, to confirm this hypothesis. Based on the proximity of the site to the Big River, general direction of regional ground-water flow, and vast quantities of water in the abandoned mines and Lamotte Sandstone, it appears unlikely contaminants from the landfill are unlikely to affect the water quality of public-supply wells in the region.

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TABLES

ABBREVIATIONS AND REPORTING UNITS FOR CHEMICAL CONSTITUENTS AND NOTATIONS USED IN TABLE 9

WL	Water level, in feet below top of casing
Q	Discharge, in cubic feet per second
SC	Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
pH	In standard units
Temp	Water temperature, in degrees Celsius
DO	Dissolved oxygen, in milligrams per liter
COD	Chemical oxygen demand, in milligrams per liter
Ca	Calcium, dissolved, in milligrams per liter
Ca_t	Calcium, total, in milligrams per liter
Mg	Magnesium, dissolved, in milligrams per liter
Mg_t	Magnesium, total, in milligrams per liter
Na	Sodium, dissolved, in milligrams per liter
Na_t	Sodium, total, in milligrams per liter
K	Potassium, dissolved, in milligrams per liter
$Alk_{(IT)}$	Alkalinity, total, in milligrams per liter as $CaCO_3$, by incremental titration
$HCO_{3(IT)}$	Bicarbonate, in milligrams per liter, by incremental titration
$Alk_{(EP)}$	Alkalinity, total, in milligrams per liter as $CaCO_3$, pH 4.5 end point
$HCO_{3(EP)}$	Bicarbonate, in milligrams per liter, pH 4.5 end point
$CO_{3(EP)}$	Carbonate, in milligrams per liter, pH 4.5 end point
SO_4	Sulfate, dissolved, in milligrams per liter
Cl	Chloride, dissolved, in milligrams per liter
F	Fluoride, dissolved, in milligrams per liter
SiO_2	Silica, dissolved, in milligrams per liter
ROE	Dissolved solids, residue at 180 degrees Celsius, in milligrams per liter
TDS	Dissolved solids, sum of constituents, in milligrams per liter
Hard	Hardness, total, in milligrams per liter as $CaCO_3$
TOC	Organic carbon, total, in milligrams per liter
NO_2+NO_3	Nitrite plus nitrate, dissolved as nitrogen, in milligrams per liter
NO_2+NO_{3t}	Nitrite plus nitrate, total as nitrogen, in milligrams per liter
NO_2	Nitrite, dissolved as nitrogen, in milligrams per liter
NO_{2t}	Nitrite, total as nitrogen, in milligrams per liter
NH_3	Ammonia, dissolved as nitrogen, in milligrams per liter
NH_{3t}	Ammonia, total as nitrogen, in milligrams per liter
NH_3+ON_t	Nitrogen, total ammonia plus organic nitrogen as nitrogen, in milligrams per liter
TON	Nitrogen, total organic, in milligrams per liter
P	Phosphorous, dissolved, in milligrams per liter
P_t	Phosphorous, total, in milligrams per liter
PO_4	Orthophosphate, dissolved, in milligrams per liter
Al	Aluminum, dissolved, in micrograms per liter
Sb_t	Antimony, total, in micrograms per liter
As	Arsenic, dissolved, in micrograms per liter
As_t	Arsenic, total, in micrograms per liter

Ba	Barium, dissolved, in micrograms per liter
Ba_t	Barium, total, in micrograms per liter
Be	Berylium, dissolved, in micrograms per liter
Be_t	Berylium, total, in micrograms per liter
B	Boron, dissolved, in micrograms per liter
B_t	Boron, total, in micrograms per liter
Cd	Cadmium, dissolved, in micrograms per liter
Cd_t	Cadmium, total, in micrograms per liter
Cr	Chromium, dissolved, in micrograms per liter
Cr_t	Chromium, total, in micrograms per liter
Co	Cobalt, dissolved, in micrograms per liter
Co_t	Cobalt, total, in micrograms per liter
Cu	Copper, dissolved, in micrograms per liter
Cu_t	Copper, total, in micrograms per liter
Fe	Iron, dissolved, in micrograms per liter
Fe_t	Iron, total, in micrograms per liter
Pb	Lead, dissolved, in micrograms per liter
Pb_t	Lead, total, in micrograms per liter
Li	Lithium, dissolved, in micrograms per liter
Mn	Manganese, dissolved, in micrograms per liter
Mn_t	Manganese, total, in micrograms per liter
Hg	Mercury, dissolved, in micrograms per liter
Hg_t	Mercury, total, in micrograms per liter
Mo	Molybdenum, dissolved, in micrograms per liter
Ni	Nickel, dissolved, in micrograms per liter
Ni_t	Nickel, total, in micrograms per liter
Se	Selenium, dissolved, in micrograms per liter
Se_t	Selenium, total, in micrograms per liter
Ag	Silver, dissolved, in micrograms per liter
Ag_t	Silver, total, in micrograms per liter
Sr	Strontium, dissolved, in micrograms per liter
Tl	Thallium, dissolved, in micrograms per liter
V	Vanadium, dissolved, in micrograms per liter
V_t	Vanadium, total, in micrograms per liter
Zn	Zinc, dissolved, in micrograms per liter
Zn_t	Zinc, total, in micrograms per liter
^3H	Tritium, total, in picocuries per liter
U	U.S. Geological Survey
C	Landfill consultant
E	U.S. Environmental Protection Agency
--	No data
$<$	Less than
$>$	Greater than

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri

Site (figs. 2, 5, and 10)	Source	Date	Time	WL	Q	SC	pH	Temp	DO	COD	Ca	Ca_t
MW-100	U	03-30-93	1745	50.96	--	1,240	7.6	14	0.3	<10	84	120
	U	06-22-93	1930	50.47	--	1,300	7.7	14.5	.1	<10	71	85
	U	08-05-93	--	50.4	--	--	--	--	--	--	--	--
	U	09-09-93	--	51.2	--	--	--	--	--	--	--	--
	U	09-28-93	1335	50.3	--	1,200	7.5	14	<.5	--	95	--
	U	10-27-93	1510	49.8	--	1,340	7.6	14	<.05	<10	87	90
	C	11-04-93	--	56.3	--	1,110	7.71	13.6	--	26	--	189
	U	11-24-93	--	49.6	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	--	36.2	--	877	7.4	--	--	14	150	--
	C	05-18-88	--	37.8	--	790	6.9	--	--	40	128	--
	C	08-11-88	--	28.6	--	915	7.4	--	--	5	--	--
	C	11-29-88	--	27.7	--	854	7.3	--	--	<1	--	--
	C	02-23-89	--	29.4	--	903	7.3	--	--	1	--	--
	C	05-11-89	--	[1]27.15	--	1,030	7.7	--	--	49	159	--
	C	08-07-89	--	26.8	--	1,150	7.5	--	--	109	--	--
	C	11-16-89	--	27	--	910	7.2	--	--	37	--	--
	C	02-08-90	--	38.5	--	1,275	7.1	--	--	44	--	--
	U	04-27-90	1000	33.4	--	1,290	6.8	20.5	--	--	--	--
	C	04-27-90	--	36.2	--	1,290	6.83	20.4	--	--	--	--
	U	04-30-90	1330	34.05	--	1,220	6.9	17	--	40	180	--
	U	06-07-90	0845	25.85	--	1,280	6.6	19	--	19	210	--
	C	06-28-90	--	27.2	--	1,430	7.4	--	--	21	204	--
	C	08-09-90	--	29.1	--	1,540	7.2	--	--	<1	--	--
	C	11-20-90	--	38	--	1,205	7.2	--	--	<1	--	--
	C	02-28-91	--	30	--	1,200	6.5	--	--	10	--	--
	C	04-26-91	--	30.8	--	1,230	7.0	15.2	--	<5	389	--
	E	06-25-91	--	--	--	--	--	--	--	--	209	221
	C	08-30-91	--	29.8	--	1,200	7.3	16.8	--	<5.0	--	--
	C	05-20-92	--	28.7	--	--	--	--	--	--	--	--
	C	08-27-92	--	Dry	--	--	--	--	--	--	--	--
	C	11-24-92	--	Dry	--	--	--	--	--	--	--	--
	C	02-11-93	--	Dry	--	--	--	--	--	--	--	--
	U	03-04-93	--	28.2	--	--	--	--	--	--	--	--
	U	03-29-93	--	26.9	--	--	--	--	--	--	--	--
	U	06-21-93	1400	25.43	--	1,470	7.4	15.5	--	--	--	--
	C	11-04-93	--	25.2	--	1,340	7.05	--	--	12.7	--	206
MW-103[2]	C	01-18-88	--	27.3	--	675	7.2	--	--	<5	120	--
	C	05-18-88	--	15.7	--	[3]3,000	6.8	--	--	13	338	--
	C	08-11-88	--	24.8	--	1,860	7.0	--	--	19	--	--
	C	11-29-88	--	24.6	--	1,420	7.1	--	--	42	--	--
	C	02-23-89	--	25.7	--	1,430	7.0	--	--	18	--	--
	C	05-11-89	--	[1]25.1	--	1,430	6.97	--	--	22	285	--
	C	08-07-89	--	[1]26.2	--	1,630	6.8	--	--	38	--	--
	C	11-16-89	--	24.1	--	1,290	7.05	--	--	402	--	--
	C	02-08-90	--	26.3	--	1,532	6.3	--	--	25	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Time	WL	Q	SC	pH	Temp	DO	COD	Ca	Ca_t
MW-103[2]—Continued	U	04-30-90	1500	24.9	--	1,230	6.3	19	--	--	200	--
	U	04-30-90	--	27	--	1,230	6.27	19.1	--	--	--	--
	U	06-08-90	0730	--	--	1,140	5.8	18.5	<0.2	--	180	--
	C	06-28-90	--	27.7	--	1,140	6.5	--	--	23	178	--
	C	08-09-90	--	26.7	--	1,020	6.7	--	--	17	--	--
	C	11-20-90	--	Dry	--	--	--	--	--	--	--	--
	C	02-28-91	--	25.7	--	1,040	6.4	--	--	45	--	--
	C	04-26-91	--	Dry	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	Dry	--	--	--	--	--	--	--	--
	C	08-11-88	--	Dry	--	--	--	--	--	--	--	--
	C	11-29-88	--	44.4	--	809	7.1	--	--	99	--	--
	C	02-23-89	--	44.9	--	1,450	7.1	--	--	16	--	--
	C	05-11-89	--	--	--	1,190	6.9	--	--	80	252	--
	C	08-07-89	--	44.4	--	1,670	7.3	--	--	150	--	--
	C	11-16-89	--	45	--	--	--	--	--	--	--	--
	C	02-08-90	--	44.5	--	1,710	6.7	--	--	13	--	--
	U	04-30-90	1600	42.5	--	1,770	7.2	19	--	--	--	--
	U	06-08-90	1000	43.5	--	--	--	--	--	--	--	--
	C	06-28-90	--	Dry	--	--	--	--	--	--	--	--
	U	06-21-93	--	45.4	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	--	25	--	632	7.3	--	--	7	90	--
	C	05-18-88	--	Dry	--	--	--	--	--	--	--	--
	C	08-11-88	--	Dry	--	--	--	--	--	--	--	--
	C	11-29-88	--	26.5	--	473	7.6	--	--	9	--	--
	C	02-23-89	--	Dry	--	--	--	--	--	--	--	--
	C	05-11-89	--	Dry	--	--	--	--	--	--	--	--
	C	08-07-89	--	Dry	--	--	--	--	--	--	--	--
	C	11-16-89	--	Dry	--	--	--	--	--	--	--	--
	C	02-08-90	--	Dry	--	--	--	--	--	--	--	--
	U	04-25-90	1700	28.2	--	--	--	--	--	--	--	--
	U	06-06-90	1445	27.3	--	560	6.6	17.5	>1.0	27	80	--
	C	06-07-90	--	Dry	--	--	--	--	--	--	--	--
	U	09-27-93	--	30.6	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	--	6	--	1,540	6.7	--	--	12	290	--
	C	05-18-88	--	[1]15.9	--	1,340	6.6	--	--	26	290	--
	C	08-11-88	--	6.1	--	1,430	6.4	--	--	17	--	--
	C	11-29-88	--	3.3	--	1,610	6.6	--	--	7	--	--
	C	02-23-89	--	6.9	--	1,690	6.7	--	--	45	--	--
	C	05-11-89	--	[1]4.9	--	1,645	6.8	--	--	56	245	--
	C	08-07-89	--	3.9	--	1,820	6.7	--	--	26	--	--
	C	11-16-89	--	3.9	--	1,880	6.5	--	--	57	--	--
	C	02-08-90	--	5.2	--	1,940	6.6	--	--	43	--	--
	U	04-26-90	1100	3.9	--	1,890	6.5	16	>1.0	150	190	--
	U	06-07-90	0930	1.88	--	1,930	6.6	15.5	.05	53	230	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Time	WL	Q	SC	pH	Temp	DO	COD	Ca	Ca_t
MW-106—Continued	C	06-28-90	--	4.2	--	1,910	6.74	--	--	21	290	--
	C	08-09-90	--	6	--	1,845	6.8	--	--	19	--	--
	C	11-20-90	--	6.5	--	1,580	6.8	--	--	16	--	--
	C	02-28-91	--	5.9	--	1,530	6.6	--	--	37	--	--
	C	04-26-91	--	5.6	--	1,620	9.3	15.2	--	21	356	--
	E	06-25-91	--	--	--	--	--	--	--	--	186	210
	C	08-30-91	--	4.5	--	1,580	6.9	18.2	--	42	--	--
	C	05-20-92	--	4.3	--	1,750	6.77	20.2	--	42	177	--
	C	08-27-92	--	5.1	--	[3]330	[3]8.03	17.3	--	51	--	--
	C	11-24-92	--	4	--	1,910	6.95	13.5	--	62	--	--
	C	02-11-93	--	3.8	--	1,900	6.86	12.7	--	38	--	--
	U	03-04-93	--	4.2	--	--	--	--	--	--	--	--
	U	03-30-93	0900	4.2	--	1,980	6.8	14	0.3	46	180	170
	U	06-23-93	0800	4.22	--	1,960	7.0	16	<.05	29	160	160
	U	09-29-93	0900	2.14	--	2,210	6.7	17.5	<.5	--	250	--
	U	10-28-93	1400	3.4	--	2,260	6.8	17	.2	<10	320	220
	C	11-04-93	--	3.8	--	1,990	6.73	--	--	31.7	--	214
	U	11-24-93	--	2	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	76.2	--	--	--	--	--	--	--	--
	U	03-30-93	1200	77.31	--	1,290	7.1	17	.3	14	130	140
	U	06-23-93	1100	76.28	--	1,240	7.0	19	<.05	<10	120	110
	U	09-09-93	--	76.2	--	--	--	--	--	--	--	--
	U	09-29-93	0930	76.14	--	1,150	7.1	16.5	<.5	--	120	--
	U	10-28-93	1500	74.58	--	1,260	7.0	16.5	.2	<10	110	110
	C	11-04-93	--	77.5	--	1,160	7.13	--	--	15.1	--	136
	U	11-24-93	--	75.8	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	11.5	--	--	--	--	--	--	--	--
	U	03-29-93	1600	11.66	--	1,520	7.6	14.5	>1.0	<10	52	95
	U	06-23-93	1315	11.85	--	1,540	7.8	14.5	<.05	<10	42	42
	U	08-05-93	--	12.4	--	--	--	--	--	--	--	--
	U	09-09-93	--	12.4	--	--	--	--	--	--	--	--
	U	09-28-93	1735	10.3	--	1,530	7.6	16	<.5	--	50	--
	U	10-27-93	1730	12.1	--	1,530	7.7	14.5	<.05	<10	48	49
	U	11-24-93	--	12	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	77.6	--	--	--	--	--	--	--	--
	U	03-31-93	1500	--	--	1,580	7.1	15.5	.3	23	110	150
	U	03-31-93	1501	77.48	--	--	--	--	--	--	--	--
	U	06-22-93	1730	76.47	--	1,410	7.8	16.5	<.05	11	120	120
	U	08-05-93	--	77.5	--	--	--	--	--	--	--	--
	U	09-09-93	--	78.4	--	--	--	--	--	--	--	--
	U	09-29-93	1030	79.55	--	1,370	7.1	16.5	<.5	--	170	--
	U	10-28-93	1320	77.27	--	1,440	7.1	16.5	.2	<10	150	170
	C	11-04-93	--	78.3	--	1,270	7.03	--	--	15.1	--	178
	U	11-24-93	--	77.1	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Time	WL	Q	SC	pH	Temp	DO	COD	Ca	Ca_t
201-P	U	03-04-93	--	62.4	--	--	--	--	--	--	--	--
	U	03-29-93	1330	61.57	--	1,480	7.2	14.5	>1.0	<10	170	200
	U	06-22-93	1230	61.3	--	1,500	7.1	15	.1	<10	180	180
	U	08-05-93	--	62.7	--	--	--	--	--	--	--	--
	U	09-09-93	--	64.2	--	--	--	--	--	--	--	--
	U	09-28-93	1030	60.71	--	1,420	6.9	14.5	.5	--	170	--
	U	10-27-93	1115	60.99	--	1,440	7.1	13.5	<.05	<10	180	180
	U	11-24-93	--	58.1	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	64.9	--	--	--	--	--	--	--	--
	U	03-30-93	1610	64.39	--	1,010	7.9	14	>1.0	27	88	510
	U	06-22-93	1045	63.06	--	1,020	7.3	14	4.5	<10	96	110
	U	08-05-93	--	63.4	--	--	--	--	--	--	--	--
	U	09-09-93	--	63.8	--	--	--	--	--	--	--	--
	U	09-28-93	1500	64.02	--	1,010	7.3	14	<1.0	--	98	--
	U	10-27-93	0950	63.58	--	990	7.5	13.5	<.0	<10	93	100
	U	11-24-93	--	62.8	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	52.5	--	--	--	--	--	--	--	--
	U	03-30-93	1600	52.38	--	940	7.3	15.5	<1.0	<10	110	110
	U	06-22-93	0745	52.29	--	930	7.3	16	2	<10	110	110
	U	08-05-93	--	52.7	--	--	--	--	--	--	--	--
	U	09-09-93	--	53.4	--	--	--	--	--	--	--	--
	U	09-28-93	1600	49.4	--	882	7.3	15.5	--	--	110	--
	U	10-29-93	0815	52.95	--	909	7.4	15	.1	<10	110	110
	U	11-24-93	--	52.1	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	11.4	--	--	--	--	--	--	--	--
	U	03-29-93	1600	11.52	--	903	7.3	14.5	>1.0	30	84	88
	U	06-23-93	1430	11.75	--	925	7.4	14.5	3.5	<10	63	55
	U	08-05-93	--	12	--	--	--	--	--	--	--	--
	U	09-09-93	--	11.4	--	--	--	--	--	--	--	--
	U	09-28-93	1840	12.19	--	957	7.4	14.5	<1.0	--	85	--
	U	10-28-93	1600	11.98	--	965	7.4	13.5	.1	<10	81	82
	U	11-24-93	--	11.9	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	39.9	--	--	--	--	--	--	--	--
	U	12-21-93	0900	41.01	--	1,040	7.2	14	<.1	--	130	--
2021-P	U	11-24-93	--	37	--	--	--	--	--	--	--	--
	U	12-20-93	1510	36.17	--	1,360	7.4	14.5	<.5	--	110	--
2022-P	U	11-24-93	--	55.4	--	--	--	--	--	--	--	--
	U	12-21-93	1100	--	--	955	7.3	14.5	<.5	--	100	--
2023-P	U	11-24-93	--	29.3	--	--	--	--	--	--	--	--
	U	12-21-93	1615	28.45	--	818	7.6	14	--	--	46	--
MW-303	U	03-04-93	--	79.8	--	--	--	--	--	--	--	--
	U	03-29-93	1100	79.45	--	950	7.2	15.5	<.05	<10	100	100
	U	06-22-93	1445	78.7	--	950	7.3	15.5	.1	<10	100	100
	U	08-05-93	--	79.9	--	--	--	--	--	--	--	--
	U	09-09-93	--	81.5	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Time	WL	Q	SC	pH	Temp	DO	COD	Ca	Ca_t
MW-303—Continued	U	09-28-93	0825	77.95	--	954	7.3	15.5	<0.5	--	100	--
	U	10-27-93	1330	78.38	--	1,010	7.3	16	<.05	<10	110	110
	C	11-04-93	--	72.3	--	911	9.18	--	--	<5.0	--	19.3
	U	11-24-93	--	75.5	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	1700	66.5	--	930	7.1	15.5	<.05	11	100	--
	U	06-08-90	0915	62.2	--	930	7	15.5	.2	--	110	--
	E	08-20-92	1120	--	--	756	7.1	--	--	--	--	--
	U	03-31-93	0915	69.6	--	946	7.2	14	.1	<10	110	100
	U	06-22-93	0930	68.83	--	936	7.2	14.5	.2	<10	110	100
	U	08-05-93	--	70.8	--	--	--	--	--	--	--	--
	U	09-09-93	--	71.7	--	--	--	--	--	--	--	--
	U	09-27-93	1730	68.11	--	938	7.3	14.5	<.5	--	100	--
	U	10-27-93	0815	68.6	--	970	7.4	14.5	.3	<10	110	110
	U	10-29-93	0930	--	--	--	--	--	--	--	--	--
	U	11-24-93	0915	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	65.7	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	1115	110.6	--	1,140	7.1	17	.2	18	130	--
	U	04-01-93	1000	--	--	1,080	7.3	15	<.05	<10	120	120
	U	06-24-93	1130	--	--	1,220	7.2	15.5	<.05	<10	130	120
	U	09-29-93	1330	110.55	--	954	7.4	15.5	<.5	--	120	--
	U	10-29-93	1030	--	--	1,130	7.3	15	<.05	<10	130	130
Drill hole[6]	U	02-24-88	1030	--	0.2	926	7.2	12	--	--	120	--
	U	05-17-88	0745	--	.11	921	7.5	14.5	--	--	120	--
	U	08-04-88	1150	--	--	970	7.1	21.5	--	--	--	--
	U	09-27-88	0900	--	.1	955	7.3	14.5	--	--	110	--
	U	10-19-88	1110	--	.08	944	7.2	14	--	--	--	--
	U	11-30-88	1630	--	.11	945	7.1	12.5	--	--	110	--
	U	01-26-89	1315	--	--	960	7.0	12	--	--	--	--
	U	03-02-89	1600	--	.14	950	7.0	13.5	--	--	110	--
	U	05-04-89	0800	--	.14	955	7.1	14	--	--	110	--
	U	09-14-89	0930	--	.1	930	6.2	15	--	--	110	--
Domestic well	U	03-31-93	1330	--	--	862	7.3	14	>1.0	<10	70	65

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Mg	Mg_t	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
MW-100	U	03-30-93	120	140	9.4	9.2	--	303	370	305	--	--
	U	06-22-93	110	120	7.5	7.5	11	288	352	283	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	120	--	7.6	--	11	268	328	267	--	--
	U	10-27-93	120	130	5.9	5.3	11.85	294	358	293	--	--
	C	11-04-93	--	150	--	3.1	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	51	--	1	--	--	--	--	--	--	--
	C	05-18-88	50	--	1	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	47	--	0	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	63	--	1.4	--	6.8	321	392	316	--	--
	U	06-07-90	66	--	1.2	--	6	333	407	329	--	--
	C	06-28-90	68	--	3	--	--	--	--	--	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	79	--	1	--	--	--	--	--	--	--
	E	06-25-91	74	77	<2	<2	5	--	--	--	--	--
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	--	70.2	--	1.8	--	--	--	--	--	--
MW-103[2]	C	01-18-88	25	--	2	--	--	--	--	--	--	--
	C	05-18-88	101	--	2	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	75	--	1	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Mg	Mg_t	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
MW-103[2]—Continued	U	04-30-90	58	--	1.5	--	3.9	346	422	--	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	50	--	1.2	--	4.3	381	465	372	--	--
	C	06-28-90	46	--	4	--	--	--	--	--	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	73	--	3	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	--	--	--	--	249	304	249	--	--
	U	06-08-90	--	--	--	--	--	--	--	--	--	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	32	--	1	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	24	--	.9	--	2.8	177	216	175	--	--
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	51	--	28	--	--	--	--	--	--	--
	C	05-18-88	50	--	50	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	52	--	50	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-26-90	58	--	77	--	28	852	1,040	841	--	--
	U	06-07-90	58	--	66	--	39	926	1,130	909	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Mg	Mg_t	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
MW-106—Continued	C	06-28-90	60	--	42	--	--	--	--	--	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	75	--	62	--	--	--	--	--	--	--
	E	06-25-91	66	72	56	62	32	--	--	--	--	--
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	67	--	74	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	70	72	96	92	--	846	1,030	844	--	--
	U	06-23-93	71	67	89	84	38	840	1,030	837	--	--
	U	09-29-93	80	--	96	--	32	935	1,140	945	--	--
	U	10-28-93	88	90	62	58	25	1,040	1,270	1,030	--	--
	C	11-04-93	--	68.1	--	110	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	70	76	33	33	--	623	760	603	--	--
	U	06-23-93	66	63	30	29	11	582	710	577	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	68	--	30	--	10	588	718	581	--	--
	U	10-28-93	69	70	29	26	10.1	588	718	584	--	--
	C	11-04-93	--	83	--	30	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	130	160	63	61	--	340	415	345	--	--
	U	06-23-93	120	120	69	67	14	345	421	345	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	130	--	69	--	15	349	426	347	426	--
	U	10-27-93	130	140	66	66	14.95	328	401	328	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	64	90	150	150	--	[7]646	[7]789	--	--	--
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	68	69	66	62	11	584	713	588	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	74	--	35	--	12	676	825	669	--	--
	U	10-28-93	73	87	28	28	12.2	528	644	527	--	--
	C	11-04-93	--	92	--	19	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Mg	Mg_t	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
201-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	96	120	14	14	--	414	505	407	--	--
	U	06-22-93	110	100	14	15	1.8	407	496	405	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	93	--	12	--	1.9	238	290	235	--	--
	U	10-27-93	100	110	12	13	2.51	406	496	403	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	69	1,300	15	15	--	[7]293	[7]358	--	--	--
	U	06-22-93	75	80	14	15	1.1	298	364	308	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	69	--	16	--	1.2	294	359	296	--	--
	U	10-27-93	66	76	15	15	1.35	292	356	294	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	56	58	8.9	8.5	--	317	387	307	--	--
	U	06-22-93	58	58	7.9	7.4	1.6	300	367	294	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	54	--	6.6	--	1.6	278	339	285	--	--
	U	10-29-93	55	53	6.8	7	1.69	279	341	278	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	53	58	35	34	--	363	443	360	--	--
	U	06-23-93	42	38	42	40	.99	364	444	362	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	53	--	42	--	1	380	464	381	--	--
	U	10-28-93	50	54	46	47	1.11	373	455	370	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	70	--	2.7	--	4.6	366	447	361	--	0
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	63	--	130	--	9.8	439	535	446	--	0
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	72	--	10	--	.73	340	415	338	--	--
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	48	--	46	--	4.6	286	349	282	--	--
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	58	58	9.4	8.8	--	277	338	280	--	--
	U	06-22-93	58	57	9.4	9.3	3.3	275	336	276	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Mg	Mg_t	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
MW-303—Continued	U	09-28-93	57	--	9.6	--	2.8	238	290	238	--	--
	U	10-27-93	58	61	9.1	8.4	2.9	283	346	284	--	--
	C	11-04-93	--	59	--	18.6	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	59	--	9	--	2.8	276	336	275	--	--
	U	06-08-90	59	--	9.5	--	2.5	296	361	--	--	--
	E	08-20-92	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	57	57	9.1	8.7	--	276	337	273	--	--
	U	06-22-93	62	56	9.4	10	2.5	273	353	272	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	55	--	9.2	--	2.4	230	280	232	--	--
	U	10-27-93	58	62	9.4	8.4	2.5	271	330	275	--	--
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	74	--	9.8	--	3.1	516	630	513	--	--
	U	04-01-93	64	68	8.5	8.5	--	305	372	302	--	--
	U	06-24-93	69	63	8.5	8.4	3	280	340	236	--	--
	U	09-29-93	58	--	6.1	--	5.1	258	314	256	--	--
	U	10-29-93	69	73	8.4	8.8	2.9	290	353	290	--	--
Drill hole[6]	U	02-24-88	64	--	9.9	--	3.2	--	--	284	350	0
	U	05-17-88	65	--	10	--	3	--	--	287	350	0
	U	08-04-88	--	--	--	--	--	--	--	280	340	0
	U	09-27-88	64	--	9.9	--	2.7	--	--	292	360	0
	U	10-19-88	--	--	--	--	--	--	--	284	350	0
	U	11-30-88	65	--	11	--	2.8	--	--	284	350	0
	U	01-26-89	--	--	--	--	--	--	--	405	490	0
	U	03-02-89	62	--	10	--	2.9	--	--	284	350	0
	U	05-04-89	61	--	9.2	--	3.1	--	--	278	340	0
	U	09-14-89	60	--	9.6	--	2.8	--	--	283	350	0
Domestic well	U	03-31-93	50	50	40	38	--	341	416	340	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC	NO_2+NO_3	NO_2+NO_{3t}
MW-100	U	03-30-93	450	3.1	0.5	9.2	954	--	700	4.2	--	<0.02
	U	06-22-93	500	3.2	.5	9.3	1,040	887	630	1.1	--	<.02
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	8.7	--	--	730	.9	--	<.02
	U	10-27-93	480	3.3	.5	8.8	978	--	710	1.1	--	<.02
	C	11-04-93	473	2.3	.58	--	--	808	1,090	14.8	--	.28
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	[3]21	4	.5	--	--	674	558	--	<0.1	--
	C	05-18-88	350	66	.8	--	--	671	525	--	.87	--
	C	08-11-88	--	1	--	--	--	708	--	--	--	--
	C	11-29-88	--	1	--	--	--	671	--	--	--	--
	C	02-23-89	--	<1	--	--	--	680	--	--	--	--
	C	05-11-89	[3]2,329	2	1.34	--	--	682	591	--	3.77	--
	C	08-07-89	--	43	--	--	--	719	--	--	--	--
	C	11-16-89	--	4	--	--	--	766	--	--	--	--
	C	02-08-90	--	<1	--	--	--	880	--	--	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	508	3.3	.4	9.4	--	--	710	14	<.10	--
	U	06-07-90	450	4.3	.3	10	--	949	800	23	<.10	--
	C	06-28-90	443	2	.44	--	--	1,060	788	8.2	2.86	--
	C	08-09-90	--	4	--	--	--	386	--	--	--	--
	C	11-20-90	--	2	--	--	--	1,075	--	--	--	--
	C	02-28-91	--	3	--	--	--	1,137	--	--	--	--
	C	04-26-91	638	1	<1	--	--	1,035	1,298	4.3	2.06	--
	E	06-25-91	--	--	--	--	--	--	--	--	--	--
	C	08-30-91	--	4	--	--	--	1,147	--	--	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	610	2.1	.5	--	--	1,029	803	19.8	--	.24
MW-103[2]	C	01-18-88	[3]<10	2	.3	--	--	474	403	--	<.1	--
	C	05-18-88	1,387	1	.5	--	--	2,600	1,164	--	<.05	--
	C	08-11-88	--	1	--	--	--	1,659	--	--	--	--
	C	11-29-88	--	1	--	--	--	1,202	--	--	--	--
	C	02-23-89	--	5	--	--	--	1,195	--	--	--	--
	C	05-11-89	[3]3,165	2	1.35	--	--	1,310	1,021	--	5.83	--
	C	08-07-89	--	46	--	--	--	1,158	--	--	--	--
	C	11-16-89	--	4	--	--	--	853	--	--	--	--
	C	02-08-90	--	<1	--	--	--	1,149	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC	NO_2+NO_3	NO_2+NO_{3t}
MW-103[2]—Continued	U	04-30-90	360	2.5	0.2	10	--	847	740	23	0.2	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	300	4.9	.2	11	808	790	660	8.4	<.10	--
	C	06-28-90	163	<1	.43	--	--	718	633	54.5	1.53	--
	C	08-09-90	--	3	--	--	--	705	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	4	--	--	--	897	--	--	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	9	--	--	--	1,077	--	--	--	--
	C	02-23-89	--	64	--	--	--	929	--	--	--	--
	C	05-11-89	[3]1,251	11	1.79	--	--	923	930	--	--	--
	C	08-07-89	--	44	--	--	--	1,192	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	4	--	--	--	1,430	--	--	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	--	--	--	--	--	--	--	<.10	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	[3]<10	3	.1	--	--	233	580	--	.4	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	1	--	--	--	335	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	120	.2	.2	2.4	--	344	300	2.7	.9	--
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	[3]<10	44	.3	--	--	471	934	--	<.1	--
	C	05-18-88	104	[3]2	.7	--	--	1,090	930	--	<.05	--
	C	08-11-88	--	[3]1	--	--	--	990	--	--	--	--
	C	11-29-88	--	105	--	--	--	1,136	--	--	--	--
	C	02-23-89	--	86	--	--	--	1,123	--	--	--	--
	C	05-11-89	[3]785	124	1.49	--	--	1,068	826	--	5.9	--
	C	08-07-89	--	157	--	--	--	1,034	--	--	--	--
	C	11-16-89	--	109	--	--	--	1,033	--	--	--	--
	C	02-08-90	--	106	--	--	--	1,058	--	--	--	--
	U	04-26-90	91	100	.4	18	--	1,110	710	33	<.10	--
	U	06-07-90	150	78	<.10	19	1,160	1,240	810	11	<.10	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC	NO_2+NO_3	NO_2+NO_{3t}
MW-106—Continued	C	06-28-90	165	48	0.4	--	--	1,125	973	8.7	1.64	--
	C	08-09-90	--	77	--	--	--	1,062	--	--	--	--
	C	11-20-90	--	78	--	--	--	1,026	--	--	--	--
	C	02-28-91	--	95	--	--	--	1,066	--	--	--	--
	C	04-26-91	150	90	<1	--	--	1,032	1,197	13.5	2.82	--
	E	06-25-91	--	--	--	--	--	--	--	--	--	--
	C	08-30-91	--	86	--	--	--	993	--	--	--	--
	C	05-20-92	57	102	.45	--	--	1,002	717	31	1.77	--
	C	08-27-92	--	[3]<1	--	--	--	1,060	--	--	--	--
	C	11-24-92	--	115	--	--	--	1,061	--	--	--	--
	C	02-11-93	--	114	--	--	--	1,015	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	100	120	.4	17	934	--	750	19	--	<0.02
	U	06-23-93	90	120	.4	22	998	1,090	690	4.6	--	<.02
	U	09-29-93	--	--	--	20	--	--	950	9.9	--	<.02
	U	10-28-93	340	70	.3	20	1,370	--	1,200	7.7	--	.02
	C	11-04-93	234	106	.37	--	--	1,271	815	71.6	--	.42
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	84	48	.3	16	616	--	620	7.1	--	<.02
	U	06-23-93	68	48	.3	18	762	713	570	1.8	--	<.02
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	--	--	15	--	--	580	2.6	--	.15
	U	10-28-93	47	38	.3	15	636	--	560	3.8	--	<.02
	C	11-04-93	77	51	.32	--	--	656	683	26.1	--	.29
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	360	95	.7	10	982	--	670	4.9	--	<.02
	U	06-23-93	360	110	.7	10	1,050	936	600	1.0	--	<.02
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	9.7	--	--	660	1.4	--	.06
	U	10-27-93	360	100	.7	9.5	1,020	--	660	1.9	--	<.02
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	220	35	.3	19	936	--	540	29	--	<.02
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	200	32	.3	22	912	872	580	1.9	--	.06
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	--	--	21	--	--	730	7.9	--	.11
	U	10-28-93	190	37	.3	20	842	--	680	4.6	--	<.02
	C	11-04-93	231	40	.33	--	--	824	822	22.6	--	.23
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC	NO_2+NO_3	NO_2+NO_{3t}
201-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	480	8.4	<0.10	10	1,050	--	820	6.5	--	0.02
	U	06-22-93	520	9.7	<.10	9.4	1,240	1,090	900	.8	--	<.02
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	10	--	--	810	1.1	--	.06
	U	10-27-93	490	9.4	<.10	11	1,150	--	860	1.3	--	.13
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	260	17	<.10	11	800	--	500	8.0	--	.05
	U	06-22-93	260	20	<.10	12	730	658	550	2.8	--	.04
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	12	--	--	530	3.2	--	.17
	U	10-27-93	260	17	<.10	11	688	--	500	1.7	--	.06
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	200	11	<.10	6.1	608	--	510	6.1	--	3.9
	U	06-22-93	210	9.6	<.10	6.2	670	584	510	1.2	--	3.7
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	5.5	--	--	500	4.9	--	3.8
	U	10-29-93	210	7.5	<.10	5.4	652	--	500	1.8	--	4.4
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	88	44	.1	9.7	538	--	430	18	--	.26
	U	06-23-93	110	45	.1	10	598	532	330	1.0	--	.22
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	10	--	--	430	1.5	--	.15
	U	10-28-93	92	44	.1	10	570	--	410	2.4	--	.09
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	250	3.5	<.10	8.5	--	690	610	--	--	<.02
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	310	44	.4	15	--	946	530	--	--	2.4
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	240	6.2	<.10	12	--	645	550	--	--	.19
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	60	78	.1	8.6	--	463	310	--	--	.04
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	250	12	.1	9.5	640	--	490	1.2	--	.16
	U	06-22-93	250	12	.1	10	714	609	490	1.1	--	.17
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC	NO_2+NO_3	NO_2+NO_{3t}
MW-303—Continued	U	09-28-93	--	--	--	9.6	--	--	480	0.8	--	0.2
	U	10-27-93	240	12	0.1	9.8	684	--	510	.9	--	.19
	C	11-04-93	294	10.1	.145	--	--	493	292	8.9	--	.34
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	230	12	<.10	9.4	665	589	490	.5	0.2	--
	U	06-08-90	240	6.8	.1	9.7	629	617	520	.4	.2	--
	E	08-20-92	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	240	13	.1	9.5	606	--	510	1.3	--	.19
	U	06-22-93	240	12	.1	9.9	692	620	530	.8	--	.2
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	9.9	--	--	480	.9	--	.22
	U	10-27-93	240	12	.1	9.8	656	--	510	1.2	--	.26
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	350	14	.2	9.1	858	902	630	.7	<.10	--
	U	04-01-93	320	13	.1	9	650	--	560	1.9	--	<.02
	U	06-24-93	420	9.9	.1	9.4	940	819	610	.6	--	<.02
	U	09-29-93	--	--	--	9.2	--	--	540	1.4	--	.71
	U	10-29-93	350	11	.1	9.2	870	757	610	1.5	--	.02
Drill hole[6]	U	02-24-88	260	11	--	9.9	683	649	560	--	--	--
	U	05-17-88	270	9.3	--	9.9	693	660	570	--	--	--
	U	08-04-88	--	--	--	--	--	--	--	--	--	--
	U	09-27-88	270	11	--	9.6	654	653	540	--	--	--
	U	10-19-88	--	--	--	--	--	--	--	--	--	--
	U	11-30-88	260	11	--	9.9	667	641	540	--	--	--
	U	01-26-89	--	--	--	--	--	--	--	--	--	--
	U	03-02-89	250	11	--	9.7	657	627	530	--	--	--
	U	05-04-89	260	11	--	9.5	665	631	530	--	--	--
	U	09-14-89	250	9.7	--	9.5	638	622	520	--	--	--
Domestic well	U	03-31-93	98	16	<.10	11	482	--	380	1.5	--	4.8

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON	P	P_t	PO_4	Al
MW-100	U	03-30-93	--	<0.01	--	0.52	--	--	--	0.12	--	--
	U	06-22-93	--	<.01	--	.44	--	--	--	1.1	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<.01	--	.43	--	--	--	.02	--	--
	U	10-27-93	--	<.01	--	.45	--	--	--	.03	--	--
	C	11-04-93	--	--	--	.50	--	--	--	1.2	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	--	--	0.2	--	--	--	0.14	--	--	--
	C	05-18-88	--	--	1.4	--	--	--	<.05	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	.03	--	--	--	3.21	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	<0.01	--	.11	--	--	--	.11	--	<0.01	--
	U	06-07-90	.02	--	.02	.17	0.5	0.33	<.01	.08	<.01	--
	C	06-28-90	--	--	.51	--	--	--	--	<.05	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	<1	--	--	--	--	<.05	--	--
	E	06-25-91	--	--	--	--	--	--	--	--	--	<50
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	--	--	--	.13	--	--	--	.63	--	--
MW-103[2]	C	01-18-88	--	--	.4	--	--	--	<.05	--	--	--
	C	05-18-88	--	--	.86	--	--	--	.08	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	.34	--	--	--	[3]4.12	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON	P	P_t	PO_4	Al
MW-103[2]—Continued	U	04-30-90	<0.01	--	0.04	--	--	--	0.03	--	<0.01	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	.01	--	.03	--	--	--	<.01	--	<.01	--
	C	06-28-90	--	--	.57	--	--	--	--	0.2	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	.17	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	--	--	0.01	2.3	2.3	--	.8	--	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	--	--	[3]8.5	--	--	--	<.05	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	.02	--	.03	.02	.2	.18	.01	.03	<.01	--
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	--	--	.6	--	--	--	<.05	--	--	--
	C	05-18-88	--	--	4.5	--	--	--	<.05	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	.06	--	--	--	3.23	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-26-90	<.01	--	21	21	27	6	<.01	.63	<.01	--
	U	06-07-90	.02	--	25	26	25	0	<.01	.03	<.01	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON	P	P_t	PO_4	Al
MW-106—Continued	C	06-28-90	--	--	16.6	--	--	--	--	<0.05	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	36.9	--	--	--		<.05	--	--
	E	06-25-91	--	--	--	--	--	--	--	--	--	[4]693
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	23.8	--	--	--	0.49	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	--	<0.01	--	28	--	--	--	.13	--	--
	U	06-23-93	--	<.01	--	24	--	--	--	.04	--	--
	U	09-29-93	--	<.01	--	23	--	--	--	.05	--	--
	U	10-28-93	--	<.01	--	13	--	--	--	.1	--	--
	C	11-04-93	--	--	--	14.5	--	--	--	.115	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	--	<.01	--	2.1	--	--	--	.15	--	--
	U	06-23-93	--	<.01	--	2.2	--	--	--	.15	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	<.01	--	3	--	--	--	.03	--	--
	U	10-28-93	--	<.01	--	3.4	--	--	--	.05	--	--
	C	11-04-93	--	--	--	3.62	--	--	--	.43	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	<.01	--	4.8	--	--	--	<.02	--	--
	U	06-23-93	--	<.01	--	2.4	--	--	--	.03	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<.01	--	2.3	--	--	--	.02	--	--
	U	10-27-93	--	<.01	--	2.7	--	--	--	.02	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	--	<.01	--	2	--	--	--	.69	--	--
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	--	.05	--	2.5	--	--	--	1.00	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	<.01	--	2.4	--	--	--	.64	--	--
	U	10-28-93	--	<.01	--	2.8	--	--	--	.42	--	--
	C	11-04-93	--	--	--	3.02	--	--	--	.96	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON	P	P_t	PO_4	Al
201-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	<0.01	--	0.16	--	--	--	0.06	--	--
	U	06-22-93	--	<.01	--	.1	--	--	--	.02	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	.03	--	.09	--	--	--	.02	--	--
	U	10-27-93	--	.09	--	.11	--	--	--	.03	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	--	<.01	--	.02	--	--	--	<.02	--	--
	U	06-22-93	--	<.01	--	1.4	--	--	--	.07	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	.1	--	.19	--	--	--	.03	--	--
	U	10-27-93	--	.01	--	.03	--	--	--	.02	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	--	<.01	--	.02	--	--	--	.05	--	--
	U	06-22-93	--	.01	--	.59	--	--	--	.05	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	.11	--	.05	--	--	--	.02	--	--
	U	10-29-93	--	<.01	--	.02	--	--	--	.03	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	.01	--	.06	--	--	--	.06	--	--
	U	06-23-93	--	<.01	--	.1	--	--	--	.07	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<.01	--	.18	--	--	--	.04	--	--
	U	10-28-93	--	.01	--	.1	--	--	--	[3]4.00	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	--	--	1.2	--	--	--	.02	--	--
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	--	--	--	.23	--	--	--	.04	--	--
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	--	--	.02	--	--	--	<.02	--	--
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	--	--	2.5	--	--	--	.13	--	--
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	<.01	--	.02	--	--	--	<.02	--	--
	U	06-22-93	--	<.01	--	.02	--	--	--	<.02	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON	P	P_t	PO_4	Al
MW-303—Continued	U	09-28-93	--	<0.01	--	0.03	--	--	--	<0.02	--	--
	U	10-27-93	--	<.01	--	.02	--	--	--	<.02	--	--
	C	11-04-93	--	--	--	.1	--	--	--	.01	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	<0.01	--	<0.01	<.01	<0.20	--	<0.01	.02	<0.01	--
	U	06-08-90	<.01	--	.02	--	--	--	<.01	--	<.01	--
	E	08-20-92	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	--	<.01	--	.01	--	--	--	<.02	--	--
	U	06-22-93	--	<.01	--	.01	--	--	--	<.02	--	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	<.01	--	.03	--	--	--	<.02	--	--
	U	10-27-93	--	<.01	--	.02	--	--	--	.02	--	--
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	<.01	--	.03	.01	<.20	--	<.01	.01	<.01	--
	U	04-01-93	--	<.01	--	.01	--	--	--	<.02	--	--
	U	06-24-93	--	<.01	--	.04	--	--	--	<.02	--	--
	U	09-29-93	--	<.01	--	.03	--	--	--	.03	--	--
	U	10-29-93	--	<.01	--	.03	--	--	--	<.02	--	--
Drill hole[6]	U	02-24-88	--	--	--	--	--	--	--	--	--	<10
	U	05-17-88	--	--	--	--	--	--	--	--	--	<10
	U	08-04-88	--	--	--	--	--	--	--	--	--	--
	U	09-27-88	--	--	--	--	--	--	<.001	--	.003	<10
	U	10-19-88	--	--	--	--	--	--	--	--	--	--
	U	11-30-88	--	--	--	--	--	--	<.002	--	<.001	<10
	U	01-26-89	--	--	--	--	--	--	--	--	--	--
	U	03-02-89	--	--	--	--	--	--	<.001	--	<.001	<10
	U	05-04-89	--	--	--	--	--	--	<.002	--	.002	<10
	U	09-14-89	--	--	--	--	--	--	<.001	--	<.001	<10
Domestic well	U	03-31-93	--	<.01	--	<.01	--	--	--	<.02	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Sb_t	As	As_t	Ba	Ba_t	Be	Be_t	B	B_t	Cd
MW-100	U	03-30-93	1	--	11	53	50	<0.5	2	--	590	<1.0
	U	06-22-93	<1	--	18	55	50	<1	<1.0	610	640	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	41	--	<.5	--	590	--	<1.0
	U	10-27-93	<1	--	30	42	50	<.5	<1.0	562	560	<1.0
	C	11-04-93	--	--	20	--	<500	--	--	--	636	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	--	4	--	50	--	--	--	100	--	<1
	C	05-18-88	--	<10	--	<50	--	--	--	188	--	10
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	22	--	37	--	--	--	130	--	<20
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	<1	--	19	--	<.5	--	80	--	81
	U	06-07-90	--	27	--	20	--	<.5	--	80	--	1
	C	06-28-90	--	11	--	24	--	--	--	406	--	<10
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	<10	--	180	--	--	--	<100	--	<20
	E	06-25-91	<50	<50	<50	21	21.3	<2	<2	--	--	<5
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	--	--	5	--	<500	--	--	--	108	--
MW-103[2]	C	01-18-88	--	2	--	40	--	--	--	60	--	1
	C	05-18-88	--	<10	--	50	--	--	--	363	--	16
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	18	--	52	--	--	--	140	--	<20
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Sb_t	As	As_t	Ba	Ba_t	Be	Be_t	B	B_t	Cd
MW-103[2]—Continued	U	04-30-90	--	20	--	28	--	<0.5	--	30	--	54
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	22	--	30	--	.5	--	40	--	3
	C	06-28-90	--	<10	--	58	--	--	--	85	--	<10
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	<20
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	--	--	--	--	--	--	--	--	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	--	<1	--	60	--	--	--	70	--	14
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	--	<1	--	17	--	.6	--	20	--	5
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	--	4	--	150	--	--	--	250	--	4
	C	05-18-88	--	<10	--	80	--	--	--	398	--	13
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	7	--	371	--	--	--	--	--	<20
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-26-90	--	27	--	250	--	<.5	--	360	--	1
	U	06-07-90	--	42	--	270	--	<.5	--	410	--	4

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Sb_t	As	As_t	Ba	Ba_t	Be	Be_t	B	B_t	Cd
MW-106—Continued	C	06-28-90	--	49	--	273	--	--	--	83	--	<10
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	20	--	158	--	--	--	<100	--	<20
	E	06-25-91	<50	<50	<50	191	199	<2	<2	--	--	<5
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	32	--	360	--	--	--	465	--	10
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	--	6	300	300	<.5	<1.0	--	460	1
	U	06-23-93	<1	--	9	270	300	<1	<1.0	520	480	<1.0
	U	09-29-93	--	--	--	300	--	<2	--	500	--	<3.0
	U	10-28-93	<1	--	7	310	300	<2	<1.0	378	380	<3.0
	C	11-04-93	--	--	<5	--	<500	--	--	--	480	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	--	39	120	100	<.5	1	--	270	3
	U	06-23-93	<1	--	34	110	100	<1	<1.0	280	310	<1.0
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	--	--	110	--	<.5	--	240	--	<1.0
	U	10-28-93	<1	--	26	110	100	<.5	<1.0	180	230	<1.0
	C	11-04-93	--	--	41	--	<500	--	--	--	346	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	--	35	54	50	<.5	1	--	380	<1.0
	U	06-23-93	<1	--	14	57	50	<1	<1.0	440	460	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	44	--	<.5	--	380	--	<1.0
	U	10-27-93	<1	--	13	42	40	<.5	<1.0	385	370	<1.0
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	1	--	36	44	60	<.5	<1.0	--	270	<1.0
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	<1	--	41	47	60	<1	<1.0	310	310	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	--	--	40	--	<.5	--	320	--	<1.0
	U	10-28-93	<1	--	27	42	50	<.5	<1.0	311	280	<1.0
	C	11-04-93	--	--	21	--	<500	--	--	--	438	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Sb_t	As	As_t	Ba	Ba_t	Be	Be_t	B	B_t	Cd
201-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	--	4	21	80	<0.5	1	--	230	<1.0
	U	06-22-93	<1	--	2	22	20	<1	<1.0	220	220	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	20	--	<.5	--	230	--	<1.0
	U	10-27-93	4	--	4	22	30	<.5	<1.0	221	210	2
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	2	--	7	26	50	<.5	2	--	130	<1.0
	U	06-22-93	<1	--	1	46	50	<1	<1.0	100	120	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	43	--	<.5	--	110	--	<1.0
	U	10-27-93	6	--	<1	40	40	<.5	<1.0	221	80	1
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	--	<1	30	80	<.5	2	--	30	<1.0
	U	06-22-93	1	--	<1	36	40	<1	<1.0	30	30	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	39	--	<.5	--	--	--	<1.0
	U	10-29-93	<1	--	<1	37	40	<.5	<1.0	27	<20	<1.0
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	3	--	<1	29	30	<.5	<1.0	--	<20	<1.0
	U	06-23-93	<1	--	2	55	90	<1	<1.0	<20	<20	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	--	--	50	--	<.5	--	<10	--	<1.0
	U	10-28-93	1	--	5	44	100	<.5	<1.0	22	<20	<1.0
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	--	--	56	--	<1	--	100	--	4
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	--	--	--	100	--	<1	--	90	--	7
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	--	--	39	--	<1	--	30	--	<1.0
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	--	--	81	--	<1	--	70	--	<1.0
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	--	<1	27	20	<.5	1	--	100	<1.0
	U	06-22-93	<1	--	2	30	30	<1	<1.0	110	110	<1.0
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Sb_t	As	As_t	Ba	Ba_t	Be	Be_t	B	B_t	Cd
MW-303—Continued	U	09-28-93	--	--	--	25	--	<0.5	--	110	--	<1
	U	10-27-93	<1	--	<1	25	30	<.5	<1	108	80	<1
	C	11-04-93	--	--	<5	--	<500	--	--	--	115	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	--	<1	--	25	--	<.5	--	60	--	<1
	U	06-08-90	--	<1	--	27	--	<.5	--	70	--	<1
	E	08-20-92	--	--	<5	--	--	--	--	--	--	--
	U	03-31-93	<1	--	<1	26	20	<.5	<1	--	100	<1
	U	06-22-93	<1	--	<1	23	30	<1	<1	100	120	<1
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	25	--	<.5	--	110	--	<1
	U	10-27-93	<1	--	<1	25	30	<.5	<1	110	90	<1
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	--	<1	--	23	--	<.5	--	70	--	<1
	U	04-01-93	<1	--	<1	24	20	<.5	<1	--	70	<1
	U	06-24-93	<1	--	3	25	20	<1	<1	60	60	<1
	U	09-29-93	--	--	--	22	--	<.5	--	90	--	<1
	U	10-29-93	<1	--	<1	20	30	<.5	<1	65	50	<1
Drill hole[6]	U	02-24-88	--	--	--	26	--	<.5	--	--	--	2
	U	05-17-88	--	--	--	27	--	<.5	--	--	--	1
	U	08-04-88	--	--	--	--	--	--	--	--	--	--
	U	09-27-88	--	--	--	27	--	<.5	--	--	--	1
	U	10-19-88	--	--	--	--	--	--	--	--	--	--
	U	11-30-88	--	--	--	28	--	<.5	--	--	--	<1
	U	01-26-89	--	--	--	--	--	--	--	--	--	--
	U	03-02-89	--	--	--	26	--	<.5	--	--	--	<1
	U	05-04-89	--	--	--	25	--	<.5	--	--	--	1
	U	09-14-89	--	--	--	27	--	<.5	--	--	--	1
Domestic well	U	03-31-93	<1	--	<1	58	50	<.5	<1	--	70	<1

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Cd_t	Cr	Cr_t	Co	Co_t	Cu	Cu_t	Fe	Fe_t	Pb
MW-100	U	03-30-93	2	<5	<5	<3	<10	<10	<10	41	8,400	<10
	U	06-22-93	<1	<5	<5	<3	4	<10	<10	130	530	<10
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<5	--	<3	--	<10	--	250	--	<10
	U	10-27-93	<1	<5	<5	<3	<3	<10	<10	180	860	<10
	C	11-04-93	7	--	11	--	43	--	34	--	28,900	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	--	<5	--	40	--	8	--	390	--	7
	C	05-18-88	--	<5	--	<60	--	9	--	[3]1,480	--	72
	C	08-11-88	--	--	--	--	--	--	--	60	--	--
	C	11-29-88	--	--	--	--	--	--	--	<20	--	--
	C	02-23-89	--	--	--	--	--	--	--	500	--	--
	C	05-11-89	--	<20	--	<20	--	<20	--	<20	--	<20
	C	08-07-89	--	--	--	--	--	--	--	<80	--	--
	C	11-16-89	--	--	--	--	--	--	--	70	--	--
	C	02-08-90	--	--	--	--	--	--	--	<100	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	<5	--	9	--	20	--	32	--	20
	U	06-07-90	--	<5	--	4	--	<10	--	700	--	<10
	C	06-28-90	--	<50	--	<50	--	<40	--	254	--	14
	C	08-09-90	--	--	--	--	--	--	--	424	--	--
	C	11-20-90	--	--	--	--	--	--	--	370	--	--
	C	02-28-91	--	--	--	--	--	--	--	<100	--	--
	C	04-26-91	--	<50	--	<50	--	<33	--	<100	--	12
	E	06-25-91	<5	<10	<10	<10	14	<10	<10	<50	585	<5
	C	08-30-91	--	--	--	--	--	--	--	<100	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	8	--	14	--	39	--	33	--	34,600	--
MW-103[2]	C	01-18-88	--	<5	--	40	--	[4]120	--	80	--	29
	C	05-18-88	--	[3]150	--	[4]300	--	<5	--	49	--	88
	C	08-11-88	--	--	--	--	--	--	--	40	--	--
	C	11-29-88	--	--	--	--	--	--	--	70	--	--
	C	02-23-89	--	--	--	--	--	--	--	70	--	--
	C	05-11-89	--	<20	--	30	--	<20	--	70	--	<20
	C	08-07-89	--	--	--	--	--	--	--	2,410	--	--
	C	11-16-89	--	--	--	--	--	--	--	70	--	--
	C	02-08-90	--	--	--	--	--	--	--	118	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Cd_t	Cr	Cr_t	Co	Co_t	Cu	Cu_t	Fe	Fe_t	Pb
MW-103[2]—Continued	U	04-30-90	--	<5	--	50	--	<10	--	1,700	--	20
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	<5	--	30	--	<10	--	8,900	--	20
	C	06-28-90	--	<50	--	<50	--	<40	--	282	--	12
	C	08-09-90	--	--	--	--	--	--	--	3,440	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	2,500	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	50	--	--
	C	02-23-89	--	--	--	--	--	--	--	<20	--	--
	C	05-11-89	--	[4]40	--	120	--	30	--	23	--	<20
	C	08-07-89	--	--	--	--	--	--	--	<80	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	<100	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	--	--	--	--	--	--	--	--	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	--	<5	--	30	--	21	--	40	--	24
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	<20	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	--	<5	--	5	--	<10	--	30	--	70
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	--	<5	--	90	--	6	--	12,600	--	13
	C	05-18-88	--	[3]120	--	<60	--	27	--	2,450	--	68
	C	08-11-88	--	--	--	--	--	--	--	1,200	--	--
	C	11-29-88	--	--	--	--	--	--	--	12,000	--	--
	C	02-23-89	--	--	--	--	--	--	--	4,000	--	--
	C	05-11-89	--	<20	--	<20	--	<20	--	3,400	--	<20
	C	08-07-89	--	--	--	--	--	--	--	1,280	--	--
	C	11-16-89	--	--	--	--	--	--	--	472	--	--
	C	02-08-90	--	--	--	--	--	--	--	7,050	--	--
	U	04-26-90	--	<5	--	<3	--	<10	--	5,100	--	20
	U	06-07-90	--	<5	--	7	--	<10	--	10,000	--	20

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Cd_t	Cr	Cr_t	Co	Co_t	Cu	Cu_t	Fe	Fe_t	Pb
MW-106—Continued	C	06-28-90	--	<50	--	<50	--	<40	--	11,500	--	21
	C	08-09-90	--	--	--	--	--	--	--	9,470	--	--
	C	11-20-90	--	--	--	--	--	--	--	8,800	--	--
	C	02-28-91	--	--	--	--	--	--	--	4,900	--	--
	C	04-26-91	--	<50	--	<50	--	<33	--	3,771	--	12
	E	06-25-91	<5	<10	<10	13	17	<10	<10	8,480	11,600	29
	C	08-30-91	--	--	--	--	--	--	--	13,900	--	--
	C	05-20-92	--	< 5	--	46	--	11	--	12,800	--	[3]420
	C	08-27-92	--	--	--	--	--	--	--	9	--	--
	C	11-24-92	--	--	--	--	--	--	--	7,640	--	--
	C	02-11-93	--	--	--	--	--	--	--	29,100	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	<5	<5	10	3	<10	<10	5,000	5,700	30
	U	06-23-93	<1	<5	<5	10	20	<10	<10	4,300	5,400	<10
	U	09-29-93	--	<20	--	<9	--	<30	--	7,200	--	<30
	U	10-28-93	3	<20	<5	20	20	<30	<10	9,800	9,800	<30
	C	11-04-93	6	--	9	--	20	--	13	--	7,880	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	1	<5	<5	10	10	<10	<10	1,400	2,900	20
	U	06-23-93	<1	<5	<5	10	10	<10	<10	1,600	1,500	<10
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	<5	--	<3	--	<10	--	2,500	--	<10
	U	10-28-93	<1	<1	<5	4	10	<1	<10	2,400	2,400	5
	C	11-04-93	8	--	9	--	30	--	24	--	10,400	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	2	<5	<5	<3	5	<10	<10	290	6,500	<10
	U	06-23-93	<1	<5	<5	<3	<3	<10	<10	240	600	<10
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<5	--	<3	--	<10	--	530	--	<10
	U	10-27-93	<1	<5	<5	<3	<3	<10	<10	660	810	<10
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	11	<5	7	10	20	<10	20	650	8,400	30
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	5	<5	<5	9	30	<10	30	730	5,500	<10
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	<5	--	7	--	<10	--	1,100	--	<10
	U	10-28-93	3	<5	<5	10	10	<10	<10	980	3,500	<10
	C	11-04-93	9	--	6	--	29	--	31	--	9,150	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Cd_t	Cr	Cr_t	Co	Co_t	Cu	Cu_t	Fe	Fe_t	Pb
201-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	4	<5	<5	20	20	<10	10	14	4,900	50
	U	06-22-93	<1	<5	<5	30	20	<10	10	69	310	50
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<5	--	20	--	<10	--	80	--	50
	U	10-27-93	6	<5	<5	20	20	<10	15	160	560	<10
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	7	<5	9	<3	50	<10	20	<3	11,000	<10
	U	06-22-93	<1	<5	<5	5	8	10	30	15	940	<10
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<5	--	4	--	<10	--	11	--	<10
	U	10-27-93	<1	<5	<5	3	<3	<10	<10	<3	80	<10
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	<5	7	<3	<3	<10	<10	6	1,100	<10
	U	06-22-93	<1	<5	<5	<3	<3	<10	10	8	280	<10
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<5	--	<3	--	<10	--	<3	--	<10
	U	10-29-93	<1	<5	<5	<3	<3	10	<10	15	80	<10
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	1	<5	<5	<3	3	<10	<10	6	1,200	<10
	U	06-23-93	<1	<5	<5	<3	<3	<10	<10	12	540	<10
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<5	--	<3	--	<10	--	<3	--	<10
	U	10-28-93	2	<5	5	<3	<3	<10	<10	5	1,100	<10
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<5	--	10	--	<10	--	330	--	<10
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	--	<5	--	5	--	11	--	37	--	<10
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<5	--	3	--	<10	--	16	--	<10
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<5	--	<3	--	<10	--	11	--	<10
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	<5	<5	20	20	<10	<10	<3	30	20
	U	06-22-93	<1	<5	<5	20	20	<10	<10	9	1,100	40
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Cd_t	Cr	Cr_t	Co	Co_t	Cu	Cu_t	Fe	Fe_t	Pb
MW-303—Continued	U	09-28-93	--	<5	--	20	--	<10	--	<3	--	30
	U	10-27-93	<1	<5	<5	10	20	<10	<10	<3	30	20
	C	11-04-93	<5	--	11	--	17	--	7	--	206	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	--	<5	--	20	--	<10	--	13	--	<10
	U	06-08-90	--	<5	--	20	--	<10	--	5	--	20
	E	08-20-92	<1	--	--	--	--	--	--	--	--	--
	U	03-31-93	<1	<5	<5	20	20	<10	<10	<3	30	<10
	U	06-22-93	<1	<5	<5	10	10	<10	<10	3	20	20
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	<5	--	10	--	<10	--	<3	--	<10
	U	10-27-93	<1	<5	<5	20	20	<10	<10	<3	40	<10
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	--	<5	--	20	--	<10	--	1,600	--	<10
	U	04-01-93	<1	<5	<5	7	6	<10	11	2,400	3,000	<10
	U	06-24-93	<1	<5	<5	10	10	<10	<10	1,300	2,000	<10
	U	09-29-93	--	<5	--	<3	--	<10	--	400	--	<10
	U	10-29-93	<1	<5	<5	10	10	<10	<10	2,300	2,300	<10
Drill hole[6]	U	02-24-88	--	<5	--	30	--	<10	--	<3	--	20
	U	05-17-88	--	<5	--	30	--	<10	--	4	--	20
	U	08-04-88	--	--	--	--	--	--	--	--	--	--
	U	09-27-88	--	<5	--	20	--	<10	--	9	--	20
	U	10-19-88	--	--	--	--	--	--	--	--	--	--
	U	11-30-88	--	<5	--	30	--	<10	--	19	--	30
	U	01-26-89	--	--	--	--	--	--	--	--	--	--
	U	03-02-89	--	<5	--	30	--	<10	--	11	--	30
	U	05-04-89	--	<5	--	20	--	<10	--	5	--	20
	U	09-14-89	--	<5	--	20	--	<10	--	17	--	18
Domestic well	U	03-31-93	<1	<5	<5	<3	<3	<10	--	<3	30	<10

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Pb_t	Li	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se
MW-100	U	03-30-93	760	28	270	1,300	--	<0.1	<10	<10	10	--
	U	06-22-93	53	29	270	290	--	<.1	10	10	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	24	250	--	--	--	20	<10	--	--
	U	10-27-93	28	27	240	340	--	<.1	10	<10	<10	--
	C	11-04-93	2,360	--	--	3,620	--	<.2	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	--	--	88	--	0.3	--	--	--	--	<1
	C	05-18-88	--	--	75	--	<10	--	--	--	--	<10
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	260	--	<.2	--	--	--	--	<5
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	13	140	--	--	--	<10	10	--	<1
	U	06-07-90	--	20	91	--	--	--	<10	<10	--	<1
	C	06-28-90	--	--	167	--	1.1	--	--	--	--	<10
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	63	--	<.2	--	--	--	--	<5
	E	06-25-91	17	--	100	123	--	--	<10	<20	<20	<50
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	<5	--	--	1,020	--	<.2	--	--	--	--
MW-103[2]	C	01-18-88	--	--	263	--	.3	--	--	--	--	<10
	C	05-18-88	--	--	191	--	<1	--	--	--	--	<10
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	140	--	<.2	--	--	--	--	<5
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Pb_t	Li	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se
MW-103[2]—Continued	U	04-30-90	--	11	420	--	--	--	<10	70	--	<1
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	16	430	--	--	--	<10	40	--	<1
	C	06-28-90	--	--	399	--	[3]2.7	--	--	--	--	<10
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	500	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	--	--	--	--	--	--	--	--	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	--	--	<15	--	[3]15.5	--	--	--	--	<1
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	--	8	2	--	--	--	<10	20	--	<1
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	--	--	168	--	.5	--	--	--	--	<1
	C	05-18-88	--	--	171	--	1	--	--	--	--	<10
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	160	--	<.2	--	--	--	--	<5
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-26-90	--	21	130	--	<.1	--	<10	50	--	<1
	U	06-07-90	--	28	180	--	--	--	<10	40	--	<1

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Pb_t	Li	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se
MW-106—Continued	C	06-28-90	--	--	248	--	2.1	--	--	--	--	<10
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	117	--	.9	--	--	--	--	<5
	E	06-25-91	617	--	104	164	--	--	<10	33	46	<50
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	211	--	< .2	--	--	--	--	< 5
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	110	17	100	120	--	<0.1	10	40	40	--
	U	06-23-93	180	20	92	96	--	<.1	<10	40	40	--
	U	09-29-93	--	32	140	--	--	--	<30	50	--	--
	U	10-28-93	41	25	210	220	--	<.1	<30	<30	20	--
	C	11-04-93	<5	--	--	173	--	<.2	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	350	13	95	260	--	<.1	<10	30	30	--
	U	06-23-93	39	13	71	73	--	<.1	<10	20	20	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	14	67	--	--	--	<10	20	--	--
	U	10-28-93	36	<10	59	59	--	<.1	<10	13	10	--
	C	11-04-93	920	--	--	944	--	<.2	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	380	5	60	970	--	<.1	<10	<10	<10	--
	U	06-23-93	78	12	52	74	--	<.1	<10	<10	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	10	53	--	--	--	<10	<10	--	--
	U	10-27-93	23	9	47	68	--	<.1	<10	<10	<10	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	2,000	33	120	980	--	.2	10	30	60	--
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	960	23	100	660	--	<.1	<10	30	40	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	23	140	--	--	--	<10	30	--	--
	U	10-28-93	320	17	130	460	--	.2	<10	20	20	--
	C	11-04-93	1,080	--	--	1,280	--	<.2	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Pb_t	Li	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se
201-P	U	03-04-93	--	--	--	--	--	--	--	--	--	<0.5
	U	03-29-93	1,200	10	710	1,200	--	0.1	<10	10	30	--
	U	06-22-93	110	8	720	720	--	<.1	<10	20	20	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	7	650	--	--	--	<10	20	--	--
	U	10-27-93	130	10	690	690	--	<.1	<10	20	20	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	1,100	6	36	1,700	--	<.1	<10	<10	30	--
	U	06-22-93	120	10	100	190	--	<.1	<10	<10	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	10	100	--	--	--	<10	<10	--	--
	U	10-27-93	15	8	57	54	--	<.1	<10	<10	<10	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	13	<4	3	57	--	<.1	<10	<10	10	--
	U	06-22-93	17	<4	2	24	--	<.1	<10	<10	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<4	<1	--	--	--	<10	<10	--	--
	U	10-29-93	15	<4	2	8	--	<.1	<10	<10	<10	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	130	<4	50	170	--	.3	<10	10	10	--
	U	06-23-93	18	8	62	84	--	<.1	<10	10	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	7	78	--	--	--	<10	<10	--	--
	U	10-28-93	25	9	46	76	--	<.1	<10	<10	<10	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<4	610	--	--	--	<10	11	--	--
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	--	18	180	--	--	--	<10	17	--	--
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<4	21	--	--	--	<10	13	--	--
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<4	53	--	--	--	<10	<10	--	--
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	41	5	22	22	--	.2	<10	60	60	--
	U	06-22-93	140	7	17	110	--	<.1	<10	60	50	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Pb_t	Li	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se
MW-303—Continued	U	09-28-93	--	<4	19	--	--	--	<10	60	--	--
	U	10-27-93	41	5	20	20	--	<0.1	<10	60	60	--
	C	11-04-93	57	--	--	9	--	<.2	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	--	6	7	--	0.1	--	<10	60	--	<1
	U	06-08-90	--	11	9	--	--	--	<10	60	--	<1
	E	08-20-92	16	--	--	--	--	--	--	--	--	--
	U	03-31-93	25	<4	10	9	--	<.1	<10	50	60	--
	U	06-22-93	27	8	7	8	--	<.1	<10	50	50	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	6	9	--	--	--	<10	60	--	--
	U	10-27-93	28	5	12	13	--	<.1	<10	50	50	--
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	--	9	160	--	<.1	--	<10	20	--	<1
	U	04-01-93	10	4	55	52	--	.1	<10	10	10	--
	U	06-24-93	21	6	64	73	--	<.1	<10	30	30	--
	U	09-29-93	--	10	42	--	--	--	<10	20	--	--
	U	10-29-93	5	7	64	62	--	<.1	<10	20	20	--
Drill hole[6]	U	02-24-88	--	17	30	--	--	--	<10	70	--	--
	U	05-17-88	--	11	22	--	--	--	<10	70	--	--
	U	08-04-88	--	--	--	--	--	--	--	--	--	--
	U	09-27-88	--	11	17	--	--	--	<10	80	--	--
	U	10-19-88	--	--	--	--	--	--	--	--	--	--
	U	11-30-88	--	10	23	--	--	--	<10	80	--	--
	U	01-26-89	--	--	--	--	--	--	--	--	--	--
	U	03-02-89	--	6	21	--	--	--	<10	70	--	--
	U	05-04-89	--	10	19	--	--	--	<10	70	--	--
	U	09-14-89	--	8	19	--	--	--	<10	70	--	--
Domestic well	U	03-31-93	4	<4	<1	1	--	<.1	<10	<10	<10	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Se_t	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t	^3H
MW-100	U	03-30-93	<1	<1.0	<1	360	<1	<6	3	8	110	--
	U	06-22-93	<1	<1.0	<1	310	<1	<1	<1	<4	7	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	2	--	290	--	<6	--	<3	--	--
	U	10-27-93	<1	<1.0	<1	320	<1	<6	<1	4	8	--
	C	11-04-93	<5	--	<5	--	--	--	--	--	424	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-101	C	01-18-88	--	3	--	--	--	--	--	32	--	--
	C	05-18-88	--	<5	--	--	--	--	--	56	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	<20	--	--	--	--	--	60	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-27-90	--	--	--	--	--	--	--	--	--	--
	C	04-27-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	<1.0	--	130	--	<6	--	220	--	--
	U	06-07-90	--	<1.0	--	130	--	<6	--	93	--	--
	C	06-28-90	--	<33	--	--	--	--	--	107	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	<40	--	--	--	--	--	89	--	--
	E	06-25-91	<50	<10	<10	--	<300	<10	<10	69	60	--
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	--	--	--	--	--	--	--	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
	C	11-04-93	<5	--	<5	--	--	--	--	--	557	--
MW-103[2]	C	01-18-88	--	3	--	--	--	--	--	32	--	--
	C	05-18-88	--	<5	--	--	--	--	--	152	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	<20	--	--	--	--	--	40	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Se_t	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t	^3H
MW-103[2]—Continued	U	04-30-90	--	<1.0	--	84	--	<6	--	280	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	<1.0	--	76	--	<6	--	73	--	--
	C	06-28-90	--	<33	--	--	--	--	--	135	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	--	--	--	--	--	--	--	--	--
MW-104[4]	C	01-18-88	--	--	--	--	--	--	--	--	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	<20	--	--	--	--	--	[3]70,000	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-30-90	--	--	--	--	--	--	--	--	--	--
	U	06-08-90	--	--	--	--	--	--	--	--	--	--
	C	06-28-90	--	--	--	--	--	--	--	--	--	--
	U	06-21-93	--	--	--	--	--	--	--	--	--	--
MW-105[5]	C	01-18-88	--	2	--	--	--	--	--	500	--	--
	C	05-18-88	--	--	--	--	--	--	--	--	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	--	--	--	--	--	--	--	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-25-90	--	--	--	--	--	--	--	--	--	--
	U	06-06-90	--	<1.0	--	22	--	<6	--	3,500	--	--
	C	06-07-90	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	--	--	--	--	--	--	--	--	--
MW-106	C	01-18-88	--	5	--	--	--	--	--	1,300	--	--
	C	05-18-88	--	<5	--	--	--	--	--	1,030	--	--
	C	08-11-88	--	--	--	--	--	--	--	--	--	--
	C	11-29-88	--	--	--	--	--	--	--	--	--	--
	C	02-23-89	--	--	--	--	--	--	--	--	--	--
	C	05-11-89	--	<20	--	--	--	--	--	710	--	--
	C	08-07-89	--	--	--	--	--	--	--	--	--	--
	C	11-16-89	--	--	--	--	--	--	--	--	--	--
	C	02-08-90	--	--	--	--	--	--	--	--	--	--
	U	04-26-90	--	<1.0	--	250	--	<6	--	470	--	--
	U	06-07-90	--	2	--	300	--	<6	--	520	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Se_t	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t	^3H
MW-106—Continued	C	06-28-90	--	<33	--	--	--	--	--	571	--	--
	C	08-09-90	--	--	--	--	--	--	--	--	--	--
	C	11-20-90	--	--	--	--	--	--	--	--	--	--
	C	02-28-91	--	--	--	--	--	--	--	--	--	--
	C	04-26-91	--	<40	--	--	--	--	--	500	--	--
	E	06-25-91	<50	<10	<10	--	<300	<10	<10	416	705	--
	C	08-30-91	--	--	--	--	--	--	--	--	--	--
	C	05-20-92	--	< 2	--	--	--	--	--	1,120	--	--
	C	08-27-92	--	--	--	--	--	--	--	--	--	--
	C	11-24-92	--	--	--	--	--	--	--	--	--	--
	C	02-11-93	--	--	--	--	--	--	--	--	--	--
	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	<1.0	<1	310	<1	<6	<1	10	120	--
	U	06-23-93	<1	<1.0	<1	310	<1	<1	<1	5	150	--
	U	09-29-93	--	<3.0	--	330	--	<18	--	11	--	--
	U	10-28-93	<1	<3.0	<1	320	<1	<18	<1	33	60	--
	C	11-04-93	6	--	<5	--	--	--	--	--	331	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-107	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	<1.0	<1	290	<1	<6	<1	59	160	--
	U	06-23-93	<1	<1.0	<1	270	<1	<1	<1	13	30	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	<1.0	--	240	--	<6	--	19	--	--
	U	10-28-93	<1	<1.0	<1	230	<1	<6	<1	28	40	--
	C	11-04-93	<5	--	<5	--	--	--	--	--	480	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
108-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	<1.0	<1	350	<1	<6	1	13	120	--
	U	06-23-93	<1	<1.0	<1	330	<1	<1	<1	4	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<1.0	--	350	--	<6	--	<3	--	16
	U	10-27-93	<1	<1.0	<1	340	<1	<6	<1	<3	6	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
MW-109	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-31-93	1	2	1	260	<1	<6	2	47	690	--
	U	03-31-93	--	--	--	--	--	--	--	--	--	--
	U	06-22-93	<1	<1.0	<1	410	<1	<1	<1	37	380	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-29-93	--	<1.0	--	430	--	<6	--	53	--	--
	U	10-28-93	<1	<1.0	<1	430	<1	<6	<1	100	210	--
	C	11-04-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Se_t	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t	^3H
201-P	U	03-04-93	--	<5	--	--	--	--	--	--	--	--
	U	03-29-93	<1	<1.0	<1	130	<1	<6	<1	140	240	--
	U	06-22-93	<1	<1.0	<1	110	<1	<1	<1	130	140	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<1.0	--	110	--	<6	--	130	--	30
	U	10-27-93	<1	<1.0	<1	120	<1	<6	<1	110	110	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
204-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	<1.0	7	130	<1	<6	7	46	1,100	--
	U	06-22-93	<1	<1.0	<1	130	<1	<1	<1	53	120	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<1.0	--	130	--	<6	--	65	--	--
	U	10-27-93	<1	<1.0	<1	120	<1	<6	<1	60	60	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
205-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-30-93	<1	<1.0	<1	58	<1	<6	<1	<3	10	--
	U	06-22-93	1	<1.0	<1	53	<1	<1	<1	<4	9	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	1	--	58	--	<6	--	7	--	--
	U	10-29-93	1	<1.0	<1	62	<1	<6	<1	15	20	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
208-P	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	<1.0	<1	110	<1	<6	<1	31	70	--
	U	06-23-93	<1	<1.0	<1	110	<1	<1	<1	4	10	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-28-93	--	<1.0	--	140	--	<6	--	8	--	<5.7
	U	10-28-93	<1	<1.0	<1	130	<1	<6	<1	30	40	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
2020-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	1	--	110	--	1	--	32	--	--
2021-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-20-93	--	1	--	290	--	1	--	38	--	--
2022-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<1.0	--	130	--	1	--	10	--	--
2023-P	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	12-21-93	--	<1.0	--	73	--	2	--	7	--	--
MW-303	U	03-04-93	--	--	--	--	--	--	--	--	--	--
	U	03-29-93	<1	<1.0	<1	92	<1	<6	<1	150	140	--
	U	06-22-93	<1	<1.0	<1	94	<1	<1	<1	140	150	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--

Table 9. Physical properties and concentrations of inorganic constituents in samples from wells and piezometers in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Source	Date	Se_t	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t	^3H
MW-303—Continued	U	09-28-93	--	<1.0	--	95	--	<6	--	180	--	--
	U	10-27-93	<1	<1.0	<1	97	<1	<6	<1	190	180	--
	C	11-04-93	<5	--	<5	--	--	--	--	--	63	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Landfill well	U	04-26-90	--	<1.0	--	93	--	<6	--	160	--	--
	U	06-08-90	--	<1.0	--	94	--	<6	--	180	--	--
	E	08-20-92	--	--	--	--	--	--	--	--	129	--
	U	03-31-93	1	<1.0	<1	91	<1	<6	<1	150	160	--
	U	06-22-93	<1	<1.0	<1	87	<1	<1	<1	150	140	--
	U	08-05-93	--	--	--	--	--	--	--	--	--	--
	U	09-09-93	--	--	--	--	--	--	--	--	--	--
	U	09-27-93	--	<1.0	--	88	--	<6	--	200	--	29
	U	10-27-93	<1	<1.0	<1	92	<1	<6	<1	160	170	--
	U	10-29-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
	U	11-24-93	--	--	--	--	--	--	--	--	--	--
Baker Mine well	U	04-25-90	--	<1.0	--	110	--	<6	--	70	--	--
	U	04-01-93	<1	<1.0	<1	100	<1	<6	<1	22	160	--
	U	06-24-93	<1	<1.0	<1	120	<1	<1	<1	29	220	--
	U	09-29-93	--	<1.0	--	110	--	<6	--	160	--	--
	U	10-29-93	<1	<1.0	<1	110	<1	<6	<1	31	90	--
Drill hole[6]	U	02-24-88	--	<1.0	--	99	--	<6	--	290	--	--
	U	05-17-88	--	<1.0	--	100	--	<6	--	310	--	--
	U	08-04-88	--	--	--	--	--	--	--	--	--	--
	U	09-27-88	--	<1.0	--	97	--	<6	--	200	--	--
	U	10-19-88	--	--	--	--	--	--	--	--	--	--
	U	11-30-88	--	<1.0	--	99	--	<6	--	210	--	--
	U	01-26-89	--	--	--	--	--	--	--	--	--	--
	U	03-02-89	--	1	--	100	--	<6	--	210	--	--
	U	05-04-89	--	1	--	94	--	<6	--	310	--	--
	U	09-14-89	--	<1.0	--	96	--	<6	--	170	--	--
Domestic well	U	03-31-93	<1	<1.0	<1	89	<1	<6	<1	64	70	--

[1] Original water level listed was depth of water above bottom of well; value was converted to depth below top of casing.
[2] Well was dry during subsequent quarterly sampling events from 06-25-91 through 11-24-93 and abandoned in December 1993.
[3] Suspect data not used in statistical analyses.
[4] Well was dry during subsequent quarterly sampling events from 06-28-90 through 03-30-93.
[5] Well was dry during subsequent quarterly sampling events from 06-28-90 through 09-27-93.
[6] Smith and Schumacher (1991).
[7] Alkalinity titration performed on a filtered sample.

Table 12. Concentrations of volatile organic compounds detected in water samples from monitoring and public-supply wells, piezometers, seeps, surface-water sites, and quality assurance/quality control samples in the vicinity of the St. Francois County Landfill site, Missouri

[All concentrations are total recoverable and in micrograms per liter; VOC, volatile organic compounds; CS_2, carbon disulfide; DCA, 1,1-Dichloroethane; TCA, 1,1,1-Trichloroethane; VC, vinyl chloride; 1,1-DCE, 1,1-Dichloroethene; cis-DCE, cis-1,2-Dichloroethene; trans-DCE, trans-1,2-Dichloroethene; TCE, 1,1,2-Trichloroethene; PCE, 1,1,2,2-Tetrachloroethene; MTBE, methyltertiarybutylether; <, less than; --, no data]

Site (figs. 2, 5, and 10)	Date	Total VOC	Chloro-methane	Dichloro-methane	Chloro-fluoro-methane (Freon 31)	Dichloro-fluoro-methane (Freon 21)	Dichloro-difluoro-methane (Freon 12)	Trichloro-fluoro-methane (Freon 11)	CS_2	Chloro-ethane	DCA
MW-100	03-30-93	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	06-22-93	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
MW-106	03-30-93	72	<.2	.4	19	15	<.2	<.2	<.2	.2	1
	06-23-93	102.1	<.2	.3	38	23	<.2	.2	<.2	.2	.8
	10-28-93	113.14	<.2	2.3	<.2	<.2	.4	<.2	1.6	1.8	.6
MW-107	03-30-93	27.6	.2	11	7.5	4.1	<.2	<.2	<.2	<.2	<.2
	06-23-93	31.6	<.2	5.4	13	7.3	<.2	<.2	<.2	<.2	<.2
	10-28-93	16.23	<.2	5.9	<.2	<.2	<.2	<.2	<.2	<.2	<.2
108-P	03-29-93	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-23-93	.9	<.2	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
MW-109	03-31-93	17.8	<.2	10	4.5	1.2	<.2	<.2	<.2	<.2	<.2
MW-109 duplicate	03-31-93	20.4	<.2	11	5.5	1.5	<.2	<.2	<.2	<.2	<.2
	06-22-93	24.7	<.2	9	2.6	2.7	<.2	<.2	<.2	<.2	<.2
	10-28-93	21.9	<.2	9.3	<.2	<.2	<.2	<.2	1.8	<.2	<.2
201-P	03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
204-P	03-30-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
205-P	03-30-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-29-93	.4	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2	<.2
208-P	[1]03-29-93	1.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-23-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-28-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
2022-P	05-31-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
MW-303	03-29-93	.9	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	.9	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	1.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 12. Concentrations of volatile organic compounds detected in water samples from monitoring and public-supply wells, piezometers, seeps, surface-water sites, and quality assurance/quality control samples in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Date	Total VOC	Chloro-methane	Dichloro-methane	Chloro-fluoro-methane (Freon 31)	Dichloro-fluoro-methane (Freon 21)	Dichloro-difluoro-methane (Freon 12)	Trichloro-fluoro-methane (Freon 11)	CS_2	Chloro-ethane	DCA
Landfill well	03-31-93	0.9	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	06-22-93	.9	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	2.23	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	01-16-94	2.5	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2
	01-26-94	18.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-20-94	1.05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Baker Mine well	04-01-93	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-24-93	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-29-93	.52	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Domestic well	03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Elvins seep at pile	03-31-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Gumbo well	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Desloge well	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Park Hills River Mines well	11-24-93	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-20-94	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Leadwood No. 1	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Leadwood No. 2	04-20-94	.74	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Seep 10+07	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Big River at Bone-hole	10-26-93	.34	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Big River downstream	10-26-93	.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Equipment blank	04-01-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-23-93	.3	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Trip blank	03-31-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-01-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-28-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	11-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	01-21-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 12. Concentrations of volatile organic compounds detected in water samples from monitoring and public-supply wells, piezometers, seeps, surface-water sites, and quality assurance/quality control samples in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Date	TCA	VC	1,1-DCE	cis-DCE	trans-DCE	TCE	PCE	Benzene	Ethyl-benzene
MW-100	03-30-93	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	10-27-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
MW-106	03-30-93	<.2	<.2	<.2	16	.2	<.2	<.2	.2	<.2
	06-23-93	<.2	.3	<.2	14	<.2	<.2	<.2	.2	<.2
	10-28-93	<.2	<.2	<.2	4.7	<.2	<.2	<.2	.14	<.2
MW-107	03-30-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-23-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
	10-28-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.13	<.2
108-P	03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
	06-23-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2
	10-27-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2
MW-109	03-31-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
MW-109 duplicate	03-31-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
	10-28-93	<.2	<.2	<.2	.2	<.2	<.2	<.2	.2	<.2
201-P	03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
204-P	03-30-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-27-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
205-P	03-30-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
208-P	[1]03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2
	06-23-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-28-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
2022-P	05-31-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
MW-303	03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2	<.2
	06-22-93	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2	<.2
	10-27-93	<.2	<.2	<.2	.2	<.2	.2	.6	<.2	<.2

Table 12. Concentrations of volatile organic compounds detected in water samples from monitoring and public-supply wells, piezometers, seeps, surface-water sites, and quality assurance/quality control samples in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Date	TCA	VC	1,1-DCE	cis-DCE	trans-DCE	TCE	PCE	Benzene	Ethyl-benzene
Landfill well	03-31-93	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.5	<0.2	<0.2
	06-22-93	.2	<.2	<.2	<.2	<.2	<.2	.4	<.2	<.2
	10-27-93	.7	<.2	.3	.1	<.2	.2	.6	<.2	<.2
	01-16-94	.7	<.2	<.2	.1	<.2	.2	.6	<.2	<.2
	01-26-94	.7	<.2	.3	.1	<.2	.2	.6	<.2	<.2
	04-20-94	<.2	<.2	<.2	.1	<.2	.15	.55	<.2	<.2
Baker Mine well	04-01-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-29-93	<.2	<.2	<.2	<.2	<.2	<.2	.1	<.2	<.2
Domestic well	03-29-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Elvins seep at pile	03-31-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Gumbo well	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Desloge well	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Park Hills River Mines well	11-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	.1	<.2	<.2
Leadwood No. 1	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Leadwood No. 2	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.74	<.2
Seep 10+07	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Big River at Bone-hole	10-26-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Big River downstream	10-26-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Equipment blank	04-01-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-23-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Trip blank	03-31-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-01-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	10-28-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	11-24-93	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	01-21-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-20-94	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 12. Concentrations of volatile organic compounds detected in water samples from monitoring and public-supply wells, piezometers, seeps, surface-water sites, and quality assurance/quality control samples in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Date	Xylenes	Toluene	Napthalene	MTBE	Ethyl ether	Acetone	2-Butanone
MW-100	03-30-93	<0.2	<0.2	<0.2	<0.2	<0.2	<5	<5
	06-22-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-27-93	<.2	.1	<.2	<.2	<.2	<5	<5
MW-106	03-30-93	<.2	<.2	<.2	2	18	<5	<5
	06-23-93	<.2	<.2	<.2	2.1	23	<5	<5
	10-28-93	<.2	<.2	<.2	4.6	97	<5	<5
MW-107	03-30-93	<.2	<.2	<.2	.8	4	<5	<5
	06-23-93	<.2	<.2	<.2	.9	4.8	<5	<5
	10-28-93	<.2	<.2	<.2	.7	9.5	<5	<5
108-P	03-29-93	<.2	<.2	<.2	.1	<.2	<5	<5
	06-23-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-27-93	<.2	<.2	<.2	<.2	<.2	<5	<5
MW-109	03-31-93	<.2	<.2	<.2	.3	1.6	<5	<5
MW-109 duplicate	03-31-93	<.2	<.2	<.2	.3	1.9	<5	<5
	06-22-93	<.2	<.2	<.2	.3	9.9	<5	<5
	10-28-93	<.2	<.2	<.2	.4	10	<5	<5
201-P	03-29-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	06-22-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-27-93	<.2	<.2	<.2	<.2	<.2	<5	<5
204-P	03-30-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	06-22-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-27-93	<.2	<.2	<.2	<.2	<.2	<5	<5
205-P	03-30-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	06-22-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-29-93	<.2	<.2	<.2	<.2	<.2	<5	<5
208-P	[1]03-29-93	.5	<.2	.6	<.2	<.2	<5	<5
	06-23-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-28-93	<.2	<.2	<.2	<.2	<.2	<5	<5
2022-P	05-31-94	<.2	<.2	<.2	<.2	<.2	<.2	<5
MW-303	03-29-93	<.2	<.2	<.2	.4	<.2	<5	<5
	06-22-93	<.2	<.2	<.2	.4	<.2	<5	<5
	10-27-93	<.2	<.2	<.2	.4	<.2	<5	<5

Table 12. Concentrations of volatile organic compounds detected in water samples from monitoring and public-supply wells, piezometers, seeps, surface-water sites, and quality assurance/quality control samples in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 2, 5, and 10)	Date	Xylenes	Toluene	Napthalene	MTBE	Ethyl ether	Acetone	2-Butanone
Landfill well	03-31-93	<.0.2	<0.2	<0.2	0.4	<0.2	<5	<5
	06-22-93	<.2	<.2	<.2	.3	<.2	<5	<5
	10-27-93	<.2	<.2	<.2	.3	<.2	<5	<5
	01-16-94	<.2	.3	<.2	.3	<.2	<5	<5
	01-26-94	<.2	.3	<.2	.3	<.2	9.7	6.1
	04-20-94	<.2	<.2	<.2	.2	<.2	<5	<5
Baker Mine well	04-01-93	<.2	<.2	<.2	.4	<.2	<5	<5
	06-24-93	<.2	<.2	<.2	.2	<.2	<5	<5
	10-29-93	<.2	<.2	<.2	.4	<.2	<5	<5
Domestic well	03-29-93	<.2	<.2	<.2	<.2	<.2	<5	<5
Elvins seep at pile	03-31-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	06-24-93	<.2	<.2	<.2	<.2	<.2	<5	<5
Gumbo well	04-20-94	<.2	<.2	<.2	<.2	<.2	<5	<5
Desloge well	04-20-94	<.2	<.2	<.2	<.2	<.2	<5	<5
Park Hills River Mines well	11-24-93	<.2	<.2	<.2	.3	<.2	<5	<5
	04-20-94	<.2	<.2	<.2	.3	<.2	<5	<5
Leadwood No. 1	04-20-94	<.2	<.2	<.2	<.2	<.2	<5	<5
Leadwood No. 2	04-20-94	<.2	<.2	<.2	<.2	<.2	<5	<5
Seep 10+07	06-24-93	<.2	<.2	<.2	<.2	<.2	<5	<5
Big River at Bone-hole	10-26-93	.2	.14	<.2	<.2	<.2	<5	<5
Big River downstream	10-26-93	.3	.2	<.2	<.2	<.2	<5	<5
Equipment blank	04-01-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	06-23-93	<.2	<.2	<.2	<.2	<.2	<5	<5
Trip blank	03-31-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	04-01-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	06-24-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	10-28-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	11-24-93	<.2	<.2	<.2	<.2	<.2	<5	<5
	01-21-94	<.2	<.2	<.2	<.2	<.2	<5	<5
	04-20-94	<.2	<.2	<.2	<.2	<.2	<5	<5

[1] This sample also contained 1,3,5-trimethylbenzene (0.2 microgram per liter); methyl iodide (0.3 microgram per liter); 2-ethyltoluene (0.2 microgram per liter); 1,2,3-trimethylbenzene (0.4 microgram per liter); 1,2,4-trimethylbenzene (0.6 microgram per liter); 1,2,3,4-tetramethylbenzene (0.3 microgram per liter); and 1,2,3,5-tetramethylbenzene (0.6 microgram per liter). All compounds tentatively identified and concentrations estimated.

ABBREVIATIONS AND REPORTING UNITS FOR CHEMICAL CONSTITUENTS AND NOTATIONS USED IN TABLE 13

Q	Discharge, in cubic feet per second
SC	Specific conductance, in microsiemens per centimeter at 25 degrees Celsius
pH	In standard units
Temp	Water temperature, in degrees Celsius
DO	Dissolved oxygen, in milligrams per liter
COD	Chemical oxygen demand, in milligrams per liter
Ca	Calcium, dissolved, in milligrams per liter
Ca_t	Calcium, total, in milligrams per liter
Mg	Magnesium, dissolved, in milligrams per liter
Mg_t	Magnesium, total, in milligrams per liter
Na	Sodium, dissolved, in milligrams per liter
Na_t	Sodium, total, in milligrams per liter
K	Potassium, dissolved, in milligrams per liter
$Alk_{(IT)}$	Alkalinity, total, in milligrams per liter as $CaCO_3$, by incremental titration
$HCO_{3(IT)}$	Bicarbonate, in milligrams per liter, by incremental titration
$Alk_{(EP)}$	Alkalinity, total, in milligrams per liter as $CaCO_3$, pH 4.5 end point
$HCO_{3(EP)}$	Bicarbonate, in milligrams per liter, pH 4.5 end point
$CO_{3(EP)}$	Carbonate, in milligrams per liter, pH 4.5 end point
SO_4	Sulfate, dissolved, in milligrams per liter
Cl	Chloride, dissolved, in milligrams per liter
F	Fluoride, dissolved, in milligrams per liter
SiO_2	Silica, dissolved, in milligrams per liter
ROE	Dissolved solids, residue at 180 degrees Celsius, in milligrams per liter
TDS	Dissolved solids, sum of constituents, in milligrams per liter
Hard	Hardness, total, in milligrams per liter as $CaCO_3$
TOC	Organic carbon, total, in milligrams per liter
NO_2+NO_3	Nitrite plus nitrate, dissolved as nitrogen, in milligrams per liter
NO_2+NO_{3t}	Nitrite plus nitrate, total as nitrogen, in milligrams per liter
NO_2	Nitrite, dissolved as nitrogen, in milligrams per liter
NO_{2t}	Nitrite, total as nitrogen, in milligrams per liter
NH_3	Ammonia, dissolved as nitrogen, in milligrams per liter
NH_{3t}	Ammonia, total as nitrogen, in milligrams per liter
NH_3+ON_t	Nitrogen, total ammonia plus organic nitrogen as nitrogen, in milligrams per liter
TON	Nitrogen, total organic, in milligrams per liter
P	Phosphorous, dissolved, in milligrams per liter
P_t	Phosphorous, total, in milligrams per liter
PO_4	Orthophosphate, dissolved, in milligrams per liter
Al	Aluminum, dissolved, in micrograms per liter
Sb_t	Antimony, total, in micrograms per liter
As	Arsenic, dissolved, in micrograms per liter
As_t	Arsenic, total, in micrograms per liter
Ba	Barium, dissolved, in micrograms per liter
Ba_t	Barium, total, in micrograms per liter
Be	Berylium, dissolved, in micrograms per liter
Be_t	Berylium, total, in micrograms per liter
B	Boron, dissolved, in micrograms per liter
B_t	Boron, total, in micrograms per liter
Cd	Cadmium, dissolved, in micrograms per liter
Cd_t	Cadmium, total, in micrograms per liter
Cr	Chromium, dissolved, in micrograms per liter
Cr_t	Chromium, total, in micrograms per liter
Co	Cobalt, dissolved, in micrograms per liter
Co_t	Cobalt, total, in micrograms per liter
Cu	Copper, dissolved, in micrograms per liter
Cu_t	Copper, total, in micrograms per liter
Fe	Iron, dissolved, in micrograms per liter
Fe_t	Iron, total, in micrograms per liter
Fe^{3+}	Ferric iron, dissolved, estimated concentration, in micrograms per liter
Pb	Lead, dissolved, in micrograms per liter
Pb_t	Lead, total, in micrograms per liter
Li	Lithium, dissolved, in micrograms per liter
Mn	Manganese, dissolved, in micrograms per liter
Mn_t	Manganese, total, in micrograms per liter
Hg	Mercury, dissolved, in micrograms per liter
Hg_t	Mercury, total, in micrograms per liter
Mo	Molybdenum, dissolved, in micrograms per liter
Ni	Nickel, dissolved, in micrograms per liter
Ni_t	Nickel, total, in micrograms per liter
Se	Selenium, dissolved, in micrograms per liter
Se_t	Selenium, total, in micrograms per liter
Ag	Silver, dissolved, in micrograms per liter
Ag_t	Silver, total, in micrograms per liter
Sr	Strontium, dissolved, in micrograms per liter
Tl	Thallium, dissolved, in micrograms per liter
V	Vanadium, dissolved, in micrograms per liter
V_t	Vanadium, total, in micrograms per liter
Zn	Zinc, dissolved, in micrograms per liter
Zn_t	Zinc, total, in micrograms per liter
e	Estimated value
--	No data
>	Greater than
<	Less than

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri

Site (figs. 1 and 5)	Date	Time	Q	SC	pH	Temp	DO	COD	Ca	Ca_t	Mg	Mg_t
Elvins tailings pile seep	[1]02-23-88	1730	0.01e	1,110	7.32	11	--	--	220	--	78	--
	[1]09-26-88	1445	--	1,420	7.08	22	--	--	220	--	76	--
	[1]11-30-88	1200	.01e	1,500	6.5	14	--	--	230	--	73	--
	[1]03-02-89	1220	--	1,220	6.41	14.5	--	--	180	--	60	--
	[1]05-03-89	1400	--	823	6.79	16.5	--	--	110	--	38	--
	[1]09-14-89	1330	.39	1,120	6.62	14.5	6.4	--	180	--	59	--
	03-31-93	1700	--	--	--	--	--	--	--	--	--	--
	03-31-93	1701	--	1,180	7.09	14.2	>1	<10	160	170	55	60
	06-24-93	0740	--	1,178	6.91	14.9	--	<10	140	130	45	44
Seep G	[2]03-18-80	1145	--	800	6.6	--	--	--	--	--	--	--
	[3]03-18-80	--	--	460	7.3	9	--	--	--	--	--	--
	[2]11-01-88	--	--	--	6.7	--	--	10	120	--	--	--
	[1]11-06-89	1630	--	2,150	6.47	13.5	--	--	310	--	140	--
	04-26-90	1600	--	984	7.23	15.1	--	28	140	--	52	--
	06-07-90	1545	--	717	--	--	--	--	96	--	36	--
	06-07-90	1600	--	730	--	--	--	--	99	--	36	--
Seep H	04-26-90	1550	--	1,855	6.93	16.4	--	22	250	--	110	--
	06-07-90	1530	--	1,920	--	--	--	--	280	--	130	--
Seep K	[1]11-07-89	1430	--	1,770	6.97	13	--	--	230	--	50	--
	04-26-90	1130	--	1,560	6.46	20.0	>1	45	190	--	47	--
	06-07-90	0945	--	1,310	6.46	17.2	--	--	170	--	40	--
Seep 10+07	06-07-90	1430	--	850	--	--	--	26	110	--	44	--
	03-31-93	1130	--	1,002	--	--	--	--	75	--	69	--
	06-24-93	1030	--	988	8.08	18.2	--	--	57	--	60	--
	10-30-93	1100	.01	--	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri–Continued

Site (figs. 1 and 5)	Date	Time	Q	SC	pH	Temp	DO	COD	Ca	Ca_t	Mg	Mg_t
Big River at Bone-hole	[3]03-18-80	--	--	310	6.0	11	--	--	--	--	--	--
	[1]02-24-88	1130	285	317	8.01	7	--	--	34	--	20	--
	[1]05-17-88	0930	67	509	7.39	19	--	--	59	--	35	--
	[1]09-27-88	0800	63	453	8.2	14.5	--	--	48	--	29	--
	[1]11-30-88	1700	271	300	8.02	7	--	--	34	--	19	--
	[1]03-02-89	1715	185	377	7.89	6.5	--	--	41	--	24	--
	[1]05-04-89	0830	134	420	7.63	15	--	--	45	--	27	--
	[1]09-14-89	0830	52	608	6.66	16.5	--	--	65	--	40	--
	[1]11-07-89	--	39.3	622	7.85	14.3	--	--	64	--	40	--
	10-26-93	1315	119	510	8.0	12.5	7	<10	50	52	28	31
Big River downstream	[3]03-18-80	--	--	260	6.4	10	--	--	--	--	--	--
	[1]11-07-89	--	44	640	8.07	15.2	--	--	65	--	40	--
	10-26-93	1500	122	468	8.0	13.5	7	<10	52	53	29	32
Mine-A-Joe Creek upstream	[2]03-18-80	1200	--	460	7.3	--	--	--	--	--	--	--
	04-26-90	1615	--	1,130	--	--	--	--	130	--	64	--
Mine-A-Joe Creek downstream	[2]03-18-80	1230	--	460	7.3	--	--	--	--	--	--	--
	[3]03-18-80	--	--	460	7.3	6	--	--	--	--	--	--
	[1]02-24-88	1230	.01	856	8.13	8	--	--	100	--	55	--
	[1]05-17-88	0830	.01	1,235	8.61	12.4	--	--	160	--	93	--
	[1]09-27-88	0930	--	1,130	8.16	15.5	--	--	150	--	67	--
	[2]11-01-88	--	--	--	7.9	--	--	12	170	--	--	--
	[1]12-01-88	0830	.01	1,075	7.99	4.5	--	--	140	--	67	--
	[1]03-02-89	1800	.15	1,010	7.95	7.1	--	--	120	--	64	--
	[1]05-04-89	0915	.05	1,207	7.64	11.9	--	--	140	--	82	--
	[1]09-14-89	0945	.15	478	6.43	15	--	--	61	--	24	--
Southwest Creek	04-26-90	1630	--	--	--	--	--	--	61	--	34	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
Elvins tailings pile seep	[1]02-23-88	5.3	--	8.5	--	--	112	140	0
	[1]09-26-88	5.7	--	10	--	--	156	190	0
	[1]11-30-88	5	--	9.8	--	--	138	170	0
	[1]03-02-89	4.6	--	9.6	--	--	121	150	0
	[1]05-03-89	3.1	--	8	--	--	120	150	0
	[1]09-14-89	3.6	--	9	--	--	127	150	0
	03-31-93	--	--	--	--	--	--	--	--
	03-31-93	3.8	3.6	--	117	143	118	--	--
	06-24-93	3.4	3.7	10	126	153	128	--	--
Seep G	[2]03-18-80	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--
	[2]11-01-88	--	--	--	--	--	--	--	--
	[1]11-06-89	24	--	12	445	543	434	--	--
	04-26-90	2.9	--	5.6	234	286	231	--	--
	06-07-90	2	--	4.5	215	263	--	--	--
	06-07-90	1.8	--	4.4	218	267	220	--	--
Seep H	04-26-90	25	--	11	378	461	373	--	--
	06-07-90	30	--	14	476	581	475	--	--
Seep K	[1]11-07-89	62	--	17	748	910	724	--	--
	04-26-90	46	--	19	516	630	--	--	--
	06-07-90	35	--	16	--	--	--	--	--
Seep 10+07	06-07-90	2.9	--	4.1	259	316	--	--	--
	03-31-93	27	--	--	--	--	--	--	--
	06-24-93	30	--	8.5	--	--	--	--	--
	10-30-93	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Na	Na_t	K	$Alk_{(IT)}$	$HCO_{3(IT)}$	$Alk_{(EP)}$	$HCO_{3(EP)}$	$CO_{3(EP)}$
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]02-24-88	3.1	--	1.4	--	--	118	140	0
	[1]05-17-88	5	--	1.6	--	--	211	260	0
	[1]09-27-88	4.1	--	1.9	--	--	195	240	0
	[1]11-30-88	2.8	--	1.5	--	--	142	170	0
	[1]03-02-89	3.6	--	1.3	--	--	168	200	0
	[1]05-04-89	3.7	--	1.8	--	--	179	220	0
	[1]09-14-89	6.1	--	2.2	--	--	226	270	0
	[1]11-07-89	5.9	--	1.9	--	--	231	280	0
	10-26-93	4.1	3.8	1.92	207	252	208	--	--
Big River downstream	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]11-07-89	5.5	--	2	--	--	235	290	0
	10-26-93	4.2	4.2	1.98	204	249	203	--	--
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	--	--
	04-26-90	15	--	4.8	286	349	--	--	--
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]02-24-88	13	--	6.3	--	--	242	295	0
	[1]05-17-88	17	--	7.5	--	--	292	337	10
	[1]09-27-88	12	--	6.1	--	--	184	224	0
	[2]11-01-88	--	--	--	--	--	--	--	--
	[1]12-01-88	13	--	6.9	--	--	290	309	22
	[1]03-02-89	16	--	7.8	--	--	294	358	0
	[1]05-04-89	15	--	7.9	--	--	305	372	0
	[1]09-14-89	9.1	--	5.4	--	--	71	86	0
Southwest Creek	04-26-90	1.1	--	.8	280	342	276	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC
Elvins tailings pile seep	[1]02-23-88	570	5.4	--	5.1	914	971	870	--
	[1]09-26-88	730	7.1	--	7.1	1,190	1,150	860	--
	[1]11-30-88	810	6.2	--	5.4	1,290	1,240	880	--
	[1]03-02-89	590	6.7	--	5.1	1,000	945	700	--
	[1]05-03-89	330	3.7	--	4.4	587	580	430	--
	[1]09-14-89	640	4.9	--	5	1,010	993	690	--
	03-31-93	--	--	--	--	--	--	--	--
	03-31-93	550	6.3	0.2	4.7	886	--	630	3.6
	06-24-93	510	5.5	.3	4.6	932	810	540	1.4
Seep G	[2]03-18-80	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--
	[2]11-01-88	--	20	--	--	--	180	--	--
	[1]11-06-89	1,000	31	.1	13	--	1,820	1,400	--
	04-26-90	340	3.7	<.1	7.6	753	696	560	5
	06-07-90	170	3.6	.2	8.5	--	452	390	2.4
	06-07-90	190	3.5	.2	7.4	--	476	400	8.3
Seep H	04-26-90	690	37	<.1	10	1,570	1,370	1,100	1.5
	06-07-90	830	34	.1	10	--	1,640	1,200	5.2
Seep K	[1]11-07-89	160	76	.3	17	--	922	780	--
	04-26-90	170	61	.4	14	--	870	670	6.3
	06-07-90	140	43	.3	18	--	795	590	8.3
Seep 10+07	06-07-90	210	6.1	.1	7.7	--	542	460	1
	03-31-93	58	44	--	9.7	--	--	470	--
	06-24-93	54	44	.1	9	564	--	390	--
	10-30-93	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	SO_4	Cl	F	SiO_2	ROE	TDS	Hard	TOC
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]02-24-88	39	4.6	--	5.5	189	179	170	--
	[1]05-17-88	77	5.3	--	4.8	307	314	290	--
	[1]09-27-88	51	5.5	--	7.1	260	264	240	--
	[1]11-30-88	38	3.4	--	7.8	191	192	160	--
	[1]03-02-89	41	4.4	--	5.5	217	222	200	--
	[1]05-04-89	51	4.2	--	3.5	249	244	220	--
	[1]09-14-89	110	6.6	--	9.8	375	375	330	--
	[1]11-07-89	93	7	--	5.4	--	356	320	--
	10-26-93	49	5.7	<0.1	6	276	269	240	2.2
Big River downstream	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]11-07-89	100	7	--	5.4	--	364	330	--
	10-26-93	54	5.9	<.1	5.9	276	276	250	2.5
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	--	--
	04-26-90	320	14	<.1	2.3	--	722	590	--
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]02-24-88	220	15	--	7.2	607	563	480	--
	[1]05-17-88	480	18	--	6.6	969	959	780	--
	[1]09-27-88	460	14	--	6.4	870	826	650	--
	[2]11-01-88	--	19	--	--	--	110	--	--
	[1]12-01-88	350	15	--	8.5	814	776	630	--
	[1]03-02-89	280	18	--	6.7	724	689	560	--
	[1]05-04-89	410	14	--	5.6	908	858	690	--
	[1]09-14-89	180	12	--	2.7	370	337	250	--
Southwest Creek	04-26-90	26	3.6	.3	7.2	--	302	290	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	NO_2+NO_3	NO_2+NO_{3t}	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON
Elvins tailings pile seep	[1]02-23-88	--	--	--	--	--	--	--	--
	[1]09-26-88	--	--	--	--	--	--	--	--
	[1]11-30-88	--	--	--	--	--	--	--	--
	[1]03-02-89	--	--	--	--	--	--	--	--
	[1]05-03-89	--	--	--	--	--	--	--	--
	[1]09-14-89	--	--	--	--	--	--	--	--
	03-31-93	--	--	--	--	--	--	--	--
	03-31-93	--	0.18	--	<0.01	--	0.01	--	--
	06-24-93	--	.05	--	<.01	--	.01	--	--
Seep G	[2]03-18-80	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--
	[2]11-01-88	--	--	--	--	--	--	--	--
	[1]11-06-89	<0.1	--	<0.01	--	0.26	--	--	--
	04-26-90	<.1	--	<.01	--	.15	.13	0.4	0.27
	06-07-90	<.1	--	<.01	--	.04	--	--	--
	06-07-90	<.1	--	<.01	--	.07	--	--	--
Seep H	04-26-90	.1	--	<.01	--	.14	.12	.2	.08
	06-07-90	2.9	--	.01	--	.14	--	--	--
Seep K	[1]11-07-89	<.1	--	<.01	--	6.8	--	--	--
	04-26-90	<.1	--	<.01	--	9	10	11	1
	06-07-90	.1	--	<.01	--	2.2	--	--	--
Seep 10+07	06-07-90	<.1	--	<.01	--	.36	--	--	--
	03-31-93	--	.09	--	--	--	1.7	--	--
	06-24-93	--	1.4	--	.03	--	2.4	--	--
	10-30-93	--	--	--	--	--	4.8	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	NO_2+NO_3	NO_2+NO_{3t}	NO_2	NO_{2t}	NH_3	NH_{3t}	NH_3+ON_t	TON
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]02-24-88	--	--	--	--	--	--	--	--
	[1]05-17-88	--	--	--	--	--	--	--	--
	[1]09-27-88	--	--	--	--	--	--	--	--
	[1]11-30-88	--	--	--	--	--	--	--	--
	[1]03-02-89	--	--	--	--	--	--	--	--
	[1]05-04-89	--	--	--	--	--	--	--	--
	[1]09-14-89	--	--	--	--	--	--	--	--
	[1]11-07-89	--	--	--	--	--	--	--	--
	10-26-93	--	0.05	--	<0.010	--	0.02	--	--
Big River downstream	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]11-07-89	--	--	--	--	--	--	--	--
	10-26-93	--	.09	--	<.010	--	.021	--	--
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	--	--
	04-26-90	<0.1	--	<0.01	--	0.05	--	--	--
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--
	[1]02-24-88	--	--	--	--	--	--	--	--
	[1]05-17-88	--	--	--	--	--	--	--	--
	[1]09-27-88	--	--	--	--	--	--	--	--
	[2]11-01-88	--	--	--	--	--	--	--	--
	[1]12-01-88	--	--	--	--	--	--	--	--
	[1]03-02-89	--	--	--	--	--	--	--	--
	[1]05-04-89	--	--	--	--	--	--	--	--
	[1]09-14-89	--	--	--	--	--	--	--	--
Southwest Creek	04-26-90	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	P	P_t	PO_4	Al	Sb_t	As	As_t	Ba	Ba_t
Elvins tailings pile seep	[1]02-23-88	--	--	--	<10	--	--	--	18	--
	[1]09-26-88	<0.001	--	0.003	<10	--	--	--	21	--
	[1]11-30-88	<.002	--	<.001	<10	--	--	--	27	--
	[1]03-02-89	<.001	--	<.001	<10	--	--	--	18	--
	[1]05-03-89	<.002	--	.002	<10	--	--	--	12	--
	[1]09-14-89	<.001	--	<.001	<10	--	--	--	16	--
	03-31-93	--	--	--	--	--	--	--	--	--
	03-31-93	--	0.02	--	--	<1	--	2	14	12
	06-24-93	--	<.02	--	--	<1	--	<1	10	12
Seep G	[2]03-18-80	--	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[2]11-01-88	--	--	--	--	--	<5	--	62	--
	[1]11-06-89	<.01	--	<.01	<10	--	--	--	35	--
	04-26-90	<.01	.09	<.01	--	--	2	--	32	--
	06-07-90	<.01	--	<.01	--	--	<1	--	55	--
	06-07-90	<.01	--	<.01	--	--	2	--	36	--
Seep H	04-26-90	<.01	<.01	.01	--	--	3	--	29	--
	06-07-90	<.01	--	<.01	--	--	<1	--	33	--
Seep K	[1]11-07-89	<.01	--	.021	20	--	--	--	130	--
	04-26-90	<.01	<.01	<.01	--	--	<1	--	150	--
	06-07-90	<.01	--	<.01	--	--	1	--	240	--
Seep 10+07	[1]06-07-90	.01	--	<.01	--	--	1	--	50	--
	03-31-93	--	--	--	--	--	--	--	440	--
	06-24-93	--	<.02	--	--	--	--	--	1,100	--
	10-30-93	--	<.02	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	P	P_t	PO_4	Al	Sb_t	As	As_t	Ba	Ba_t
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[1]02-24-88	--	--	--	<10	--	--	--	57	--
	[1]05-17-88	--	--	--	<10	--	--	--	110	--
	[1]09-27-88	0.008	--	0.003	<10	--	--	--	100	--
	[1]11-30-88	.007	--	<.001	<10	--	--	--	64	--
	[1]03-02-89	.009	--	.002	<10	--	--	--	69	--
	[1]05-04-89	.004	--	.002	<10	--	--	--	81	--
	[1]09-14-89	.01	--	.006	<10	--	--	--	100	--
	[1]11-07-89	--	--	--	<10	--	--	--	100	--
	10-26-93	--	0.13	--	--	<1	--	<1	98	100
Big River downstream	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[1]11-07-89	--	--	--	<10	--	--	--	95	--
	10-26-93	--	.02	--	--	<1	--	<1	96	100
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	--	--	--
	04-26-90	<.01	--	<.01	--	--	<1	--	69	--
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[1]02-24-88	--	--	--	<10	--	--	--	53	--
	[1]05-17-88	--	--	--	<10	--	--	--	74	--
	[1]09-27-88	<.001	--	.003	<10	--	--	--	58	--
	[2]11-01-88	--	--	--	--	--	<5	--	62	--
	[1]12-01-88	<.002	--	<.001	<10	--	--	--	60	--
	[1]03-02-89	.003	--	<.001	<10	--	--	--	55	--
	[1]05-04-89	<.002	--	.002	<10	--	--	--	58	--
	[1]09-14-89	.002	--	.001	<10	--	--	--	25	--
Southwest Creek	04-26-90	--	--	--	--	--	<1	--	33	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Be	Be_t	B	B_t	Cd	Cd_t	Cr	Cr_t	Co
Elvins tailings pile seep	[1]02-23-88	<0.5	--	--	--	17	--	<5	--	480
	[1]09-26-88	<.5	--	--	--	21	--	<5	--	610
	[1]11-30-88	<.5	--	--	--	28	--	<5	--	550
	[1]03-02-89	<1.5	--	--	--	26	--	<10	--	450
	[1]05-03-89	<.5	--	--	--	15	--	<5	--	310
	[1]09-14-89	<.5	--	--	--	21	--	<5	--	--
	03-31-93	--	--	--	--	--	--	--	--	--
	03-31-93	<.5	<1	--	46	21	30	<5	<5	400
	06-24-93	<1	<1	38	42	18	18	<5	<5	560
Seep G	[2]03-18-80	--	--	--	--	4.5	4.6	--	--	--
	[3]03-18-80	--	--	--	--	5	--	--	--	--
	[2]11-01-88	--	--	--	--	10	--	40	--	--
	[1]11-06-89	<1	--	--	--	<2	--	<10	--	<50
	04-26-90	<.5	--	90	--	<1	--	<5	--	190
	06-07-90	<.5	--	100	--	14	--	<5	--	20
	06-07-90	<.5	--	100	--	1	--	<5	--	110
Seep H	04-26-90	<.5	--	180	--	3	--	<5	--	490
	06-07-90	<.5	--	270	--	5	--	<5	--	360
Seep K	[1]11-07-89	<.5	--	--	--	<1	--	2	--	6
	04-26-90	<.5	--	280	--	<1	--	<5	--	20
	06-07-90	<.5	--	320	--	2	--	<5	--	38
Seep 10+07	06-07-90	<.5	--	80	--	<1	--	<5	--	<3
	03-31-93	<.5	--	--	--	<1	--	<1	--	<1
	06-24-93	<1	--	190	--	<1	--	<5	--	<3
	10-30-93	--	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Be	Be_t	B	B_t	Cd	Cd_t	Cr	Cr_t	Co
Big River at Bone-hole	[3]03-18-80	--	--	--	--	2	--	--	--	--
	[1]02-24-88	<0.5	--	--	--	<1	--	<5	--	<3
	[1]05-17-88	<.5	--	--	--	1	--	<5	--	<3
	[1]09-27-88	<.5	--	--	--	<1	--	<5	--	3
	[1]11-30-88	<.5	--	--	--	<1	--	<5	--	<3
	[1]03-02-89	<.5	--	--	--	<1	--	<5	--	<3
	[1]05-04-89	<.5	--	--	--	<1	--	<5	--	<3
	[1]09-14-89	<.5	--	--	--	<1	--	<5	--	2
	[1]11-07-89	<.5	--	--	--	1	--	<5	--	2
	10-26-93	<.5	<1	16	<20	<1	<1	<5	<5	<3
Big River downstream	[3]03-18-80	--	--	--	--	3	--	--	--	--
	[1]11-07-89	<.5	--	--	--	<1	--	<5	--	1
	10-26-93	<.5	<1	23	<20	1	<1	<5	<5	<3
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	.1	.1	--	--	--
	04-26-90	<.5	--	100	--	<1	--	<5	--	<3
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	.3	.3	--	--	--
	[3]03-18-80	--	--	--	--	4	--	--	--	--
	[1]02-24-88	<.5	--	--	--	1	--	<5	--	62
	[1]05-17-88	<.5	--	--	--	1	--	<5	--	61
	[1]09-27-88	<.5	--	--	--	3	--	<5	--	16
	[2]11-01-88	--	--	--	--	4	--	<5	--	--
	[1]12-01-88	<.5	--	--	--	2	--	<5	--	88
	[1]03-02-89	<.5	--	--	--	<1	--	<5	--	22
	[1]05-04-89	<.5	--	--	--	<1	--	<5	--	<3
	[1]09-14-89	<.5	--	--	--	1	--	<5	--	6
Southwest Creek	04-26-90	<.5	--	30	--	<1	--	<5	--	<3

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Co_t	Cu	Cu_t	Fe	Fe_t	Fe^{3+}	Pb	Pb_t	Li
Elvins tailings pile seep	[1]02-23-88	--	<10	--	9	--	--	30	--	17
	[1]09-26-88	--	<10	--	10	--	--	70	--	19
	[1]11-30-88	--	<10	--	7	--	--	70	--	21
	[1]03-02-89	--	<30	--	60	--	--	80	--	<12
	[1]05-03-89	--	<10	--	5	--	--	30	--	10
	[1]09-14-89	--	10	--	5	--	--	67	--	14
	03-31-93	--	--	--	--	--	--	--	--	--
	03-31-93	360	<10	--	5	1,200	--	80	560	4
	06-24-93	550	<10	10	12	420	--	70	230	10
Seep G	[2]03-18-80	--	--	--	8	85	--	38	52	--
	[3]03-18-80	--	--	--	--	--	--	48	--	--
	[2]11-01-88	--	--	--	3,500	--	--	80	--	--
	[1]11-06-89	--	<20	--	1,500	--	200	23	--	34
	04-26-90	--	<10	--	25	--	20	<10	--	12
	06-07-90	--	<10	--	10	--	--	60	--	13
	06-07-90	--	<10	--	9	--	--	<10	--	13
Seep H	04-26-90	--	<10	--	250	--	120	20	--	23
	06-07-90	--	<10	--	9	--	--	170	--	44
Seep K	[1]11-07-89	--	<1	--	91	--	--	<1	--	15
	04-26-90	--	<10	--	7	--	40	<10	--	15
	06-07-90	--	<10	--	6,100	--	5,200	<10	--	19
Seep 10+07	06-07-90	--	<10	--	<3	--	--	<10	--	13
	03-31-93	--	<1	--	29	--	--	<1	--	<4
	06-24-93	--	<10	--	9	--	--	<10	--	4
	10-30-93	--	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Co_t	Cu	Cu_t	Fe	Fe_t	Fe^{3+}	Pb	Pb_t	Li
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	43	--	--
	[1]02-24-88	--	<10	--	<3	--	--	10	--	<4
	[1]05-17-88	--	<10	--	<3	--	--	<10	--	6
	[1]09-27-88	--	<10	--	10	--	--	20	--	7
	[1]11-30-88	--	<10	--	8	--	--	10	--	<4
	[1]03-02-89	--	<10	--	5	--	--	<10	--	<4
	[1]05-04-89	--	<10	--	8	--	--	<10	--	4
	[1]09-14-89	--	<10	--	8	--	--	2	--	5
	[1]11-07-89	--	<10	--	4	--	--	2	--	5
	10-26-93	<3	<10	<10	24	170	--	<10	27	<4
Big River downstream	[3]03-18-80	--	--	--	--	--	--	30	--	--
	[1]11-07-89	--	<10	--	5	--	--	4	--	6
	10-26-93	<3	<10	<10	22	130	--	<10	16	<4
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	--	--	--
	04-26-90	--	<10	--	9	--	--	<10	--	7
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	40	679	--	13	15	--
	[3]03-18-80	--	--	--	--	--	--	36	--	--
	[1]02-24-88	--	<10	--	8	--	--	10	--	10
	[1]05-17-88	--	<10	--	5	--	--	<10	--	17
	[1]09-27-88	--	<10	--	10	--	--	10	--	16
	[2]11-01-88	--	--	--	20	--	--	100	--	--
	[1]12-01-88	--	<10	--	9	--	--	20	--	14
	[1]03-02-89	--	<10	--	4	--	--	<10	--	6
	[1]05-04-89	--	<10	--	4	--	--	<10	--	12
	[1]09-14-89	--	<10	--	9	--	--	18	--	6
Southwest Creek	04-26-90	--	<10	--	17	--	--	<10	--	<4

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se	Se_t
Elvins tailings pile seep	[1]02-23-88	45	--	--	--	<10	510	--	--	--
	[1]09-26-88	2	--	--	--	<10	640	--	--	--
	[1]11-30-88	5	--	--	--	<10	570	--	--	--
	[1]03-02-89	8	--	--	--	<30	430	--	--	--
	[1]05-03-89	1	--	--	--	<10	270	--	--	--
	[1]09-14-89	<1	--	--	--	10	350	--	--	--
	03-31-93	--	--	--	--	--	--	--	--	--
	03-31-93	2	170	--	<0.1	<10	370	400	--	<1
	06-24-93	3	59	--	<.1	<10	510	500	--	<1
Seep G	[2]03-18-80	--	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[2]11-01-88	5,600	--	<0.5	--	--	--	--	<5	--
	[1]11-06-89	5,300	--	--	--	<20	680	--	--	--
	04-26-90	1,500	--	--	--	10	70	--	<1	--
	06-07-90	65	--	--	--	<10	30	--	--	--
	06-07-90	890	--	--	--	<10	40	--	<1	--
Seep H	04-26-90	2,600	--	.2	--	<10	380	--	<1	--
	06-07-90	780	--	--	--	<10	440	--	<1	--
Seep K	[1]11-07-89	570	--	--	--	<1	33	--	<1	--
	04-26-90	520	--	.1	--	<10	30	--	<1	--
	06-07-90	1,300	--	--	--	<10	20	--	<1	--
Seep 10+07	06-07-90	510	--	--	--	<10	10	--	<1	--
	03-31-93	170	--	--	--	<10	2	--	--	--
	06-24-93	79	--	--	--	<10	10	--	--	--
	10-30-93	--	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Mn	Mn_t	Hg	Hg_t	Mo	Ni	Ni_t	Se	Se_t
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[1]02-24-88	27	--	--	--	<10	<10	--	--	--
	[1]05-17-88	92	--	--	--	<10	<10	--	--	--
	[1]09-27-88	49	--	--	--	<10	<10	--	--	--
	[1]11-30-88	24	--	--	--	<10	<10	--	--	--
	[1]03-02-89	34	--	--	--	<10	<10	--	--	--
	[1]05-04-89	54	--	--	--	<10	10	--	--	--
	[1]09-14-89	73	--	--	--	10	10	--	--	--
	[1]11-07-89	60	--	--	--	<10	<10	--	--	--
	10-26-93	41	61	--	<0.10	<10	<10	<10	--	<1
Big River downstream	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[1]11-07-89	43	--	--	--	<10	<10	--	--	--
	10-26-93	40	46	--	<.10	<10	<10	<10	--	<1
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	--	--	--
	04-26-90	290	--	--	--	<10	<10	--	<1	--
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	--	--	--	--	--
	[3]03-18-80	--	--	--	--	--	--	--	--	--
	[1]02-24-88	520	--	--	--	<10	20	--	--	--
	[1]05-17-88	430	--	--	--	<10	40	--	--	--
	[1]09-27-88	42	--	--	--	<10	40	--	--	--
	[2]11-01-88	<20	--	<0.5	--	--	--	--	<5	--
	[1]12-01-88	460	--	--	--	<10	60	--	--	--
	[1]03-02-89	150	--	--	--	<10	30	--	--	--
	[1]05-04-89	25	--	--	--	<10	20	--	--	--
	[1]09-14-89	67	--	--	--	<10	20	--	--	--
Southwest Creek	04-26-90	7	--	--	--	<10	10	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t
Elvins tailings pile seep	[1]02-23-88	<1	--	130	--	<6	--	11,000	--
	[1]09-26-88	<1	--	[4]1,400	--	<6	--	18,000	--
	[1]11-30-88	2	--	140	--	<6	--	17,000	--
	[1]03-02-89	<3	--	110	--	<18	--	16,000	--
	[1]05-03-89	<1	--	70	--	<6	--	11,000	--
	[1]09-14-89	1	--	120	--	<6	--	15,000	--
	03-31-93	--	--	--	--	--	--	--	--
	03-31-93	<1	1	94	<1	<6	<1	15,000	18,400
	06-24-93	<1	<1	83	<1	<1	<1	15,000	16,100
Seep G	[2]03-18-80	--	--	--	--	--	--	3.4	--
	[3]03-18-80	--	--	--	--	--	--	548	--
	[2]11-01-88	7	--	--	--	--	--	12,000	--
	[1]11-06-89	<2	--	280	--	<12	--	19,000	--
	04-26-90	<1	--	110	--	<6	--	1,200	--
	06-07-90	<1	--	70	--	<6	--	1,600	--
	06-07-90	<1	--	72	--	<6	--	650	--
Seep H	04-26-90	<1	--	220	--	<6	--	9,700	--
	06-07-90	<1	--	230	--	<6	--	12,000	--
Seep K	[1]11-07-89	1	--	220	--	<1	--	67	--
	04-26-90	<1	--	210	--	<6	--	390	--
	06-07-90	<1	--	210	--	<6	--	220	--
Seep 10+07	06-07-90	<1	--	93	--	<6	--	740	--
	03-31-93	<1	--	150	--	<6	--	7	--
	06-24-93	<1	--	140	--	<1	--	17	--
	10-30-93	--	--	--	--	--	--	--	--

Table 13. Physical properties and concentrations of inorganic constituents in samples from seeps and surface water in the vicinity of the St. Francois County Landfill site, Missouri—Continued

Site (figs. 1 and 5)	Date	Ag	Ag_t	Sr	Tl	V	V_t	Zn	Zn_t
Big River at Bone-hole	[3]03-18-80	--	--	--	--	--	--	23	--
	[1]02-24-88	<1	--	34	--	<6	--	120	--
	[1]05-17-88	<1	--	60	--	<6	--	98	--
	[1]09-27-88	1	--	47	--	<6	--	83	--
	[1]11-30-88	2	--	34	--	<6	--	51	--
	[1]03-02-89	<1	--	41	--	<6	--	55	--
	[1]05-04-89	<1	--	46	--	<6	--	69	--
	[1]09-14-89	<1	--	66	--	<6	--	95	--
	[1]11-07-89	<1	--	62	--	<6	--	100	--
	10-26-93	<1	<1	52	<1	<6	<1	60	80
Big River downstream	[3]03-18-80	--	--	--	--	--	--	50	--
	[1]11-07-89	<1	--	62	--	<6	--	150	--
	10-26-93	<1	<1	53	<1	<6	<1	93	100
Mine-A-Joe Creek upstream	[2]03-18-80	--	--	--	--	--	--	9	16
	04-26-90	1	--	100	--	<6	--	63	--
Mine-A-Joe Creek downstream	[2]03-18-80	--	--	--	--	--	--	72	89
	[3]03-18-80	--	--	--	--	--	--	80	--
	[1]02-24-88	<1	--	110	--	<6	--	250	--
	[1]05-17-88	<1	--	[4]190	--	<6	--	250	--
	[1]09-27-88	<1	--	160	--	<6	--	420	--
	[2]11-01-88	--	--	--	--	--	--	390	--
	[1]12-01-88	2	--	140	--	<6	--	740	--
	[1]03-02-89	<1	--	130	--	<6	--	420	--
	[1]05-04-89	<1	--	170	--	<6	--	220	--
	[1]09-14-89	2	--	75	--	<6	--	120	--
Southwest Creek	04-26-90	<1	--	44	--	<6	--	24	--

[1] Smith and Schumacher (1991).
[2] Data from Missouri Department of Natural Resources, Division of Environmental Quality (written commun., 1980, 1988).
[3] Data from Missouri Department of Natural Resources, Division of Geology and Land Survey (written commun., 1980).
[4] Questionable value.