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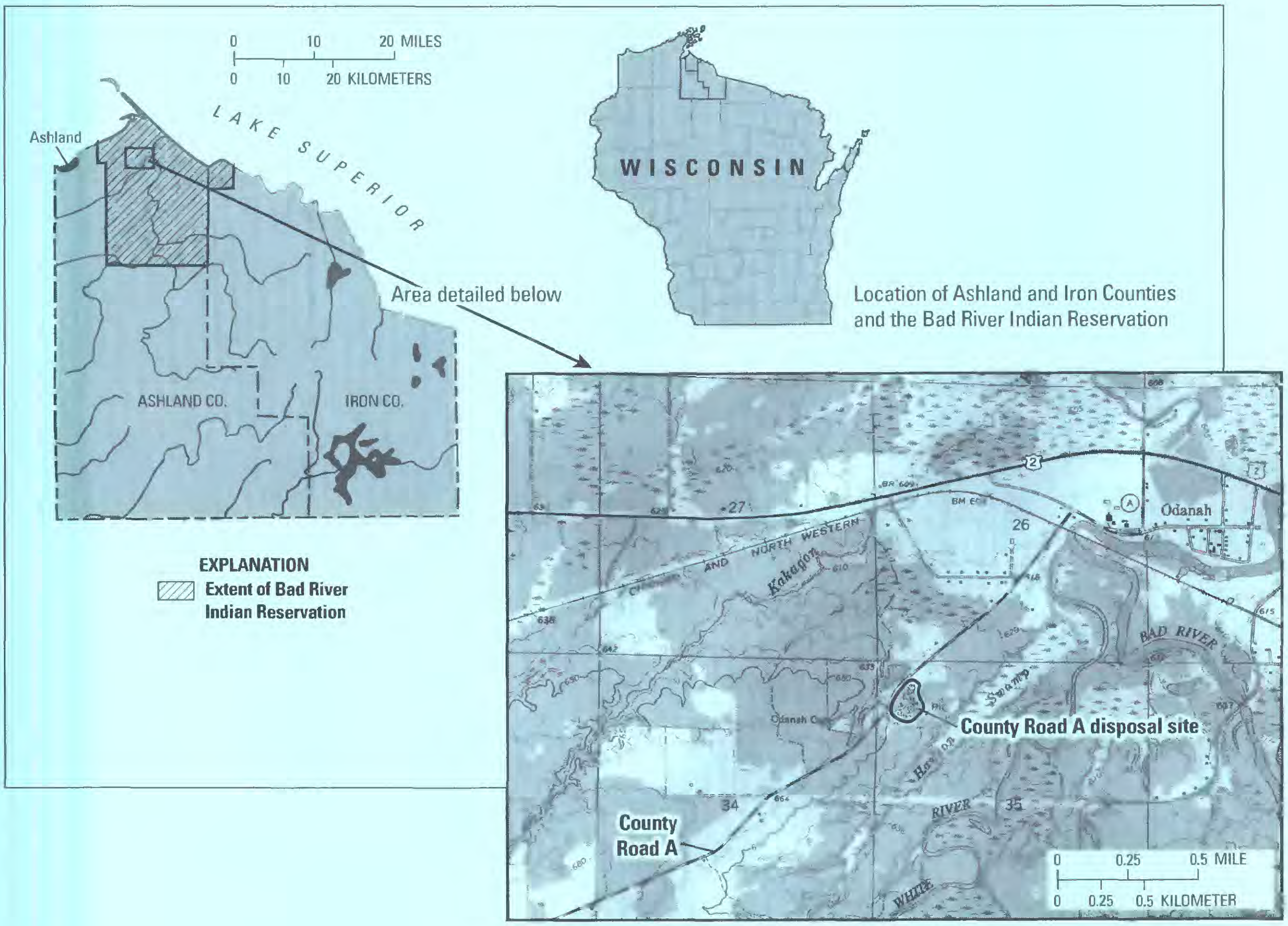
Hydrogeology and Ground-Water Quality of the County Road A Disposal Site on the Bad River Indian Reservation, Ashland County, Wisconsin: 1997–98

Water-Resources Investigations Report 01–4082



Location of Ashland and Iron Counties and the Bad River Indian Reservation

Prepared in cooperation with the
U.S. Environmental Protection Agency, Region 5 and
The Bad River Band of Lake Superior Tribe of Chippewa Indians

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Hydrogeology and Ground-Water Quality of the County Road A Disposal Site on the Bad River Indian Reservation, Ashland County, Wisconsin: 1997–98

By C.P. Dunning (U.S. Geological Survey) and D.J. Yeskis (U.S. Environmental Protection Agency)

U.S. GEOLOGICAL SURVEY
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Middleton, Wisconsin
2001

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
	Length	
inch (in)	25.4	millimeter
foot (ft)	.3048	meter
mile (mi)	1.609	kilometer
	Hydraulic Conductivity*	
feet per day (ft/d)	0.3048	meters per day

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by use of the following equation:
°F = 1.8 (°C) + 32.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)— geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

***Hydraulic conductivity:** The standard unit for hydraulic conductivity is cubic foot per day per square foot of aquifer cross-sectional area (ft^3/d)/ ft^2. In this report, the mathematically reduced form, feet per day (ft/d), is used for convenience.

Hydraulic gradient: Hydraulic gradient is given in feet per foot; the difference in measured hydraulic head at two points divided by the distance (vertical or horizontal) between the points of measurement.

Abbreviated water-quality units used in this report: Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Oxidation-reduction potential (ORP) is given in millivolts (mV).

Dissolved oxygen (DO) is given in milligrams per liter (mg/L).

Turbidity is given in nephalometric turbidity units.

Other Abbreviations Used in this Report:

ml/min	milliliters per minute

Hydrogeology and Ground-Water Quality of the County Road A Disposal Site on the Bad River Indian Reservation, Ashland County, Wisconsin: 1997–98

By C.P. Dunning *and* D.J. Yeskis

Abstract

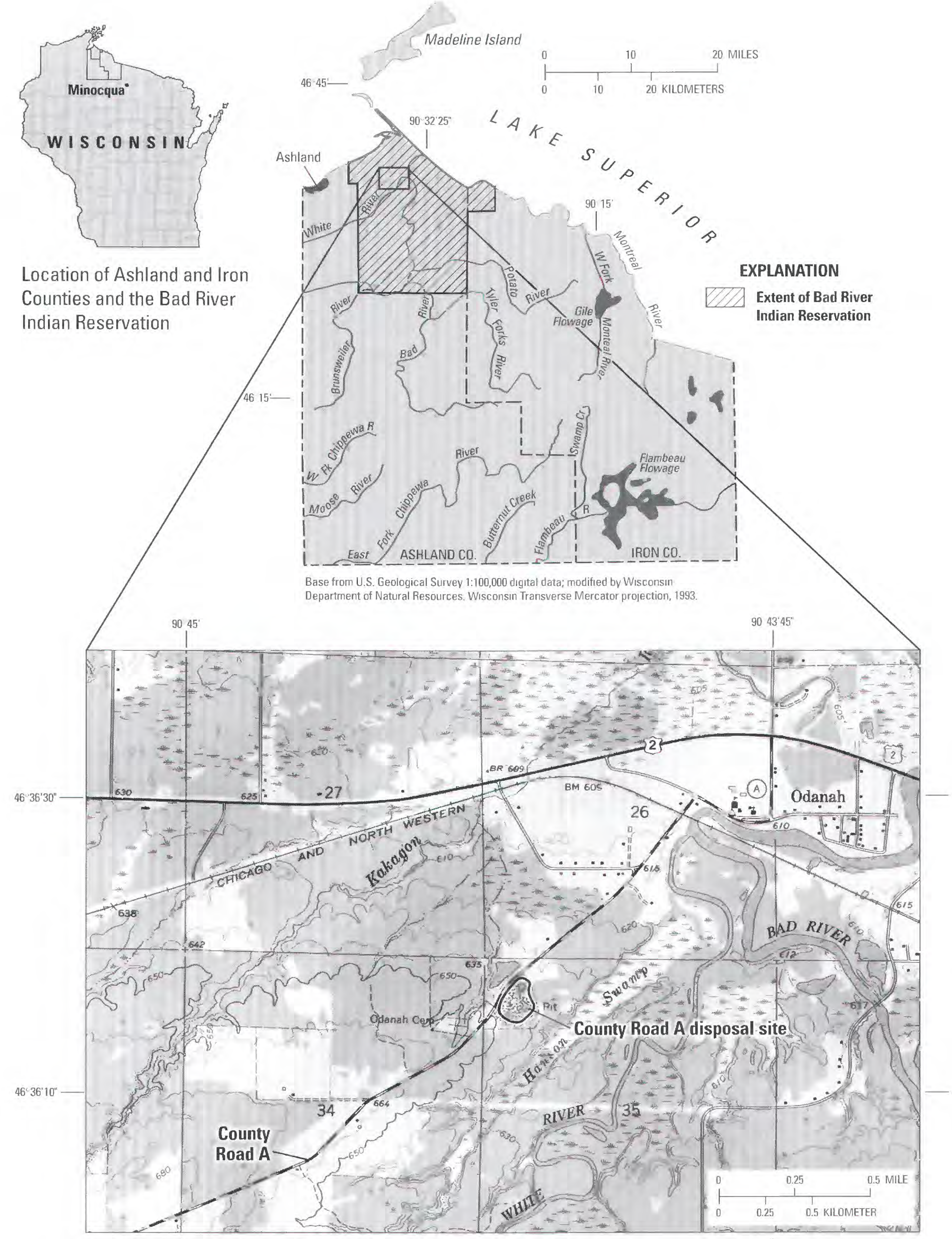
The County Road A disposal site, located on the Bad River Indian Reservation, Ashland County, Wisconsin, contains papermill sludge generated by a former mill in the City of Ashland. Since the time of disposal (1968–1970) the site has been the subject of investigations by the U.S. Bureau of Indian Affairs, the U.S. Environmental Protection Agency, and private consultants. During 1997–1998, an investigation was conducted by the U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency and the Natural Resources Department of the Bad River Indian Tribe, to evaluate the hydrogeology and ground-water quality of the disposal site, particularly with respect to the hydraulic connection between two ponds at the site and the shallow ground-water-flow system. Additional monitoring wells and well points were installed, and additional hydrogeologic, ground-water quality, and geophysical data were collected. The data from this and previous studies were integrated and interpreted.

Data collected during this investigation indicate the ponds are hydraulically connected to the shallow ground-water system. Pond stage and meteorological data collected from May 6 through August 18, 1998 indicate evaporation and seepage from Pond A, the southernmost pond, to ground water accounted for the measured declines in pond stage. Seepage was estimated to be from 0.008–0.012 feet per day over the area of Pond A. Increases in the stage of Pond A following precipitation events resulted in increases in the hydraulic head in pond sediments as measured in well point WP-2 in the southwestern area of the pond. Hydraulic gradients were consistently downward across the pond sediments, ranging from 0.24 to 0.38 feet per foot. Although the estimated vertical hydraulic conductivity of the pond sediments is low (0.021–0.050 feet per day), limited flow occurs through the pond sediments. A complex hydraulic connection between Pond A and the shallow sediments was defined by changes in water levels in well points in and adjacent to the pond. Neutron logs indicated that the sediments under Pond A were saturated.

The hydraulic connection between the ponds and the shallow ground-water system is supported by water-quality data. Inorganic and organic constituents of the papermill sludge have been detected in water-quality samples collected from on-site monitoring wells. Concentrations of acetone, aluminum, antimony, 2-butanone, lead, sodium, and possibly cobalt exceeded background concentrations for this site. Concentrations of inorganic constituents, with the exception of potassium and zinc, were considerably lower in samples from local residential wells than those from monitoring wells. Elevated concentrations of potassium and zinc, however, are consistent with concentrations measured previously in other wells and springs on the Bad River Indian Reservation. None of the organic compounds identified in the papermill sludge have been detected in water sampled from the residential wells.

INTRODUCTION

The Bad River Indian Reservation is located in Ashland and Iron Counties, Wisconsin (fig. 1). The County Road A disposal site is located within the reservation, about 1 mi southwest of the intersection of U.S. Highway 2 and Ashland County Road A. The site is bordered by forest, with the nearest private residence



Base from U.S. Geological Survey 1:100,000 digital data; modified by Wisconsin Department of Natural Resources. Wisconsin Transverse Mercator projection, 1993.

Base from U.S. Geological Survey 1:24,000, Odanah, Wisconsin, 1975; detailed area shown above: T 48N, R 3E.

Figure 1. Location of the Bad River Indian Reservation and County Road A disposal site in Ashland County, Wisconsin

located approximately 500 ft to the north across County Road A. To the south and east is Hanson Swamp, which drains into the White River northeast of the site. The site covers approximately four acres and contains two ponds, designated Pond A (the southern pond) and Pond B (the northern pond). The property is owned by Ashland County.

The site was used as a source for roadbed material (borrow pit) for the construction of U.S. Highway 2. Subsequently, during the years 1968 to 1970 the site was used for the disposal of papermill sludge generated at a former mill in the City of Ashland (Geraghty & Miller, Inc., 1996a). Since the time of disposal the site has been the subject of investigations by the U.S. Bureau of Indian Affairs (USBIA), the U.S. Environmental Protection Agency (USEPA) and private consultants. During a Phase I screening investigation completed by Geraghty & Miller, Inc., analysis of water samples from the ponds indicated the presence of two volatile organic compounds (VOC), one semivolatile organic compound (SVOC), and several dioxins/furans (Geraghty & Miller, Inc., 1996a). During 1997 and 1998, the U.S. Geological Survey (USGS), in cooperation with USEPA Region 5 and the Bad River Natural Resources Department (BRNRD), conducted an investigation of the hydrogeology and ground-water quality of the site. A primary objective of this investigation was to assess the potential for migration of water from the ponds on the County Road A disposal site to the shallow ground-water-flow system.

Purpose and Scope

This report presents and interprets hydrogeologic and water-quality data collected by the USGS and the USEPA in support of this investigation. Included in this report is information on wells installed for the investigation, geophysical logs, ground-water and surface-water levels, estimates of horizontal hydraulic conductivity of the shallow aquifer, a water budget for Pond A, and an estimate of the vertical hydraulic conductivity of Pond A sediments. Ground-water-flow directions and possible contaminant-migration pathways, particularly with respect to Pond A, are presented.

Hydrogeologic Setting

The general geologic setting of the northern part of the Bad River Indian Reservation is that of bedrock overlain by glacial and post-glacial deposits (fig. 2). The Precambrian Oronto and Cambrian Bayfield Groups compose the upper bedrock (Mudrey and others, 1982). The Oronto Group is composed of feldspathic sandstone, siltstone, shale and conglomerate. The younger Bayfield Group is composed of feldspathic quartzose sandstone with some orthoquartzitic sandstone (Mudrey and others, 1982). The Bayfield Group sandstones are believed to be present only in the far northwestern part of the reservation (Batten and Lidwin, 1995) and absent at the site.

The northern part of the reservation is within the Superior Lowland of the Lake Superior Physiographic Region (fig. 3) (Clayton, 1984). This region was glaciated many times during the Pleistocene Epoch, though evidence is abundant only for the last part of the Wisconsin glaciation, which began about 20,000 years before present. During this glaciation, the Superior and Chippewa Lobes advanced over the region.

At the site, glacial deposits include the Copper Falls Formation and the stratigraphically younger Miller Creek Formation (fig. 2). All monitoring wells at the site are open to varying intervals in the upper 50 ft of the Miller Creek Formation. Post-glacial deposits include stream and organic deposits of Holocene age.

The topography at and around the site is described as Lake-Modified Glacial Topography (Clayton, 1984). The topography is subdued as the result of wave action, or as the result of sediments deposited in waterlogged conditions during high stages of Lake Superior. The topography is characterized by low relief with hummocky, collapsed features; however, drumlins are present in some areas.

The principal water-supply aquifers in the northern part of the reservation are the Precambrian sandstone and the overlying sand and gravel deposits of the Copper Falls Formation. The lower portion of the Miller Creek Formation is composed of a massive red clay (Batten and Lidwin, 1995), which may act as a confining or semi-confining unit between the aquifer of the Copper Falls Formation from the upper part of the Miller Creek Formation. The extent and character of the clay portion of the Miller Creek Formation at the site were not evaluated during this investigation. The upper part of the Miller Creek Formation, in which the site monitoring wells are screened, is composed of

Geologic time interval	Years before present	Stratigraphic unit	Lithology
Quaternary Period	0 10,000	(Holocene) sediments	Soil and alluvial deposits
	10,000 11,000	(Pleistocene) Miller Creek Formation	Interbedded sand, silt, and clay Lower massive red clay
	11,000 20,000	(Pleistocene) Copper Falls Formation	Sandy till, sand and gravel
Middle to Late Proterozoic Era	600 million 1,000 million	Bayfield Group	Feldspathic quartzose sandstone
	1,000 million 1,150 million	Oronto Group	Feldspathic sandstone, siltstone, shale, and conglomerate

Figure 2. Stratigraphic section for the northern Bad River Indian Reservation, Ashland County, Wisconsin (modified from Mudrey and others, 1982).

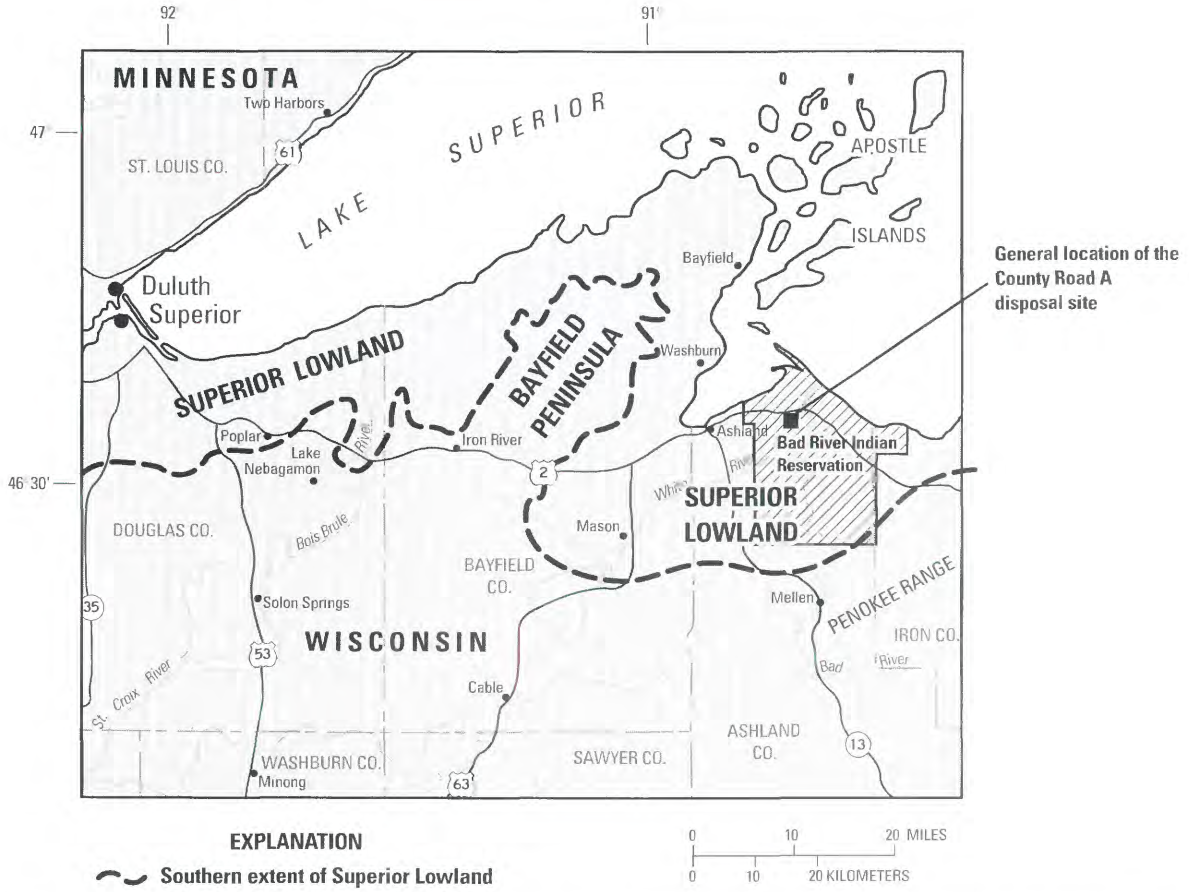


Figure 3. Location of the Superior Lowland of the Lake Superior Region, northern Wisconsin (modified from Clayton, 1984).

interbedded sand, silt and clay and is overlain by soil (Geraghty & Miller, Inc., 1996a).

The shallow ground-water-flow system at the site is presumed to be controlled largely by topography and local variations in sediment lithology. On the basis of topography, flow is generally from local topographic highs west and northwest of the site to Hanson Swamp to the southeast, and eventually to the White River (fig.1).

Previous Work

Waste-characterization, water-quality, and hydrogeologic investigations have been conducted in and around the County Road A site since 1990. The USBIA, with field support from the USGS, conducted an investigation of the site from 1990 to 1992 (U.S. Bureau of Indian Affairs, 1992). During 1994, 3 Bears Environmental Services sampled surface-water sites and selected water-supply wells for water-quality analysis (3 Bears Environmental Services, 1994). From 1994 through 1995, the USEPA and their contractors sampled water-supply wells, soil, pond sediment, sludge and surface water. A Phase I screening investigation was completed by Geraghty & Miller, Inc. (now known as Arcadis-Geraghty & Miller, Inc. [A-G&M]) on behalf of MRC Holdings, Inc., the owners of the assets and liabilities of the former mill (Geraghty & Miller, Inc, 1996a, 1996b, 1997).

As part of the A-G&M site activities from August 1995 to January 1996, monitoring wells were installed, and soil borings, surface soil samples, sludge samples, and Geoprobe samples were taken. Monitoring wells were installed at five locations in and near the site. A-G&M established a naming convention for monitoring wells that begins with the acronym CAMW (County Road A Monitoring Well). The acronym is followed by a hyphen and the number of the site location, 1 through 5. Following the number of the site location is a suffix "A" or "B". The "A" suffix identifies wells screened across the water table, generally 10 to 15 ft below ground level. The "B" suffix identifies wells screened 15 to 20 ft below the water table. The locations of monitoring wells installed by A-G&M—CAMW-1A, -1B, -2A, -2B, -3A, -3B, -4A, -4B and -5A—are shown on figure 4. Construction details for all wells on site are provided in table 1. Monitoring wells CAMW-1A, -1B, and -5A are located generally upgradient of the ponds and sludge deposits, and therefore assumed to best represent background conditions at the site.

Information collected from monitoring well construction, soil borings, surface soil samples, and Geoprobe samples was used to characterize the subsurface geology and sludge thickness (Geraghty & Miller, Inc., 1996a). A-G&M interpreted data collected during their investigation as indicating shallow ground-water flow generally from west to east across the site. The conceptual model developed by A-G&M suggested no hydraulic connection between the ponds and the ground-water-flow system (Geraghty & Miller, Inc., 1996a).

As a part of A-G&M site activities, papermill-sludge samples and surface-water samples were collected from the site for chemical analysis (Geraghty & Miller, Inc., 1996a). Analytical results from that study are presented in appendix A. The sludge was heterogeneous with a wide variation in concentrations of VOC's, SVOC's, metals, and dioxins/furans. Analysis of water samples from the ponds indicated the presence of two VOC's (4-methyl-2-pentanone and acetone), one SVOC (bis(2-ethylhexyl) phthalate) and several dioxins/furans (2,3,7,8-Tetrachlorodibenzofuran [TCDF (total)], Hexachlorodibenzo-p-dioxin [HpCDD (total)], 1,2,3,4,6,7,8-HpCDD, and 1,2,3,4,6,7,8,9-Octachlorodibenzodioxin [OCDD]).

Acknowledgments

The authors would like to acknowledge the contributions of the following people and organizations. Tracey Ledder, Matthew Eitrem, and Ann Barnes of the BRNRD assisted with planning the field investigation, and devoted significant time to field activities. Beth Reiner, Laura Evans, and Arunas Draugalis of USEPA Region 5 provided project management and assisted with field activities. James Rauman, Ty Sabin, John DeWild, James Krohelski, Frederick Paillet, Richard Hodges, and Barbara Corland of the USGS assisted with monitoring-well construction and a wide variety of sampling activities and geophysical logging. Kevin Daleness and Bruce Evans of Arcadis-Geraghty & Miller, Inc. assisted with many field activities.

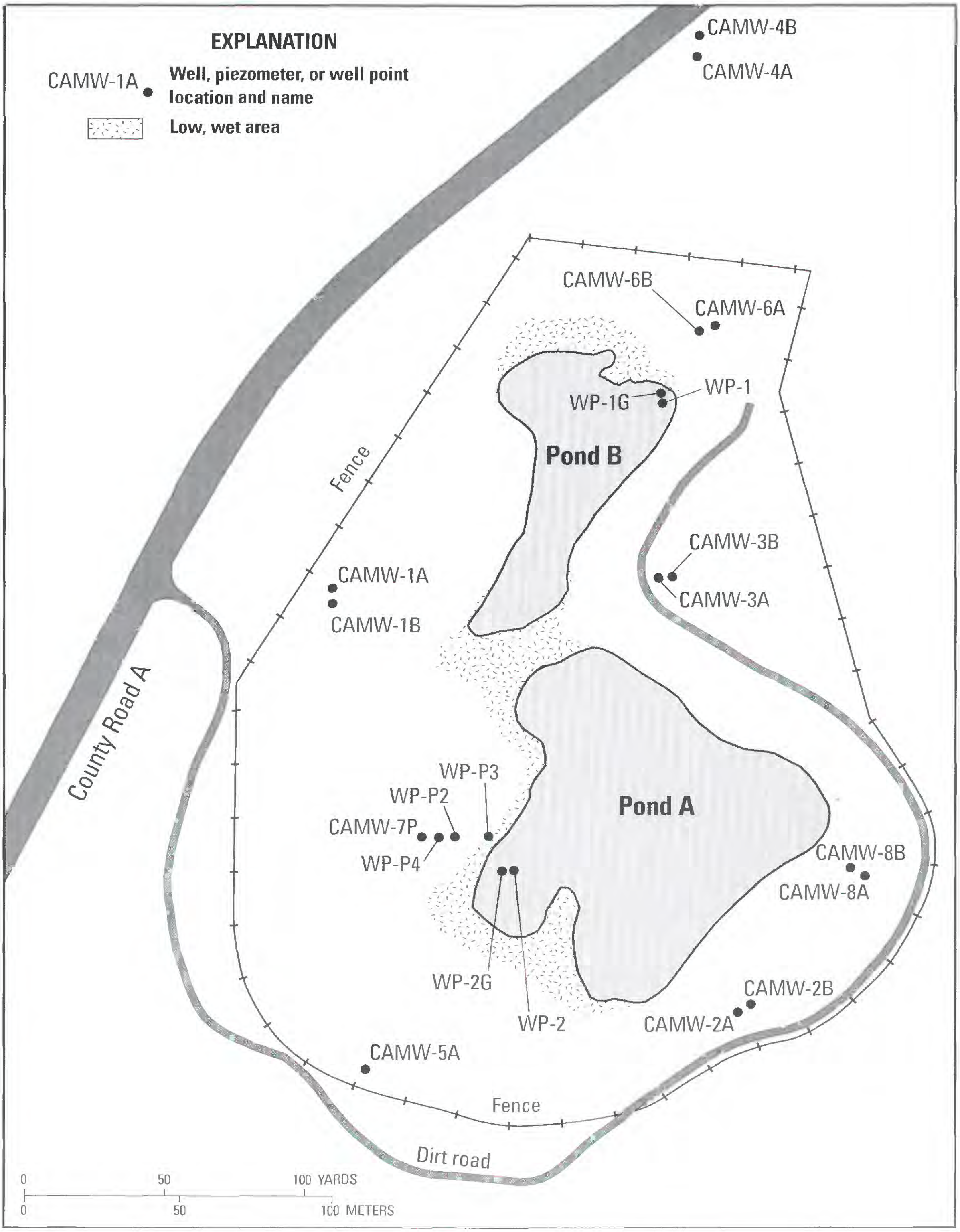


Figure 4. Locations of monitoring wells and well points at the County Road A disposal site, Ashland County, Wisconsin (base map modified from Geraghty & Miller, Inc., 1996a).

Table 1. Description of monitoring wells and well-points at the County Road A disposal site, Ashland County, Wisconsin

[–, not yet decommissioned; nd, not determined; na, not applicable; Construction type: WT, water table; BWT, below water table; DWP, driven well point]

Monitoring well or well-point designation	Construction type	Installation date	Decommission date	Land-surface altitude, in feet above sea level	Measuring-point altitude, in feet above sea level	Bottom of hole, in feet above sea level	Packed or screened interval, in feet below land surface
CAMW-1A	WT	12-06-95	–	645.1	647.32	621.6	11.0–23.5
CAMW-1B	BWT	12-05-95	–	645.1	647.47	599.6	38.0–45.5
CAMW-2A	WT	12-01-95	–	640.8	642.77	621.3	8.0–19.5
CAMW-2B	BWT	11-30-95	–	640.8	642.66	598.3	36.0–42.5
CAMW-3A	WT	11-30-95	–	640.9	643.32	621.4	8.0–19.5
CAMW-3B	BWT	11-29-95	–	640.9	643.57	598.4	35.0–42.5
CAMW-4A	WT	11-28-95	–	635.8	638.12	619.3	5.5–16.5
CAMW-4B	BWT	11-28-95	–	635.8	638.09	598.0	31.0–38.5
CAMW-5A	WT	12-05-95	–	645.1	647.45	621.6	11.0–23.5
CAMW-6A	WT	10-17-97	–	638.0	640.63	620.1	7.0–17.9
CAMW-6B	BWT	10-16-97	–	637.3	640.80	605.3	20.0–32.0
CAMW-7P	DWP	05-01-98	–	632.9	637.20	628.4	1.0–3.0
CAMW-8A	WT	10-16-97	–	641.6	644.56	619.1	10.7–22.5
CAMW-8B	BWT	10-15-97	–	641.0	644.32	596.4	38.6–44.6
WP-1	DWP	04-28-98	08-20-98	nd	635.39	628.6	629.1–630.1 [a]
WP-1G	DWP	08-18-98	08-20-98	nd	636.70	625.6	na
WP-2	DWP	04-28-98	08-20-98	nd	637.54	630.7	631.3–632.3 [a]
WP-2G	DWP	08-19-98	08-20-98	nd	638.41	624.9	na
WP-P2	DWP	05-05-98	08-20-98	636.4	637.00	630.2	4.7–5.7
WP-P3	DWP	05-05-98	08-20-98	636.4	639.86	633.1	1.9–2.9
WP-P4	DWP	05-05-98	08-20-98	nd	636.88	630.1	630.6–631.6a [a]

[a] Where land-surface altitude has not been determined, screen interval is provided in feet above sea level.

METHODS OF DATA COLLECTION AND ANALYSIS

During the course of this investigation, a variety of hydrogeologic data were collected to assess the potential for migration of water from ponds at the County Road A disposal site to the shallow ground-water-flow system.

Well Siting and Installation

In October 1997, the USGS installed a water-table monitoring well and a deep monitoring well at each of two locations within the County Road A site. The monitoring wells were sited and constructed to provide additional information about the local hydrogeology, and to provide sampling locations for water-quality analyses directly downgradient from the site ponds and known sludge-disposal areas. The USGS continued the naming convention established by A-G&M for the earlier installed wells. The locations of the new monitoring wells, CAMW-6A, -6B, -8A, and -8B, are shown in figure 4. The wells were drilled using 4-1/4-inch inside diameter (ID) hollow-stem augers. The wells were constructed with flush-threaded, 2-inch polyvinyl chloride (PVC) risers and wire-wound screens. Monitoring well construction reports for these wells are included in appendix B. Because of site conditions, monitoring well CAMW-6B was installed with a 10-foot screen, rather than the intended 5-foot screen. Approximately one week before water-quality sampling began, the wells were developed by vigorously surging with Teflon bailers.

Six well points were installed during a site visit from April 27 to May 6, 1998. One permanent well point, CAMW-7P, was installed, along with five temporary well points. The temporary well points include WP-1 and WP-2 installed in Ponds B and A, respectively, and WP-P2, WP-P3 and WP-P4 installed on land between WP-2 and CAMW-7P (fig. 4). All well points except CAMW-7P were constructed with a 1-foot length of 2-inch-diameter stainless steel screen with a pointed metal drive-tip, and a 2-inch-diameter, 5-ft long, stainless steel riser pipe. CAMW-7P has identical construction except for a 2-foot length of screen. Installation involved hand-augering a hole as deep as practical (generally 1–2 ft below top of soil saturation) and then driving the point with a sledge hammer to the desired depth. The location for well point CAMW-7P was chosen to monitor a sludge pile on the west side of Pond A. CAMW-7P was installed in a topographic depression where sludge was absent although the well was surrounded by the sludge pile. Temporary well points WP-1 and WP-2 were installed in the ponds to monitor stage and water levels in the pond sediments. Both were installed by placing the well point in a hole that had been hand-augered and driving the point to depth with a sledge hammer. Temporary well points WP-P2, WP-P3 and WP-P4 were installed near Pond A to evaluate changes in ground-water level as a function of distance from the pond to CAMW-7P. The monitoring well construction report for CAMW-7P is included in appendix B. No monitoring well construction reports were completed for the temporary well points, but a summary of their construction is included in table 1.

During a subsequent site visit from August 17 to 21, 1998, two additional temporary well points, WP-1G and WP-2G, were installed specifically for geophysical logging of the bottom sediments of Ponds B and A, respectively (fig. 4). Construction of these well points was the same as the others except no screens were used, only solid pipe (table 1). As a result, the completed well points allowed the neutron and natural-gamma tools to be run in air, rather than in water, across the pond bottom sediments. This was necessary for a meaningful evaluation of sediment saturation by the neutron tool.

Water Levels, Precipitation, and Evaporation

Water levels in monitoring wells and well-points were measured using an electric tape on 10 dates from December 18, 1995 through August 20, 1998. These measurements were made by A-G&M, USEPA/U.S. Geological Survey, or BRNRD. From May 6 through August 18, 1998, water levels were measured on a nearly continuous basis (60-minute intervals) in monitoring wells CAMW-1A, -1B, -7P, -8A and -8B, and well points WP-2, WP-P2, WP-P3 and WP-P4. These monitoring wells and well points were chosen because of their locations upgradient, or downgradient, or adjacent to Pond A so that the interaction between the pond and the shallow ground-water-flow system could be investigated. Water levels were measured with pressure transducers and recorded with data loggers. Nearly continuous measurement of stage in Pond A was conducted over the same period by hanging a transducer on the outside of well point WP-2.

A weather station was set up onsite to collect meteorological data concurrently with water-level data. Unfortunately, the station stopped collecting data after eight days, necessitating use of meteorological data from locations further from the site. Precipitation data were obtained from the University of Wisconsin experimental farm near Ashland, Wisconsin (fig. 1) for the period May 6, 1998 through August 18, 1998. Pond evaporation for this period was estimated using the method of Linsley and others (1982, equation 5–30), which was applied to unpublished meteorological data from the airport at Minocqua, Wisconsin (fig. 1) (Jim Krohelski, USGS, oral comm., 1999). These meteorological data are maintained by the North Temperate Lakes Long-Term Ecological Research (NTL-LTER) program. Because the farm near Ashland and the airport at Minocqua experience excess precipitation and average annual evaporation similar to the study site (Dunne and Leopold, 1978; Novitzki, 1982), these data are appropriate to use for this investigation.

Slug Tests

Slug tests (displacement/recovery tests) were performed during April 1998 on monitoring wells CAMW-4A, -4B, -6A, -8A and -8B. Slug tests are initiated by quickly lowering a solid cylinder below the water level in a well, causing water level to quickly rise. The recovery of the water to its static level with time is measured (falling-head test). Quick removal of the cylinder provides the opportunity to measure the recovery of the lowered water level to its static level (rising-head test). The change in water level in the well due to the slug and the recovery of water level to its static level were measured using a pressure transducer. Data were collected using a data logger.

Slug-test data were analyzed using the techniques of Bouwer and Rice (Bouwer and Rice, 1976; Bouwer, 1989) and Hvorslev (1951). These techniques were developed for use in unconfined aquifers and can be applied to wells that either fully or partially penetrate an aquifer. The following conditions are assumed in the application of the Bouwer and Rice and the Hvorslov techniques:

(1) Drawdown of the water table in the vicinity of the well during the test is negligible;

(2) Unsaturated flow above the water table can be ignored;

(3) Head losses as the water enters the well are negligible; and

(4) The hydraulic unit is homogeneous and isotropic.

These conditions are likely to be met or approximated at the site wells over the small volume of aquifer affected by the slug tests.

In the analysis of the slug-test data, the borehole radius was assumed to equal the diameter of the auger used in well construction. Because no site wells penetrated the entire shallow aquifer, its thickness is unknown. It is shown to be at least 100 ft thick, however, in the area around the site on the basis of residential well logs (U.S. Bureau of Indian Affairs, 1992). Although the greatest saturated thickness encountered in any of the tested wells was about 30 ft, a thickness of 35 ft was used for analysis of all the slug tests. To test the sensitivity of the slug test analysis to saturated thickness, a 100-ft thickness was also used, and resulted in very little change in estimated K_h values.

Some slug-test data did not show a logarithmic recovery in water level with time, complicating data analysis. These results were most likely influenced by well construction, including skin effects and filter packs (Bouwer, 1989). Where possible, these affected data were analyzed in accordance with the recommendations of Bouwer (1989) to obtain an estimate most representative of the horizontal hydraulic conductivity of the aquifer materials.

Geophysical Logs

Geophysical logs were run in monitoring wells CAMW-6B and -8B, and in temporary well points WP-1G and WP-2G, which were installed in bottom sediments of Pond B and A (fig. 4). Geophysical logging was conducted by the USGS Borehole Research Group, based in Lakewood, Colorado.

The first geophysical method used was natural-gamma logging. Natural-gamma logs record the relative amounts of naturally occurring gamma radiation in geologic materials. This radiation is primarily the composite result of the radioisotopes potassium-40, uranium-238, and thorium-232. Natural-gamma logs usually indicate the clay content of sediment or rock, which provides a useful tool for stratigraphic correlation. Several limitations are inherent with natural-gamma logs. The volume of aquifer sampled by the logging sonde is limited (usually 6 to 12 inches around the borehole) and will be reduced when run in a cased hole. In addition, differences in well construction may result in inconsistent measurements between wells (Keys, 1990).

Neutron logging was also performed. The neutron tool uses a radioactive source that emits radioactive particles that are absorbed by hydrogen atoms, the principal component of water. The greater the neutron count returning to the receiver pad on the probe, the fewer neutrons that were absorbed by hydrogen/water, indicating lower porosity and/or saturation of the aquifer. Generally, the neutron tool penetrates approximately the same distance into the aquifer (6 to 12 inches) as the natural-gamma tool (Keys, 1990).

Formation conductivity logs were run in CAMW- 6B and CAMW-8B to aid stratigraphic correlation. For example, clays generally exhibit greater conductance of electrical current than sands. Though open boreholes are preferred, conductivity logs can be run in non-conductive casing such as PVC. The volume of formation sampled by the logging sonde will be reduced when run in a cased hole, and differences in well construction may result in inconsistent measurements between wells.

Water-Quality Samples

During the site visit of April 28 through May 6, 1998, samples for water-quality analyses were collected from all monitoring wells. Analyses were conducted for a range of inorganic constituents, VOC's, SVOC's, and dioxins/furans. Samples were collected using methods described in the sampling and analysis plan for the site (U.S. Environmental Protection Agency and U.S. Geological Survey, 1998), which requires the purging of a well until field parameters stabilize.

Considering the glacial origin of the Miller Creek Formation, spatial variability (horizontal and vertical) of sediments within the shallow aquifer is to be expected. This variability may affect dissolved constituents in ground water and suspended materials being transported by ground water. For this site investigation, low-flow sampling techniques were used so that mobilization of fine materials was minimized.

The purging of wells and collection of water-quality samples were completed using a low-flow, positive-displacement Fultz pump that was lowered to a depth generally within the interval of the well screen. Wells were purged by pumping at a rate of 500 milliliters per minute (ml/min) or less. The field parameters measured include water temperature, turbidity, pH, dissolved oxygen (DO), specific electrical conductance (SEC), and oxidation-reduction potential (ORP). Field parameters were monitored during purging using a multi-parameter Hydrolab sonde. After these field parameters had stabilized according to the following criteria, a representative water sample could be taken: turbidity ±10 percent, pH ±0.1, DO ±10 percent, SEC ±3 percent, and ORP ±10 mV.

A bailer stuck in CAMW-6B prevented sufficient development of the well. Because this could bias concentrations of inorganic constituents, CAMW-6B was not sampled for inorganic constituents.

Monitoring well CAMW-7P could not be sampled using the low-flow sampling procedure because a restriction at the top of the well screen prevented the use of the sampling pump. Instead, a check-valve connected to Teflon tubing was used to purge the well and collect a sample. CAMW-7P had insufficient yield to allow for monitoring of field parameters, so water was evacuated from the well point and it was allowed to recharge prior to sampling. CAMW-7P also had insufficient recharge to allow for sampling of inorganic constituents or SVOC's; therefore, only VOC's were analyzed for this well point. The action of the check valve may result in increased turbulence in water in the well and during the transfer of water from the tubing into the bottles. Both of these situations may result in increased exposure of the water to the atmosphere, which would result in a negative bias in the VOC analysis.

Water-quality samples were submitted to a USEPA Contract Laboratory Program (CLP) laboratory for analysis of inorganic constituents, VOC's, SVOC's, polychlorinated biphenyls (PCB's), and pesticides. Water-quality samples analyzed by the CLP laboratories included field samples, duplicate samples, and method (pump) blanks. A shipping blank of VOC-free water was included for the VOC samples only. Analytical methods conform to criteria established by the USEPA, which are referenced in the sampling and analysis plan (U.S. Environmental Protection Agency and U.S. Geological Survey, 1998). Prior to the release of the data to the site investigators, the analytical results from the laboratory were reviewed to insure compliance with USEPA laboratory QA/QC requirements. As a part of this review, matrix spike sample results were reviewed to determine matrix effects. Field and laboratory blank samples were analyzed to determine if field and/or laboratory handling practices resulted in unintentional contamination of samples. Duplicate samples were analyzed to determine the precision and accuracy of analytical results. The data results were "flagged" with appropriate data qualifiers by laboratory and data reviewers prior to the release of the data to the site investigators, along with a narrative summarizing the analytical and review process.

Field parameters of the water in Ponds A and B also were measured. The Hydrolab sonde was submerged approximately one foot below the water surface and allowed to equilibrate. Data were collected at two locations within each pond.

Six nearby residential wells were sampled by tribal representatives during the same time period (April 28 through May 6, 1998) for the same water-quality parameters and constituents as the monitoring wells. To protect the privacy of the residents, the Bad River Tribe requested that these well locations be considered proprietary information. These wells are identified only as Res 1 through Res 6. Although exact locations of the residential wells are unknown, they are all reasonably close (within few miles or so) and probably represent background conditions. Aerators were removed from residential taps and pipes were flushed before sampling. Field parameters were measured with a Hydrolab. Samples were shipped to the same USEPA CLP laboratory as were samples from the monitoring wells. Dissolved-oxygen concentrations at these residential wells were determined by titration rather than using the Hydrolab.

Well CAMW-6A was re-sampled for VOC's in August 1998 to confirm analytical results from samples collected in May 1998. Well point CAMW-7P was to be re-sampled at this time but was dry. Four of the five residential wells were re-sampled for VOC's.

HYDROGEOLOGY OF THE COUNTY ROAD A DISPOSAL SITE

The removal of natural material for highway construction and the subsequent addition of papermill sludge at the County Road A disposal site has altered the topography, surface-water drainage and hydrogeology of the site in ways that can only be estimated. There is an incomplete understanding of the physical evolution of the site and the extent to which the site hydrogeology has been affected by these changes.

Lithology

The shallow geology of the site is characterized by glacial diamictons containing sand, silt, and clay. These lithologies were logged by A-G&M during the drilling of monitoring wells (Geraghty & Miller, Inc., 1996a). The lithologic logs for the deeper of each pair of A-G&M wells are shown in figure 5. Samples were not collected during the drilling of wells by the USGS, but auger returns showed sands, silts, and clays similar to those reported by Geraghty and Miller, Inc. (1996a). In general, the relative proportion of sand was greatest on the western side of the site, and the relative proportion of silt was greatest on the eastern side. Clay was reported in the upper 2 to 5 ft of CAMW-1B, -2B and -5A. Natural-gamma logs from monitoring wells CAMW-6B and -8B also indicate lithologic variability (figures 5 and 6); the higher gamma counts generally indicate a greater proportion of clay in the sediment. Trace amounts of sludge were encountered just below the ground surface while drilling CAMW-6A and -6B. Trace amounts also were encountered at a depth of approximately five feet below land surface while drilling CAMW-8A and -8B.

The natural-gamma and neutron logs for well points WP-1G and WP-2G, located in Ponds B and A, respectively, are presented in figure 7. The natural-gamma logs show that the proportion of clay in sediments that compose the bottom of the ponds is spatially variable, both vertically and horizontally. The generally low response seen in the neutron logs suggests the sediments beneath the ponds are saturated. The variable nature of the neutron response, seen particularly in Pond A (well point WP-2G) suggests that the sediment porosity and/or degree of saturation is variable. Scattered probing of the bottom sediments of the ponds indicated clayey-silt to silty-clay (thickness unknown) under much of the pond. The restriction to vertical flow caused by these fine-grained sediments is likely responsible for the existence of the pond, and constrains the degree of hydraulic connection between the ponds and shallow ground-water system. The extent of hydraulic connection between the surface water and ground-water system in turn determines the potential for solutes to move from the ponds to the shallow ground water.

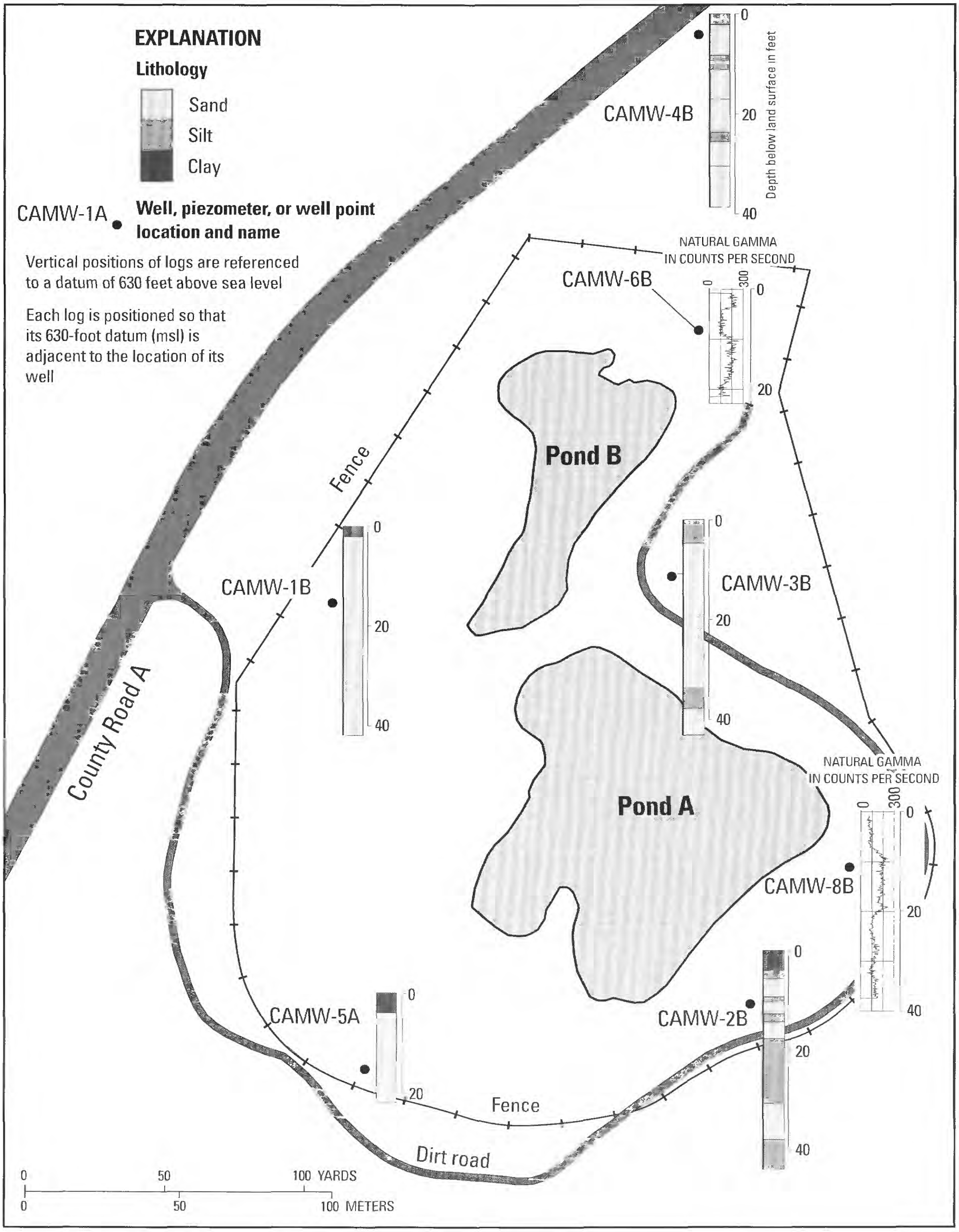


Figure 5. Lithologic logs and natural-gamma logs of unconsolidated sediments encountered in selected monitoring wells at the County Road A disposal site, Ashland County, Wisconsin (base map modified from Geraghty & Miller, Inc., 1996a).

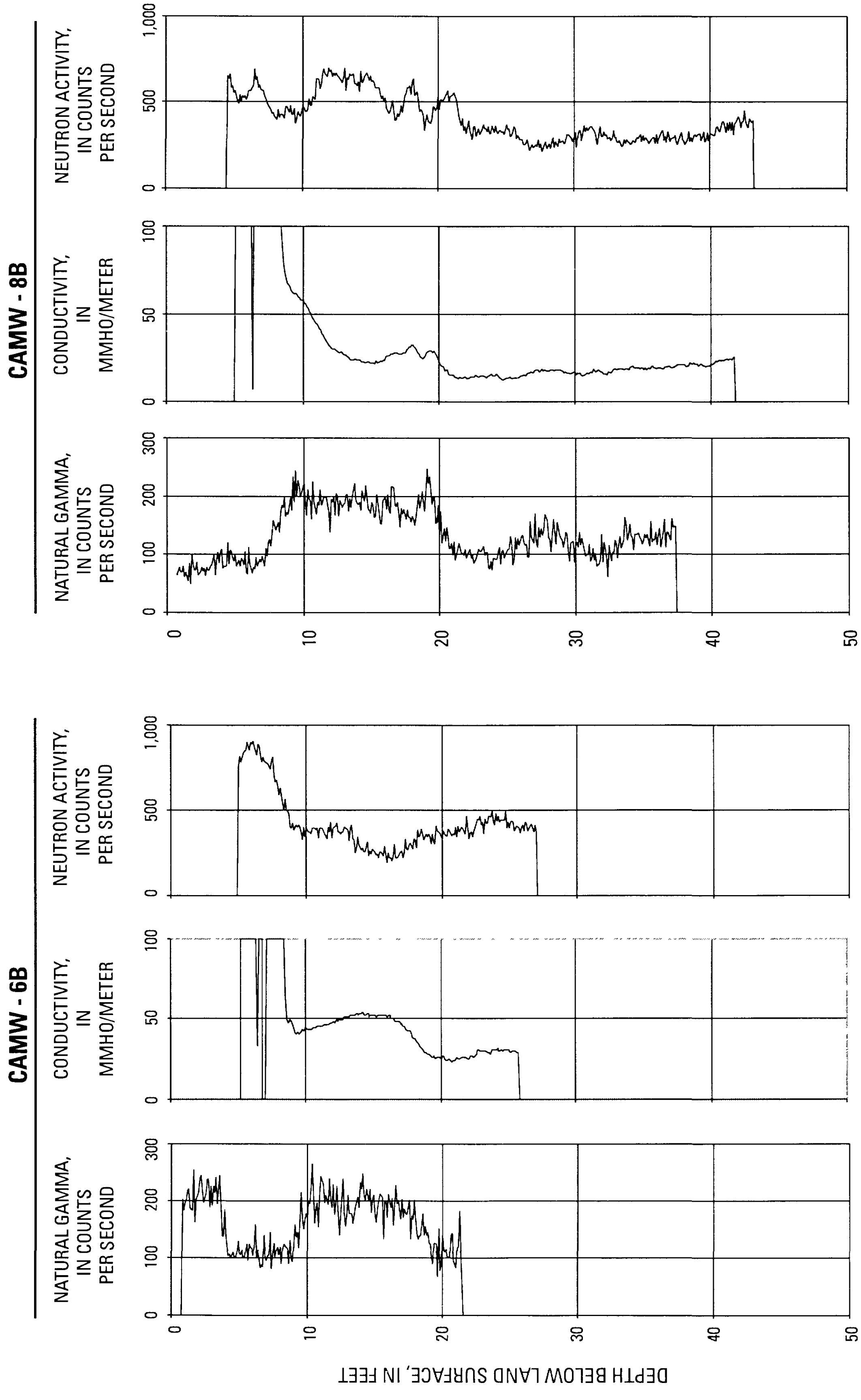


Figure 6. Geophysical logs from monitoring wells CAMW-6B and CAMW-8B at the County Road A disposal site, Ashland County, Wisconsin.

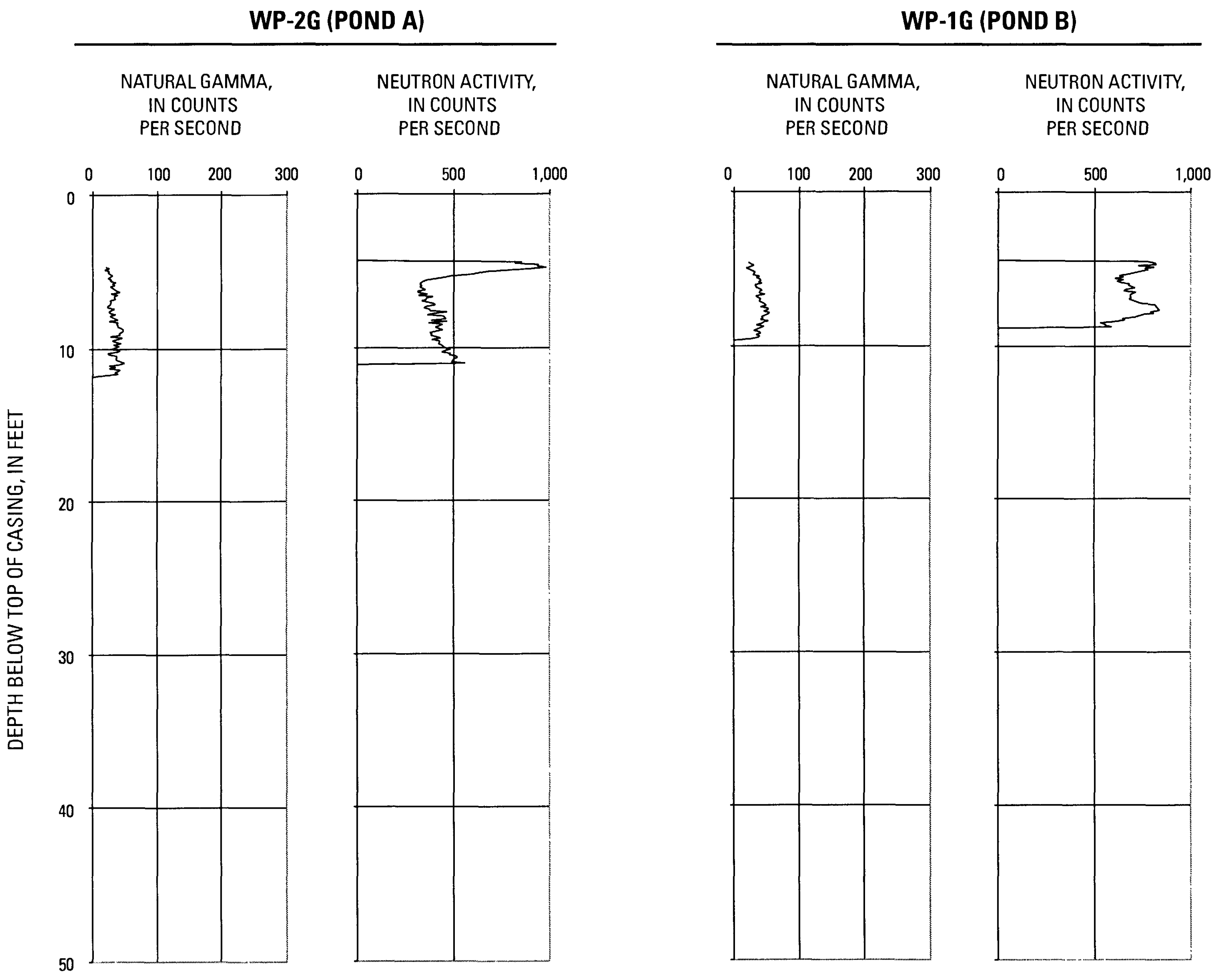


Figure 7. Geophysical logs from temporary well points WP-2G and WP-1G in Ponds A and B at the County Road A disposal site, Ashland County, Wisconsin.

Table 2. Estimates of horizontal hydraulic conductivity (K_h) from slug tests conducted at the County Road A disposal site, Ashland County, Wisconsin
[--, no measurement]

Monitoring well and test number	Horizontal hydraulic conductivity (K_h) in feet per day: Bouwer and Rice (1976) method, Falling head	Bouwer and Rice (1976) method, Rising head	Hvorslev (1951) method, Falling head	Hvorslev (1951) method, Rising head
CAMW-4A				
Test 1	--	1.4	--	--
Test 2	--	.9	--	--
CAMW-4B				
Test 1	2.1	2.1	2.7	2.6
CAMW-6A				
Test 1	--	.3	--	--
CAMW-8A				
Test 1	--	6.6	--	--
Test 2	--	6.6	--	--
CAMW-8B				
Test 1	1.3	1.4	1.7	1.7
Test 2	1.1	1.5	1.8	1.4

Hydraulic Conductivity

The Darcy equation relates ground-water discharge to hydraulic gradient through a coefficient of proportionality referred to as hydraulic conductivity (Gupta, 1989):

$$Q = KA\frac{\Delta h}{\Delta l}, \qquad (1)$$

where

Q is ground-water flow (L^3T^{-1});
K is hydraulic conductivity (LT^{-1});
A is the cross-sectional area perpendicular to flow (L^2);
Δh is the change in head along the length Δl (L); and
Δl is the length (L).

On the basis of slug tests, the estimated K_h of sediments in the screened intervals of monitoring wells CAMW-4A, -4B, -6A, -8A and -8B ranged from 0.3 to 6.6 ft/d (table 2). These values are consistent with published K_h values for silt and silty sand (Freeze and Cherry, 1979, p. 29). In each well, results of the rising-head and falling-head slug tests generally were similar. For wells where the water table intersected the screened interval, the falling-head tests were not analyzed. In these tests, the displaced water entered the unsaturated zone, which violated analytical assumptions.

Water Budget for Pond A

Ponds A and B within the County Road A disposal site have relatively simple hydrologic budgets because there is little surface-water inflow and no outflow. Inflow to the ponds is limited to direct precipitation and local surface runoff, and outflow from the ponds is limited to evaporation and, possibly, seepage through the pond bottoms. Water-level data from monitoring wells in the area and stages of the ponds over the period of study suggest no ground-water discharge to the ponds. Water levels in monitoring wells and well-points were measured using an electric tape on 10 dates from December 18, 1995 through August 20, 1998 (table 3 and fig. 8). These measurements were made by A-G&M, USEPA/USGS or BRNRD. From May 6 through August 18, 1998, water levels were measured on a nearly continuous basis (60-minute intervals) in monitoring wells CAMW-1A, -1B, -7P, -8A and -8B, and well points WP-2, WP-P2, WP-P3 and WP-P4 (fig. 9).

Table 3. Measured water-level altitudes in monitoring wells, well points, and ponds at the County Road A disposal site, Ashland County, Wisconsin

[est., estimated; --, no measurement]

Monitoring well or well-point designation	Packed or screened interval, in feet above sea level	Water-level altitude, in feet above sea level									
		12/18/1995 [a]	1/15/1996 [a]	8/5/1996 [a]	11/4/1996 [a]	4/28/1998 [b]	5/6/1998 [b]	5/22/1998 [c]	6/15/1998 [c]	7/20/1998 [c]	8/20/1998 [b]
CAMW-1A	622.08 - 632.08	629.49	629.32	633.72	632.53	631.11	--	-	630.78	-	630.04
CAMW-1B	600.08 - 605.08	629.33	629.15	633.58	632.50	631.06	--	-	630.73	-	629.66
CAMW-2A	621.75 - 631.75	624.23	624.10	627.45	626.85	625.54	--	625.38	625.30	625.33	624.83
CAMW-2B	598.75 - 603.75	624.07	623.96	626.95	626.52	625.27	--	625.13	625.07	625.11	624.62
CAMW-3A	621.88 - 631.88	627.55	627.30	632.95	631.43	629.57	--	629.31	629.24	629.09	628.14
CAMW-3B	598.88 - 603.88	627.37	627.12	632.26	630.97	629.24	--	628.96	628.93	628.79	627.88
CAMW-4A	619.76 - 629.76	626.42	626.27	629.10	628.46	627.63	--	627.39	627.38	627.39	626.48
CAMW-4B	597.76 - 602.76	626.43	626.27	629.07	628.48	627.63	--	627.37	627.42	627.33	626.44
CAMW-5A	622.06 - 632.06	628.55	628.45	631.39	631.21	629.90	--	629.65	629.70	629.62	629.16
CAMW-6A	620.6 - 630.6	--	--	--	--	628.30	--	628.15	628.05	628.14	627.15
CAMW-6B	605.8 - 615.8	--	--	--	--	628.39	--	628.15	628.13	628.10	627.15
CAMW-7P	628.9 - 631.9	--	--	--	--	--	632.05	--	--	--	dry
CAMW-8A	619.5 - 629.5	--	--	--	--	623.83	--	--	623.78	--	623.24
CAMW-8B	597.0 - 602.0	--	--	--	--	624.23	--	--	624.23	--	623.57
WP-1 (pond stage)		--	--	--	--	--	635.11 [e]	--	--	--	634.11
WP-1 (inside)	est. 629.1 - 630.1	--	--	--	--	631.90 [d]	--	--	--	--	630.39
WP-2 (pond stage)		--	--	--	--	--	635.13	--	--	--	634.12
WP-2 (inside)	est. 631.3 - 632.3	--	--	--	--	--	634.72	--	--	--	633.32
WP-P2	630.68 - 631.68	--	--	--	--	--	632.01	--	--	--	dry
WP-P3	633.54 - 634.54	--	--	--	--	--	635.09	--	--	--	dry
WP-P4	630.6 - 631.6	--	--	--	--	--	632.08	--	--	--	dry

[a] Measured by Arcadis-Geraghty & Miller.

[b] Measured by U.S. Environmental Protection Agency/U.S. Geological Survey.

[c] Measured by Bad River Natural Resources Department.

[d] Measurement on April 29, 1998.

[e] Measurement on May 5, 1998.

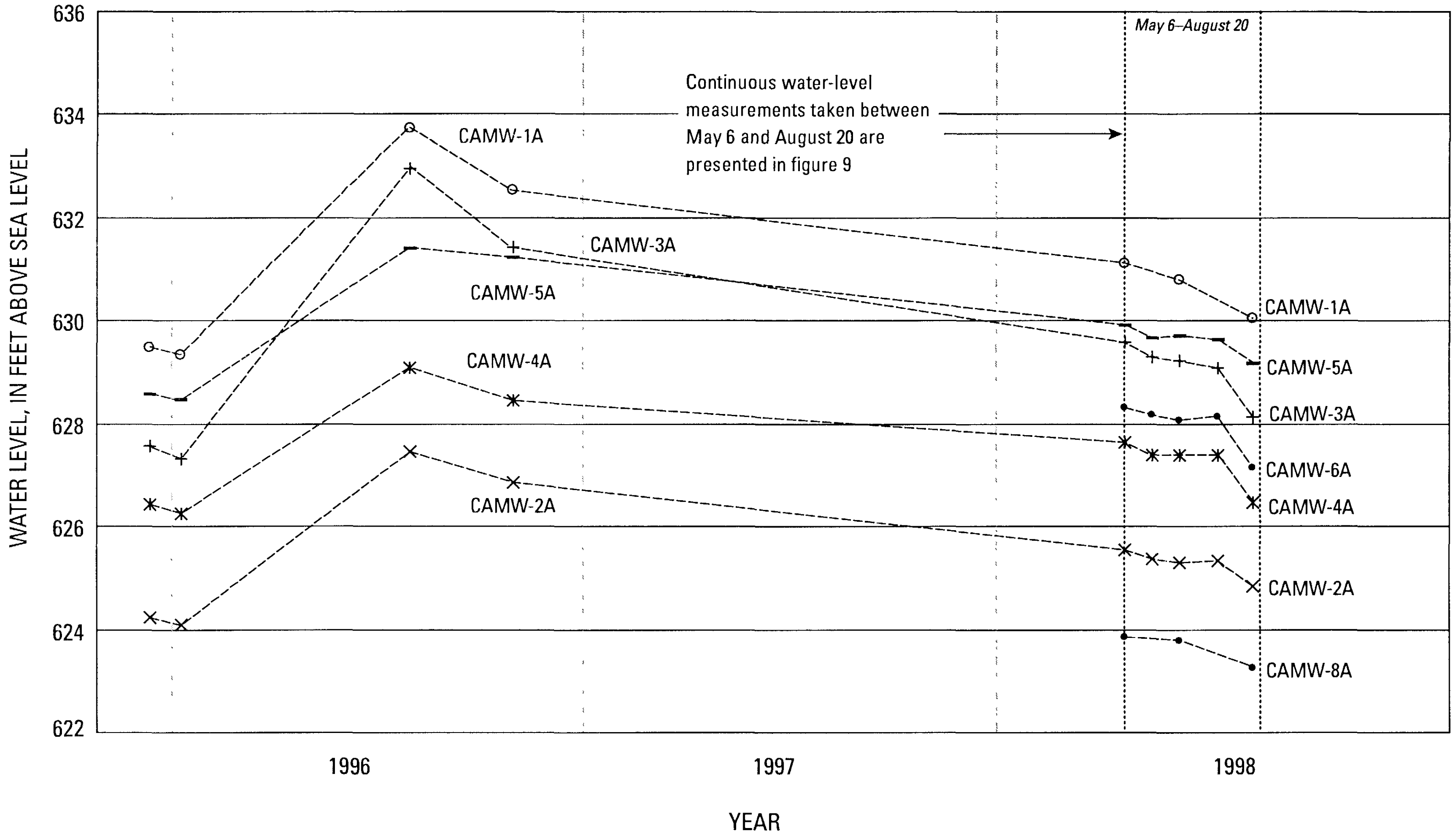


Figure 8. Water-table altitudes in monitoring wells measured December 18, 1995 through August 20, 1998 at the County Road A disposal site, Ashland County, Wisconsin.

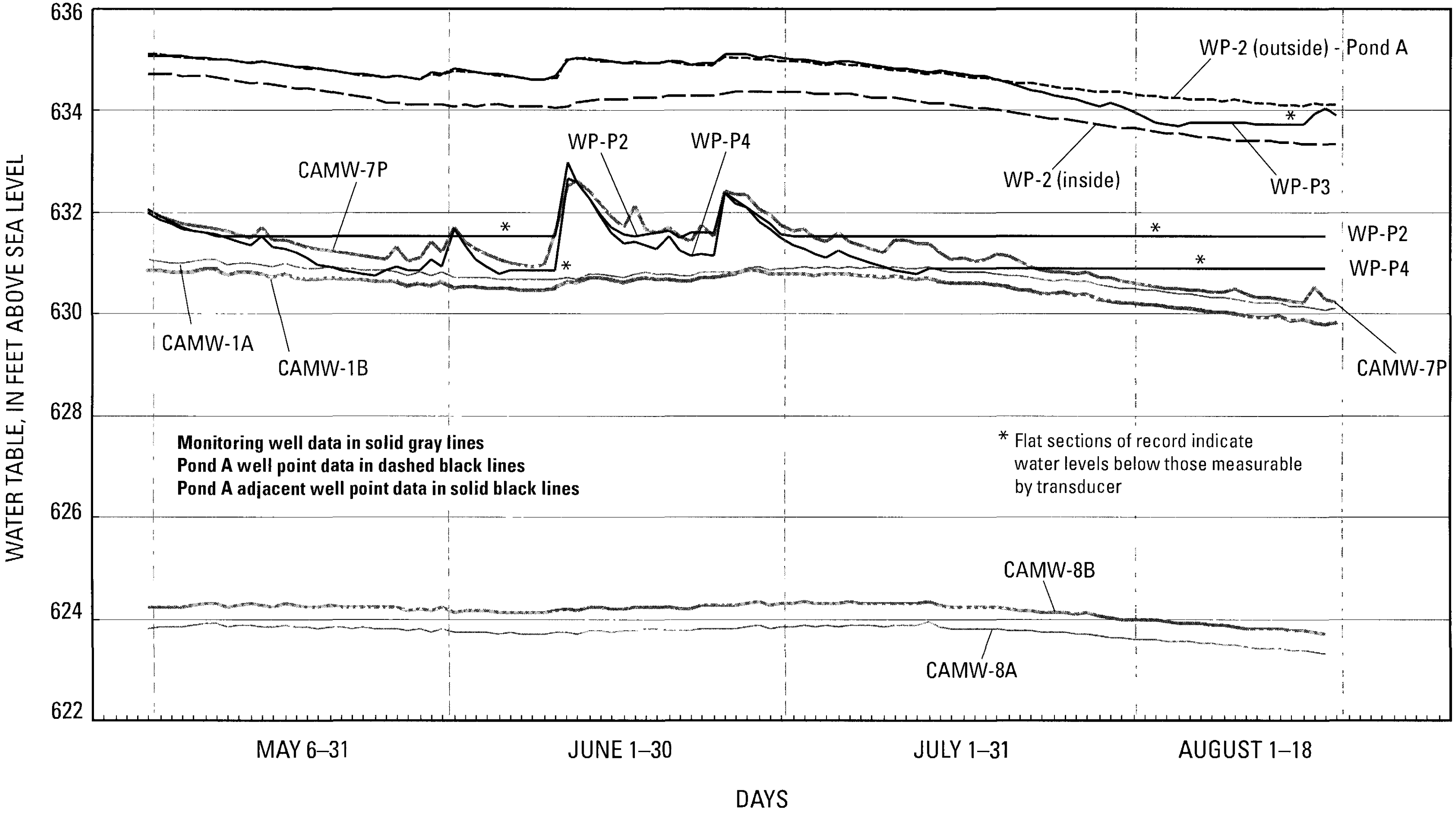


Figure 9. Water-level altitudes in monitoring wells, well points, and Pond A, measured May 6 through August 20, 1998 at the County Road A disposal site, Ashland County, Wisconsin

A general form of the water balance equation (Gupta, 1989) can be modified to express the water balance at the County Road A as:

$$\Delta S = P + R - E - Q_{GO}, \qquad (2)$$

where

ΔS is change in pond storage ($L^3\ T^{-1}$);
P is precipitation ($L^3\ T^{-1}$);
R is direct surface runoff ($L^3\ T^{-1}$);
E is evaporation ($L^3\ T^{-1}$); and
Q_{GO} is seepage to ground water ($L^3\ T^{-1}$).

For the purposes of this study, the water balance can be rewritten to solve for seepage from the ponds:

$$Q_{GO} = P + R - \Delta S - E \qquad (3)$$

The water budget for Pond A was developed using the following data for May 6 through August 18, 1998:

1. Daily precipitation at the University of Wisconsin experimental farm near Ashland, Wisconsin (fig. 1 and fig. 10),
2. Estimates of evaporation based on the method of Linsley and others (1982, equations 5–30) and meteorological data from the airport at Minocqua, Wisconsin (appendix A and fig. 1), and
3. Pond A stage measured by a pressure transducer outside well point WP-2 (fig. 6).

Daily measured values of precipitation and stage of Pond A for May 6 through August 18, 1998 are presented in figure 10. For periods during which there is no precipitation or runoff (P=0, R=0), only two terms on the right hand side of the hydrologic budget (equation 3) remain, specifically change in pond storage (ΔS) and evaporation (E). With no precipitation or runoff, change in storage can only be negative; in this case, equation 3 can be rewritten as

$$Q_{GO} = \Delta S - E \qquad (4)$$

Four time periods which had no measured precipitation were selected from this data set (designated periods 1 through 4) and were used to determine the water budget (fig. 10).

The components of any water balance can be expressed either as a volumetric rate ($L^3\ T^{-1}$) or as a depth over an implied area per unit time ($L\ T^{-1}$) (Dunne and Leopold, 1978). In this report, water budget terms are reported as depths per day; the implied area is the area of Pond A (assumed to be constant over the range of stages observed).

Using the Minocqua airport data and an evaporation pan coefficient of 0.8 (Wentz and Rose, 1991), daily evaporation from Pond A was estimated. The estimate of evaporation and the measured rate of change in pond stage during the four time periods are presented in table 4. On the basis of the daily estimates, an average evaporation rate ($\bar{E}$) was calculated for each time period (table 4, column 5). The daily measured pond stage was taken directly from the continuous pond stage measurements, and the average rate of change of pond stage ($\overline{\Delta S}$) was calculated for each of the chosen periods (table 4, column 8). A comparison of the average rate of evaporation ($\bar{E}$) and the average rate of stage change ($\overline{\Delta S}$) for each of the periods suggests that evaporation alone does not fully account for changes in the stage of Pond A. The difference between the average rate of change of pond stage and the average evaporation rate is attributed to seepage (Q_{GO}) from Pond A to ground water. The seepage of water from Pond A to ground water is estimated to be from 0.008 to 0.012 ft/d (table 4, column 9).

Vertical Hydraulic Gradients Beneath Pond A

Well point WP-2 (fig. 4) provides useful information about the hydraulic connection between Pond A and the underlying sediments. The top of the well point's 1-ft screen is estimated to be 1.3 ft below the pond bottom (table 1 and fig. 11). The measurement is approximate because of the soft muck in the uppermost pond sediment.

Well point WP-2 provides a measure of the difference between the pond stage and the hydraulic head in the sediment intersected by the screen. The pond stage and the hydraulic head in the well point were measured nearly continuously from May 6 through August 18, 1998 (fig. 9). WP-2 (outside) is the stage in Pond A, and WP-2 (inside) is the water level inside the well point (fig. 9). These data indicate a consistent downward hydraulic gradient between Pond A and the sediments underlying the pond. The hydraulic gradient in Pond A is the difference between pond stage and hydraulic head in WP-2 divided by the distance from the pond bottom to mid-screen (1.8 ft). The average downward gradient determined for each of the four periods ranges from about 0.2 to 0.4 ft/ft (table 4). As would be expected,

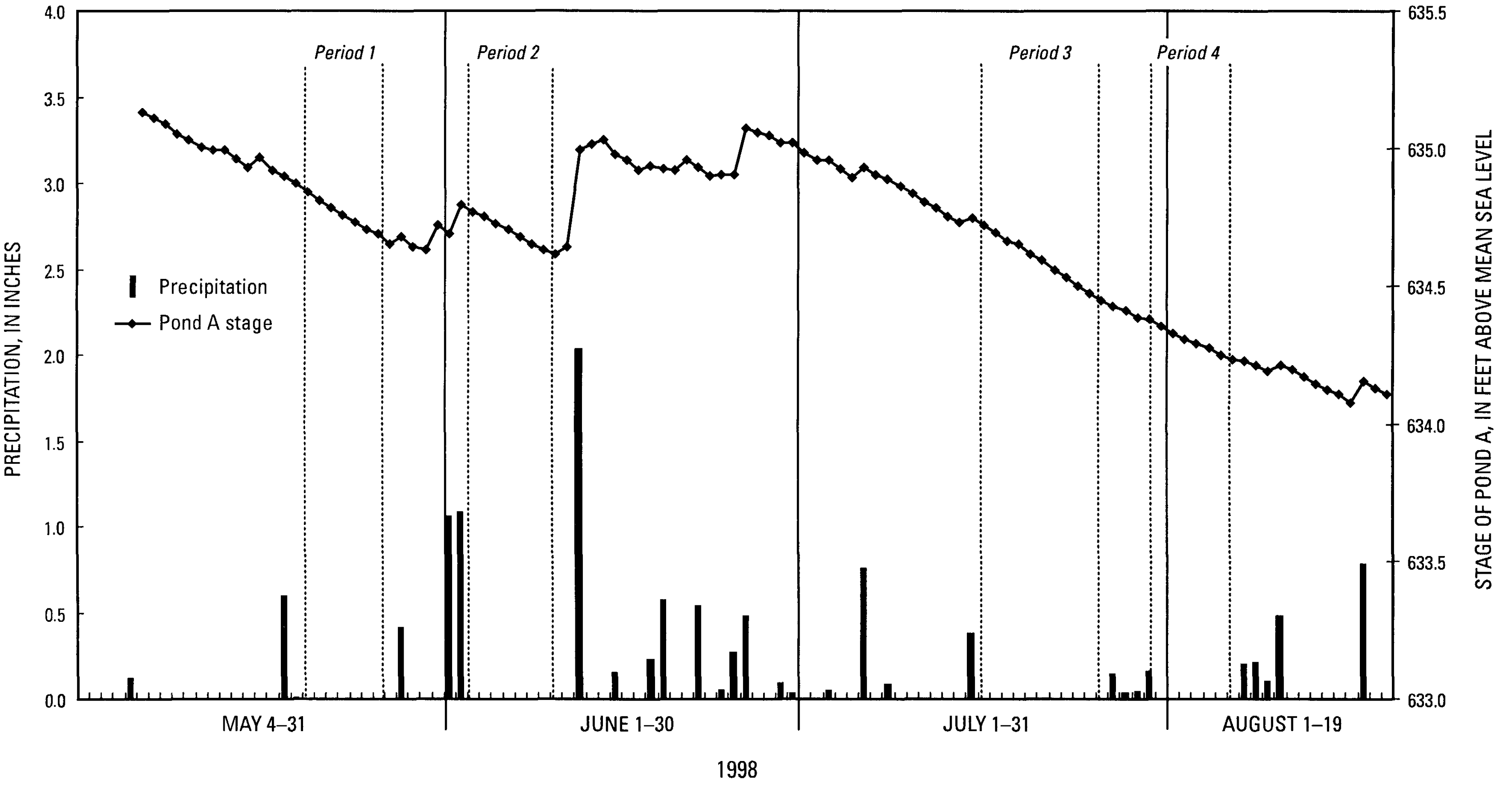


Figure 10. Precipitation and stage of Pond A for the period of May 5 through August 18, 1998, at the County Road A disposal site, Ashland County, Wisconsin.

Table 4. Estimated evaporation, measured stage, rate of stage change, estimated seepage, and estimated vertical hydraulic conductivity during selected periods for Pond A at the County Road A disposal site, Ashland County, Wisconsin

Period defined by no precipitation	Measurement date	Estimated daily evaporation, [a] in inches	Total evaporation for period, in inches	Average rate of evaporation for period, ($\overline{E}$), [b] in feet per day	Measured stage, in feet above sea level	Daily change in stage, in feet	Average rate of stage change for period ($\overline{\Delta S}$), in feet per day	Average rate of ground-water seepage for period (Q_{GO}), [c] in feet per day	Downward gradient determined from Pond A stage and water level in well point WP-2, [d] in feet per foot	Average downward gradient for period, in feet per foot	Estimate of vertical hydraulic conductivity (K_v), [e] in feet per day
1	5/19/98				634.88						
	5/20/98	0.22			634.85	0.03			0.23		
	5/21/98	.20			634.81	.04			.23		
	5/22/98	.18			634.79	.02			.22		
	5/23/98	.19			634.76	.03			.23		
	5/24/98	.13			634.73	.03			.23		
	5/25/98	.23			634.71	.02			.23		
	5/26/98	.19			634.69	.02			.25		
	5/27/98	.22	1.56	0.016	634.66	.03	0.028	0.012	.27	0.24	0.050
2	6/2/98				634.79						
	6/3/98	.18			634.77	.02			.36		
	6/4/98	.17			634.75	.02			.36		
	6/5/98	.06			634.73	.02			.34		
	6/6/98	.13			634.71	.02			.33		
	6/7/98	.11			634.68	.03			.32		
	6/8/98	.13			634.65	.03			.30		
	6/9/98	.08			634.63	.02			.29		
	6/10/98	.04	.90	.009	634.62	.01	.021	.012	.28	.32	.038

Table 4. Estimated evaporation, measured stage, rate of stage change, estimated seepage, and estimated vertical hydraulic conductivity during selected periods for Pond A at the County Road A disposal site, Ashland County, Wisconsin—Continued

Period defined by no precipitation	Measurement date	Estimated daily evaporation,[a] in inches	Total evaporation for period, in inches	Average rate of evaporation for period, ($\bar{E}$),[b] in feet per day	Measured stage, in feet above sea level	Daily change in stage, in feet	Average rate of stage change for period ($\overline{\Delta S}$), in feet per day	Average rate of ground-water seepage for period (Q_{GO}),[c] in feet per day	Downward gradient determined from Pond A stage and water level in well point WP-2,[d] in feet per foot	Average downward gradient for period, in feet per foot	Estimate of vertical hydraulic conductivity (K_v),[e] in feet per day
3	7/15/98				634.75						
	7/16/98	.19			634.73	.02			.33		
	7/17/98	.22			634.70	.03			.33		
	7/18/98	.20			634.66	.04			.33		
	7/19/98	.25			634.65	.01			.33		
	7/20/98	.24			634.62	.03			.33		
	7/21/98	.27			634.60	.02			.33		
	7/22/98	.21			634.56	.04			.34		
	7/23/98	.21			634.53	.03			.34		
	7/24/98	.15			634.50	.03			.34		
	7/25/98	.12			634.48	.02			.34		
	7/26/98	.22	2.28	.017	634.45	.03	.027	.010	.34	.33	.030
4	7/30/98				634.38						
	7/31/98	.17			634.35	.03			.37		
	8/1/98	.17			634.33	.02			.37		
	8/2/98	.21			634.31	.02			.37		
	8/3/98	.12			634.29	.02			.39		
	8/4/98	.21			634.27	.02			.39		
	8/5/98	.11			634.25	.02			.39		
	8/6/98	.07	1.06	.013	634.23	.02	.021	.008	.39	.38	.021

[a] Evaporation rate estimated using meteorological data from Minocqua Airport, Minocqua, Wisconsin, about 70 miles southeast of the site.

[b] The average rate of evaporation was calculated by converting the total evaporation to feet and dividing by one less than the number of days in the period.

[c] The average rate of stage change due to ground-water seepage is the average rate of stage change minus the average rate of evaporation for the period.

[d] The downward gradient in Pond A is the difference between pond stage and water level in well point WP-2, divided by 1.8 (the distance in feet from pond bottom to mid-screen).

[e] The average vertical hydraulic conductivity is estimated by dividing the average seepage rate (Q_{GO}) by the average gradient.

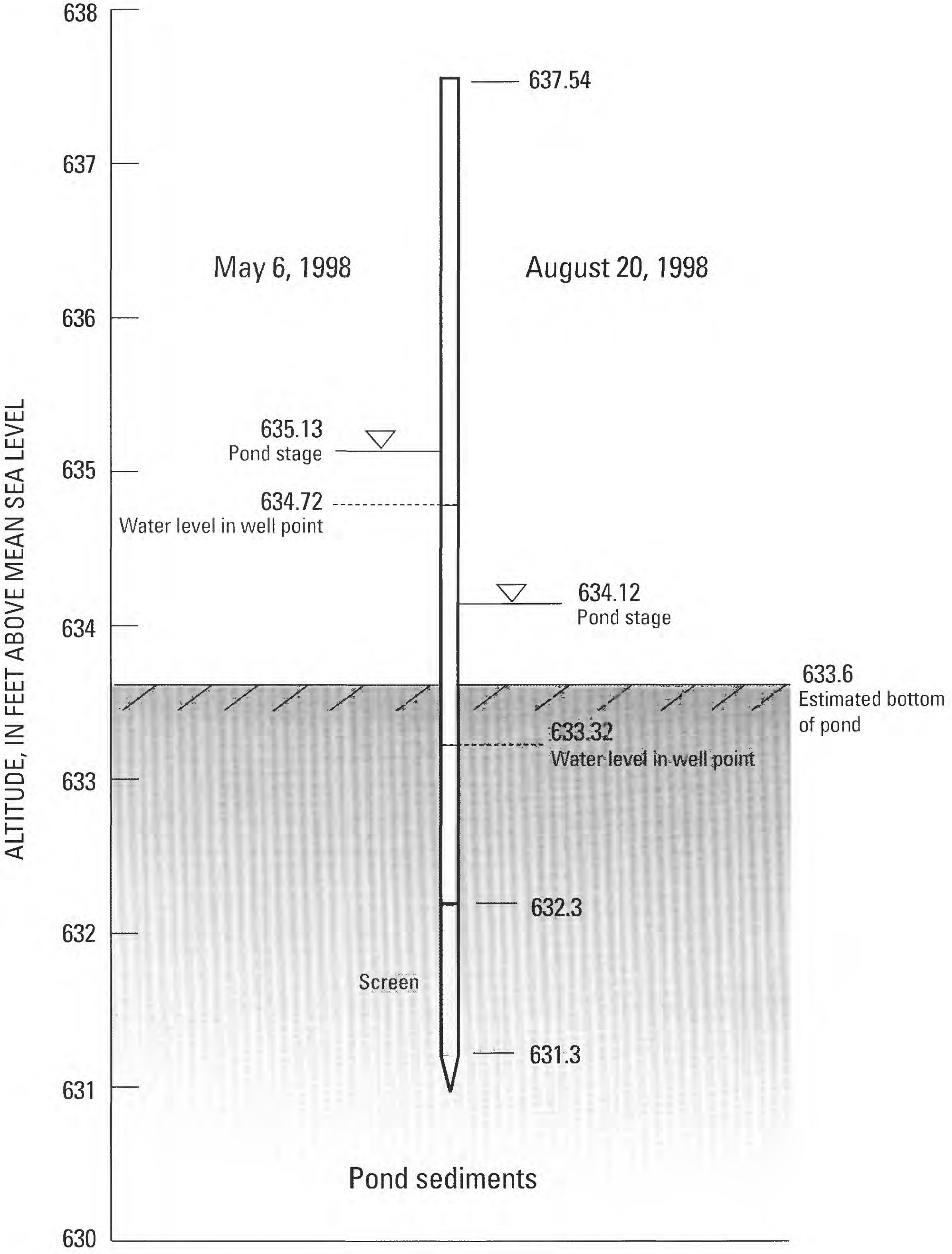


Figure 11. Construction of well point WP-2 in Pond A, and water levels on May 6, 1998 and August 20, 1998, at the County Road A disposal site, ashland County, Wisconsin.

precipitation results in an increase in stage in Pond A (fig. 10). The measured head in WP-2 shows a subdued response to the change in stage of Pond A (fig. 9). Thus, the vertical gradient, which increased due to pond stage rise with precipitation, decreased with time as the hydraulic head in the underlying sediment increased in response. These observations suggest that Pond A is hydraulically connected to the underlying shallow ground-water system. Data from WP-1 suggest that the hydraulic connection between Pond B and the underlying sediments is similar to that of Pond A.

The altitude and variation in water levels in well points WP-P2, WP-P3, WP-P4, and CAWP-7P provide additional evidence that Pond A is in hydraulic connection with the shallow ground-water system (fig. 9). However, the relation between water levels in the ponds and in adjacent shallow sediments is likely to be complex due to the history of the site.

Vertical Hydraulic Conductivity of Bottom Sediments of Pond A

The Darcy equation (equation 1) can be used to estimate the vertical hydraulic conductivity (K_v) of the bottom sediments of Pond A by considering the estimated ground-water-seepage rates and the vertical gradients measured at well point WP-2. Using the average vertical gradient and estimated seepage rate for each of periods 1 through 4, the estimated K_v of the bottom sediments ranges from 0.021 to 0.050 ft/d (table 4). These values of K_v are about one to two orders of magnitude less than K_h values estimated from slug tests (table 3). The lower K_v values are to be expected because the pond bottom sediments are composed of more silt, clay, and sludge than the aquifer sediments (Miller Creek Formation) where the monitoring wells are screened.

Ground-Water-Flow Directions

A water table map (fig. 12) was constructed for the site on the basis of water levels collected on August 20, 1998, the date when the most complete set of data was available (table 3). A direct hydraulic connection between the ponds and the shallow ground-water-flow system was assumed on the basis of water-level data from WP-2, neutron-log data from well points WP-1G and WP-2G, and the calculated water budget of Pond A. Although the principal flow direction in the shallow ground-water system is to the east and northeast, flow is downward and radially away from the ponds because they are a local high point in the water table. Hydraulic heads measured on August 20, 1998 in the deep monitoring wells are presented in figure 13. The vertical hydraulic gradient at each nested monitoring well site was calculated from water levels in the water-table wells and deep monitoring wells. Four of six sites, CAMW-1, -2, -3, and -4, exhibited downward gradients on this date. The gradient was zero at the CAMW-6 site, and at CAMW-8 site, there was an upward gradient.

WATER QUALITY

An assessment of water quality at the County Road A disposal site was conducted through measurement of field parameters and laboratory analysis of inorganic and organic constituents in surface-water and ground-water samples.

Field Parameters

Field parameters were measured to characterize surface water and ground water at the County Road A disposal site (table 5). At most of the monitoring wells, DO was 1 μg/L or less and ORP was less than 0 mV, indicating reducing or anaerobic conditions. The pond water was aerobic as indicated by concentrations of DO greater than 1 μg/L and ORP greater than 0 mV. The SEC of ground water sampled from monitoring wells ranged from 183 to 1,320 μS/cm; samples for the residential wells had a narrower range, from 218 to 295 μS/cm. Pond water had even lower SEC readings and a narrower range, from 56 to 82 μS/cm. The pH of surface water and ground water sampled from monitoring wells ranged from 6.0 to 7.9. Water sampled from nearby residential wells generally had higher pH values (ranging from 7.7 to 8.7) than water sampled from the monitoring wells. This finding is consistent with previous studies of residential wells in the area (Batten and Lidwin, 1995). No ORP readings were obtained for water samples from residential wells.

Inorganic Analyses

The inorganic constituent analytical data for water samples collected from the monitoring wells are presented in table 6. Data for water samples collected from the residential wells are presented in table 7. A "B" data

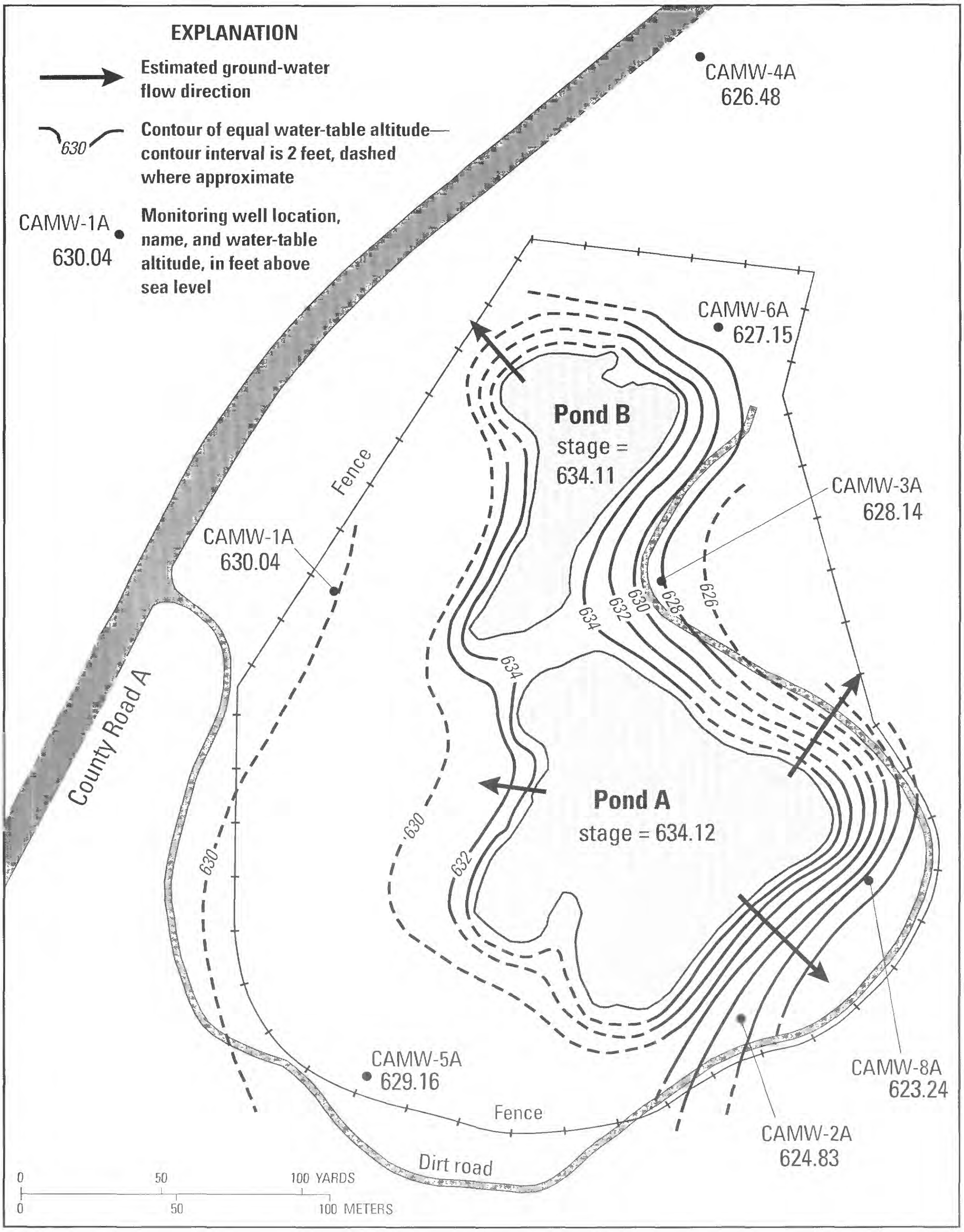


Figure 12. Water-table map constructed using data collected on August 20, 1998, illustrating the interpreted relationship between the local water table and ponds at the County Road A disposal site, Ashland County. Wisconsin (base map modified from Geraghty & Miller, Inc., 1996a).

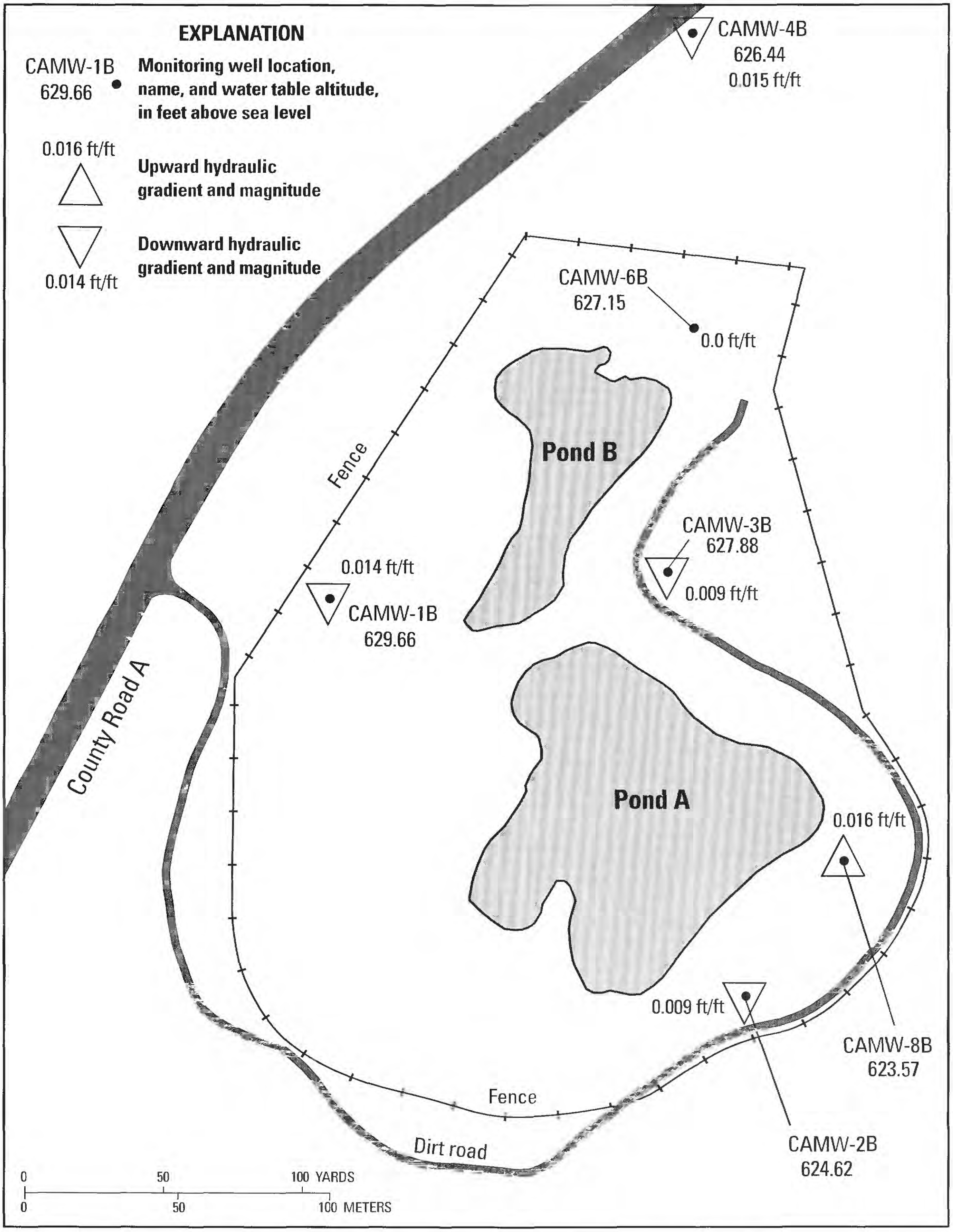


Figure 13. Hydraulic heads measured in deep monitoring wells, and direction and magnitude of vertical hydraulic gradients on August 20, 1998, at the County Road A disposal site, Ashland County, Wisconsin, (base map modified from Geraghty & Miller Inc., 1996a).

Table 5. Field parameters measured April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin

[--, no measurement; ?, data uncertain]

Monitoring well, pond, or residential well designation	Dissolved oxygen, in milligrams per liter	Temperature, in degrees Celsius	Specific conductance, in microsiemens per centimeter	pH, in standard units	Oxidation-Reduction potential, in millivolts	Turbidity, in nephalometric turbidity units
CAMW-1A	0.41	14.3	728	6.4	173[a]	86.6
CAMW-1B	.27[a]	9.5	183	7.9	143	562.0
CAMW-2A	.36	14.0	850	6.5	-65	18.3
CAMW-2B	.11	11.3	859	7.3	15[a]	365.0
CAMW-3A	.10	8.8	608	6.2	-65	8.0
CAMW-3B	.23	16.0	508	7.0	-57	41.0
CAMW-4A	8.35?	8.9	527	6.8[b]	234	144.0?
CAMW-4B	.17	12.3	537	7.3	-10	31.2
CAMW-5A	.24	10.5	1,130	6.7	-82	204.0[a]
CAMW-6A	.76[a]	11.9	1,320	6.0	-20[a]	15.8
CAMW-6B	.59[a]	14.8	1,060	6.5	15[a]	65.0
CAMW-7P	--[e]	--[e]	--[e]	--[e]	--[e]	--[e]
CAMW-8A	.28	12.9	297	6.6	-89	19.0
CAMW-8B	.21	12.2	904	6.3	-75[a]	32.1[a]
Pond A (near isthmus)	6.47	17.6	57	6.5	186	[c]0.0
Pond A (near CAMW-8)	5.86	17.7	56	6.4	213	erratic[c]
Pond B (near CAMW-6)	6.10	17.0	82	6.5	201	0.0[c]
Pond B (at west end)	6.95	17.2	64	6.6	192	0.0[c]
Residence 1	.92	8.9	295	8.2	--	--
Residence 3	3.58[d]	8.1	244	7.7	--	--
Residence 4	3.52[d]	8.1	2?	8.5	--	--
Residence 5	1.86[d]	9.7	280	8.4	--	--
Residence 6	1.26[d]	8.9	218	8.7	--	--

[a] Value is decreasing, but pumped volume exceeded purge criteria.

[b] Value is increasing, but pumped volume exceeded purge criteria.

[c] Very sunny day when measured, value is unreliable.

[d] Value determined by titration.

[e] Insufficient water to measure field parameters.

qualifier in these tables indicates the analytical result may be the result of laboratory contamination because the constituent also was found in the laboratory blank(s).

No concentrations of beryllium, cadmium, mercury, selenium, silver, or thallium were found above the detection limit; however, some results indicated laboratory contamination at concentrations approximating the detection limits (table 6). Detected constituents were compared to the maximum contaminant levels (MCL's) established by the USEPA for protection of public water supplies (U.S. Environmental Protection Agency, 1996). Concentrations of arsenic, barium, chromium, copper, nickel, and zinc did not exceed the MCL's. The detection limit for thallium (4 µg/L) was higher than its MCL (2 µg/L). Antimony exceeded the MCL (6 µg/L) and detection limit (3 µg/L) in one sample (CAMW-6A, at 8.1 µg/L); however, antimony was detected in the laboratory blank (3.0 µg/L), indicating possible laboratory contamination. The concentration measured at CAMW-6A was above the concentrations in the laboratory blank and should therefore be considered a possible detection. Lead exceeded the MCL (15 µg/L) and detection limit in one sample (CAMW-8B at 49.1 µg/L).

Aluminum and iron exceeded the secondary MCL in almost all of the samples. Because these samples were unfiltered and exceeded 5 NTUs (table 5), some aluminum and iron may be the result of clay and silt in the samples. Although manganese concentrations exceeded the MCL (50 µg/L) in every sample, these concentrations were not substantially greater than background concentrations determined from samples from wells CAMW-1A, -1B and -5A.

Although MCL's have not been established for calcium, cobalt, magnesium, potassium, sodium, or vanadium, by comparing the concentration of these constituents in samples from the downgradient monitoring wells to concentrations in samples from the background wells (CAMW-1A, -1B and -5A), some tentative conclusions can be reached. Allowing for some variability in background conditions, concentrations of calcium, magnesium, potassium, and vanadium from downgradient locations do not exceed background concentrations. The concentration of cobalt in the sample from CAMW-6A, however, was above background concentrations. The concentration of sodium in a sample from CAMW-6A may also have been elevated above background concentrations.

Only samples from the newly constructed wells were analyzed for cyanide. This constituent had not been detected in the previously sampled wells. Detections were flagged with "B" (table 6) as a result of apparent laboratory contamination. No concentrations of cyanide exceeded the MCL of 200 µg/L.

The disposal of the papermill sludge at the site has apparently resulted in localized concentrations above established MCL's for lead at well CAMW-8B, and for antimony at well CAMW-6A. Analysis of sludge samples reported in appendix A shows the concentration of lead ranged from 14,100 to 414,000 µg/L, and antimony ranged from 1,010 to 2,090 µg/L. According to tribal representatives, there are no other nearby potential sources of lead or antimony. Elevated concentrations of sodium and cobalt (at well CAMW-6A) may be related to disposal activities at the site; however, these constituents were not reported in previous sludge samples. With two exceptions, concentrations of inorganic constituents were considerably greater in samples from monitoring wells than in those from residential wells (table 7). Samples from residential wells Res 5 and Res 6 had higher concentrations of potassium and zinc than samples from any monitoring wells. The high concentrations of potassium are consistent with the maximum concentrations seen in residential wells and springs previously sampled on the reservation (Batten and Lidwin, 1995). Zinc concentrations were below the MCL of 500 µg/L and were within the range of concentrations reported by Batten and Lidwin (1995). The elevated concentrations of potassium may be related to aquifer lithology. The elevated concentration of zinc may also be related to aquifer lithology and (or) well construction.

Organic Analyses

The results of analyses for organic compounds in samples from monitoring wells are presented in table 8. VOC's were detected in several of the monitoring wells. A "J" qualifier (table 8) indicates the result is an estimate because it was above the instrument detection limit, but below the laboratory detection limit. Acetone was found in monitoring wells CAMW-6A and -7P at concentrations of 61 and 110 µg/L, respectively, in May 1998 samples. CAMW–6A was resampled in August 1998 and found to have an acetone concentration of 27 µg/L. 2-butanone was detected in the sample from CAMW-7P at 39 µg/L. Toluene was detected at trace concentrations (qualified as an estimate in table 8) in samples from CAMW-6A, -6B, and -8B. Various

Table 6. Inorganic analytical data for monitoring wells sampled April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than the indicated detection limit; (B), detected in laboratory blank; --, not analyzed]

Parameter	MCL	CAMW -1A	CAMW -1B	CAMW -2A	CAMW -2B	CAMW -3A	CAMW -3B	CAMW - 3B [d]
Aluminum	50–200 [b]	2,160	8,380	94.5 (B)	3,290	102 (B)	2,050	2,030
Antimony	6 [a]	< 3	< 3	< 3	< 3	3 (B)	< 3	< 3
Arsenic	50 [a]	< 3	4.4 (B)	3.7 (B)	< 3	4.8 (B)	< 3	< 3
Barium	2,000 [a]	150 (B)	99.7 (B)	157 (B)	257	107 (B)	111 (B)	110 (B)
Beryllium	4 [a]	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Cadmium	5 [a]	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Calcium	-	120,000	45,300	131,000	130,000	102,000	82,600	77,300
Chromium	100 [a]	83.9	27.6	< 1	12.6	< 1	5.6 (B)	5.8 (B)
Cobalt	-	6.1 (B)	4.7 (B)	14.7 (B)	3.8 (B)	16.5 (B)	2.4 (B)	2.9 (B)
Copper	1,000 [b]	29.3	23 (B)	4.6 (B)	18.5 (B)	4.1 (B)	35.8	38.4
Iron	300 [b]	12,100	8,080	27,400	4,190	23,600	2,660	2,650
Lead	15 [a]	2.7 (B)	3.9	1.5 (B)	3.2	4.2	2.2 (B)	1.8 (B)
Magnesium	-	27,900	13,500	16,400	37,700	17,900	24,800	24,600
Manganese	50 [b]	3,080	226	1,550	878	2,670	1,450	1,430
Mercury	2 [a]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	100 [a]	45.6	21.2 (B)	6.7 (B)	11.5 (B)	10 (B)	7.9 (B)	7.6 (B)
Potassium	-	1,190 (B)	2,490 (B)	814 (B)	2,780 (B)	727 (B)	1,050 (B)	978 (B)
Selenium	50 [a]	< 3	< 3	< 3	< 3	3.7 (B)	< 3	< 3
Silver	100 [b]	< 1	< 1	< 1	< 1	< 1	< 1	1 (B)
Sodium	20,000 [c]	9,930	5,120	2,800 (B)	18,000	3,370 (B)	7,780	7,640
Thallium	2 [a]	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Vanadium	-	11.3 (B)	29.1 (B)	3.3 (B)	9 (B)	3.5 (B)	6.9 (B)	7.9 (B)
Zinc	5,000 [b]	21.1	35	11.4 (B)	325	142	219	14.8 (B)
Cyanide	200 [a]	--	--	--	--	--	--	--

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b] Secondary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[c] Drinking Water Equivalent Level (U.S. Environmental Protection Agency, 2000).

[d] Duplicate sample.

Table 6. Inorganic analytical data for monitoring wells sampled April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin—Continued

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than the indicated detection limit; (B), detected in laboratory blank; --, not analyzed]

Parameter	MCL	CAMW-4A	CAMW -4B	CAMW -5A	CAMW -6A	CAMW -8A	CAMW -8A [d]	CAMW -8B
Aluminum	50–200 [b]	6,030	18,300	2,490	1,560	156 (B)	282	329
Antimony	6 [a]	4.6 (B)	2.7 (B)	3.1 (B)	8.1 (B)	< 3	< 3	3.5 (B)
Arsenic	50 [a]	4.1 (B)	3.6 (B)	5.9 (B)	7.5 (B)	6.3 (B)	5.1 (B)	4.9 (B)
Barium	2,000 [a]	118 (B)	106	713	203	88.4 (B)	86.8 (B)	601
Beryllium	4 [a]	< 1	0.99(B)	< 1	< 1	< 1	< 1	< 1
Cadmium	5 [a]	< 1	.39	< 1	< 1	< 1	< 1	3.9 (B)
Calcium	-	106,000	6,400	161,000	215,000	68,200	66,900	174,000
Chromium	100 [a]	13.5	33.5	20.7	75.8	< 1	< 1	4.4 (B)
Cobalt	-	4.5 (B)	12.6 (B)	18.5 (B)	71.4	6.4 (B)	6.1 (B)	14.7 (B)
Copper	1,000 [b]	20.4 (B)	26.9	18 (B)	10.4 (B)	2.9 (B)	2.7 (B)	< 2
Iron	300 [b]	6,340	25,400	45,800	74,700	9,410	9,260	41,600
Lead	15 [a]	3.3	2.6	3.6	6.5	< 1	< 1	49.1
Magnesium	-	31,500	8,220	50,600	62,000	9,230	9,110	64,400
Manganese	50 [b]	152	333	5,570	8,050	1,250	1,220	787
Mercury	2 [a]	< 0.1	.09	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	100 [a]	13.1 (B)	28.1	13.7 (B)	71.3	2.6 (B)	2 (B)	17.1 (B)
Potassium	-	1,960 B	2,340	1,560 (B)	1,410 B	1,320 (B)	1,340 (B)	2,020 (B)
Selenium	50 [a]	< 3	1.2	< 3	< 3	< 3	< 3	< 3
Silver	100 [b]	1.5 (B)	.39	< 1	< 1	< 1	< 1	< 1
Sodium	20,000 [c]	39,700	521 (B)	18,400	41,700	2,000 (B)	1,970 (B)	19,400
Thallium	2 [a]	< 4	1.6	< 4	4.1 (B)	< 4	< 4	< 4
Vanadium	-	26.3 (B)	49.9	6.5 (B)	10.4 (B)	1.9 (B)	1.4 (B)	2.5 (B)
Zinc	5,000 [b]	78.6	107	22.9	25.4	10.5 (B)	7.6 (B)	16.8 (B)
Cyanide	200 [a]	2.1 (B)	0.27(B)	--	< 1	1.3 (B)	< 1	< 1

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b] Secondary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[c] Drinking Water Equivalent Level (U.S. Environmental Protection Agency, 2000).

[d] Duplicate sample.

Table 7. Inorganic analytical data for residential wells sampled April 28 through May 6, 1998 near the County Road A disposal site, Ashland County, Wisconsin

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than the indicated detection limit; (B), detected in laboratory blank; --, not analyzed]

Parameter	MCL	Res 1	Res 1 [d]	Res 3	Res 4	Res 5	Res 6
Aluminum	50–200[b]	< 24	< 24	< 24	< 24	< 24	137 (B)
Antimony	6[a]	< 3	< 3	< 3	< 3	< 3	< 3
Arsenic	50[a]	< 3	< 3	< 3	< 3	< 3	3.4 (B)
Barium	2,000[a]	76.6 (B)	80 (B)	125 (B)	24.1 (B)	64.6 (B)	22.3 (B)
Beryllium	4[a]	< 1	< 1	< 1	< 1	< 1	< 1
Cadmium	5[a]	< 1	< 1	< 1	< 1	< 1	< 1
Calcium	-	25,700	26,500	21,200	15,200	24,800	15,500
Chromium	100[a]	< 1	1.1 (B)	< 1	< 1	1.1 (B)	< 1
Cobalt	-	< 1	< 1	< 1	< 1	< 1	< 1
Copper	1,000[b]	< 2	7.4 (B)	5.9 (B)	6.6 (B)	10 (B)	21.6 (B)
Iron	300[b]	111	127	364	20 (B)	715	52.1 (B)
Lead	15[a]	1 (B)	< 1	1.1 (B)	1.5 (B)	1.6 (B)	2.4 (B)
Magnesium	-	8,770	9,020	8,200	3,350 (B)	5,220	3,410 (B)
Manganese	50[b]	79.7	80.3	8.6 (B)	8 (B)	10.8 (B)	9 (B)
Mercury	2[a]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	100[a]	< 1	1.6 (B)	1.1 (B)	< 1	1.3 (B)	5.8 (B)
Potassium	-	3,580 (B)	3,710 (B)	3,850 (B)	4,020 (B)	6,140	5,340
Selenium	50[a]	< 3	< 3	< 3	< 3	< 3	< 3
Silver	100[b]	< 1	< 1	< 1	< 1	< 1	1.1 (B)
Sodium	20,000[c]	18,600	19,600	17,300	23,500	25,200	23,800
Thallium	2[a]	< 4	< 4	< 4	< 4	< 4	4 (B)
Vanadium	-	< 1	< 1	< 1	< 1	1.3 (B)	< 1
Zinc	5,000[b]	72.2	75. 9	48.5	43	225	220
Cyanide	200[a]	< 1	< 1	< 1	< 1	2.4 (B)	< 1

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b] Secondary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[c] Drinking Water Equivalent Level (U.S. Environmental Protection Agency, 2000).

[d] Duplicate sample.

Table 8. Organic analytical data for monitoring wells sampled April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than detection limit; (J), estimated value; --, not analyzed; [a],Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000); [b], Duplicate sample]

Compound	MCL [a]	-1A	-1B	-2A	-2B	-3A	-3B	-3B [b]	-4A	-4B	-5A	-6A	-6B	-7P	-8A	-8A [b]	-8B
Chloromethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bromomethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Vinyl Chloride	2	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chloroethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Methylene Chloride	-	< 10	< 10	2 (J)	< 10	3 (J)	2 (J)	2 (J)	3 (J)	< 10	< 10	< 10	2 (J)	2 (J)	2 (J)	< 10	< 10
Acetone	-	< 10	< 10	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10	< 10	< 10 (J)	61	< 10 (J)	110 (J)	< 10 (J)	< 10 (J)	< 10 (J)
Carbon Disulfide	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,1-Dichloroethene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,1-Dichloroethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,2-Dichloroethene (total)	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chloroform	-	< 10	< 10	<10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,2-Dichloroethane	-	< 10 (J)	< 10 (J)	<10	< 10	< 10	< 10	< 10	< 10 (J)	< 10 (J)	< 10	< 10 (J)	< 10	< 10	< 10	< 10	< 10
2-Butanone	-	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	39 (J)	< 10 (J)	< 10 (J)	< 10 (J)
1,1,1-Trichloroethane	200	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Carbon Tetrachloride	5	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bromodichloromethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,2-Dichloropropane	5	< 10	< 10	< 10	< 10	< 10 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
cis-1,3-Dichloropropene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Trichloroethene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibromochloromethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,1,2-Trichloroethane	5	< 10 (J)	< 10 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10 (J)	< 10	< 10 (J)	< 10	< 10	< 10	< 10	< 10
Benzene	5	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
trans-1,3-Dichloropropene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bromoform	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Methyl-2-Pentanone	-	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)
2-Hexanone	-	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)	< 10 (J)
Tetrachloroethene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,1,2,2-Tetrachloroethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Toluene	1,000	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1 (J)	2 (J)	< 10	< 10	< 10	3 (J)
Chlorobenzene	100	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b] Duplicate sample.

Table 8. Organic analytical data for monitoring wells sampled April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin—Continued

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than detection limit; (J), estimated value; --, not analyzed; [a],Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000); [b], Duplicate sample]

Compound	MCL [a]	-1A	-1B	-2A	-2B	-3A	-3B	-3B [b]	-4A	-4B	-5A	-6A	-6B	-7P	-8A	-8A [b]	-8B
Ethylbenzene	700	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Styrene	100	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Xylene (total)	10,000	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
bis(2-Chloroethyl)ether	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2-Chlorophenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
1,3-Dichlorobenzene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
1,4-Dichlorobenzene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
1,2-Dichlorobenzene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2-Methylphenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,2-oxybis(1-chloropropane)	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
4-Methylphenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	2 (J)	3 (J)	--	< 10	< 10	< 10
N-Nitroso-di-n-propylamine	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Hexachloroethane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Nitrobenzene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Isophorone	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2-Nitrophenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,4-Dimethylphenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
bis(2-Chloroethoxy)methane	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,4-Dichlorophenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
1,2,4-Trichlorobenzene	70	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Naphthalene	-	< 10	< 10	0.6 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	0.9 (J)	< 10	--	< 10	< 10	2 (J)
4-Chloroaniline	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Hexachlorobutadiene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
4-Chloro-3-methylphenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2-Methylnaphthalene	-	< 10	< 10	.7 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1 (J)	0.7 (J)	--	< 10	< 10	1 (J)
Hexachlorocyclopentadiene	50	< 10 (J)	< 10 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10 (J)	< 10	< 10 (J)	< 10	--	< 10	< 10	< 10
2,4,6-Trichlorophenol	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,4,5-Trichlorophenol	-	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	--	< 25	< 25	< 25
2-Chloronaphthalene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10

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[a]Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b]Duplicate sample.

Table 8. Organic analytical data for monitoring wells sampled April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin—Continued

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than detection limit; (J), estimated value; --, not analyzed; [a],Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000); [b], Duplicate sample]

Compound	MCL [a]	-1A	-1B	-2A	-2B	-3A	-3B	-3B [b]	-4A	-4B	-5A	-6A	-6B	-7P	-8A	-8A [b]	-8B
2-Nitroaniline	-	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	--	< 25	< 25	< 25
Dimethylphthalate	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Acenaphthylene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,6-Dinitrotoluene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
3-Nitroaniline	-	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	--	< 25	< 25	< 25
Acenaphthene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,4-Dinitrophenol	-	< 25 (J)	< 25 (J)	< 25	< 25	< 25	< 25	< 25	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25	--	< 25	< 25	< 25
4-Nitrophenol	-	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	< 25 (J)	--	< 25 (J)	< 25 (J)	< 25 (J)
Dibenzofuran	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
2,4-Dinitrotoluene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Diethylphthalate	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1 (J)	--	< 10	< 10	< 10
4-Chlorophenyl-phenylether	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Fluorene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
4-Nitroaniline	-	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	--	< 25	< 25	< 25
4,6-Dinitro-2-methylphenol	-	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25 (J)	< 25	< 25 (J)	< 25	< 25	--	< 25	< 25	< 25
N-Nitrosodiphenylamine (1)	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
4-Bromophenyl-phenylether	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Hexachlorobenzene	1	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Pentachlorophenol	1	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	--	< 25	< 25	< 25
Phenanthrene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Anthracene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Carbazole	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Di-n-butylphthalate	-	< 10	< 10	10	2 (J)	4 (J)	6 (J)	7 (J)	< 10	< 10	8 (J)	< 10	7 (J)	--	1 (J)	0.7 (J)	< 10
Fluoranthene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Pyrene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Butylbenzylphthalate	-	< 10	< 10	< 10	< 10	0.5 (J)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
3,3'-Dichlorobenzidine	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Benzo(a)anthracene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Chrysene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
bis(2-Ethylhexyl)phthalate	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b] Duplicate sample.

Table 8. Organic analytical data for monitoring wells sampled April 28 through May 6, 1998 at the County Road A disposal site, Ashland County, Wisconsin—Continued

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than detection limit; (J), estimated value; --, not analyzed; [a],Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000); [b], Duplicate sample]

Compound	MCL [a]	-1A	-1B	-2A	-2B	-3A	-3B	-3B [b]	-4A	-4B	-5A	-6A	-6B	-7P	-8A	-8A [b]	-8B
Di-n-octylphthalate	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Benzo(b)fluoranthene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Benzo(k)fluoranthene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Benzo(a)pyrene	0.2	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Dibenz(a,h)anthracene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
Benzo(g,h,i)perylene	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10
alpha-BHC	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05
beta-BHC	-	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
delta-BHC	-	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
gamma-BHC (Lindane)	-	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
Heptachlor	0.4	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
Aldrin	-	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
Heptachlor epoxide	0.2	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
Endosulfan I	-	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
Dieldrin	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	< .1	< .1	< .1
4,4'-DDE	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	< .1	< .1	< .1
Endrin	2	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	< .1	< .1	< .1
Endosulfan II	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	< .1	< .1	< .1
4,4'-DDD	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	< .1	< .1	< .1
Endosulfan sulfate	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	0.033 (J)
4,4'-DDT	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	< .1	< .1	< .1
Methoxychlor	40	< .5	< .5	< .5	< .5	< .5	< .5	< .5	< .5	< .5	< .5	< .5	< .5	--	< .5	< .5	< .5
Endrin ketone	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	0.049 (J)	< 1	--	< .1	< .1	< .1
Endrin aldehyde	-	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1	0.054 (J)	< 1	--	< .1	< .1	< .1
alpha-Chlordane	2	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
gamma-Chlordane	2	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05
Toxaphene	3	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	--	< 5	< 5	< 5
Aroclor-1016	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1
Aroclor-1221	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	--	< 2	< 2	< 2
Aroclor-1232	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1
Aroclor-1242	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1
Aroclor-1248	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1
Aroclor-1254	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1
Aroclor-1260	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

[b] Duplicate sample.

SVOC's were detected at concentrations below the laboratory detection limit and were qualified with J's in table 8. These compounds were 4-methylphenol (detected in CAMW-6A and -6B), naphthalene (detected in CAMW-2A, -6A, and -8A), 2-methylnaphthalene (detected in CAMW-2A, -6A, -6B and -8B), diethylphthalate (detected in CAMW-6B), and butylbenzylphthalate (detected in CAMW-3A). Methylene Chloride and Di-n-butylphalate were also detected in a number of monitoring wells at concentrations below the laboratory detection limit; however, detections of both are attributed to laboratory and/or field contamination. No pesticides or PCB's were detected in the ground-water samples.

Samples from the residential wells had detectable concentrations of 1,2-dichloroethane below the laboratory detection limit in four of the six samples collected (table 9). Many of the wells were subsequently resampled, at which time 1,2-dichloroethane was not detected. No SVOC's, PCB's, or pesticides were detected in any of the residential samples.

The mobility of a compound is expressed by its water-solubility product, which measures the capacity with which the compound dissolves in water (high numbers indicate high capacity to dissolve), and its Log K_{OC}, the partition coefficient to organic fraction of aquifer materials (low numbers indicate low capacity to sorb onto organic material). According to data on acetone and 2-butanone provided in Montgomery and Welkom (1990), solubility products for these compounds are high and their Log K_{OC}'s are low compared to other compounds detected in ground water at the site (table 10). These more mobile organic compounds were detected at higher concentrations in the ground-water samples and the less mobile compounds were detected at trace concentrations. Most of the organic compounds detected in the ground-water samples had been detected in samples of papermill sludge (appendix A) at significantly higher concentrations (Geraghty & Miller, Inc., 1996a). Diethylphthalate was detected in ground water but not reported in analysis of the papermill sludge and thus may not be related to disposal activities. Unless natural-attenuation processes occur, such as biodegradation or abiotic degradation, less mobile compounds eventually may migrate and be detected in ground water.

Table 10. Organic carbon partitioning coefficient and water solubility product for selected organic compounds detected in ground water, County Road A disposal site, Ashland County, Wisconsin

[K_{oc}, partition coefficient; mg/L, milligram per liter]

Organic compound	Log K_{OC}	Water solubility product (mg/L)
acetone	-0.43	Miscible in all proportions
2-butanone	.09	353,000 at 10°C
butylbenzylphthalate	2.2	2.82 at 20°C
diethylphthalate	1.84	760 at 20°C
2-methylnapthalene	3.9	25 at 25°C
napthalene	3	32 at 25°C
toluene	2.06	32 at 25°C

SUMMARY

The County Road A disposal site, located on the Bad River Indian Reservation in Ashland County, Wisconsin, contains papermill sludge generated by a former mill in the City of Ashland. The U.S. Geological Survey (USGS), in cooperation with United State Environmental Protection Agency (USEPA) Region 5 and the Bad River Natural Resources Department (BRNRD), conducted an investigation of the hydrogeology and ground-water quality of the site. A primary objective of this investigation was to assess the potential for migration of water from ponds on the site to the shallow ground-water-flow system. This report presents and interprets hydrogeologic and water-quality data collected by the USGS and the USEPA in support of this investigation.

At the County Road A disposal site, unconsolidated sediments of glacial and post-glacial origin overlie sandstone bedrock. The unconsolidated sediments are primarily fine-grained sand and silt, with localized clay layers. Within the upper 50 ft of sediment, the proportion of sand is greatest on the western side of the site and the proportion of silt and clay increases to the east. Bottom sediments of the ponds range from clayey-silt to silty-clay, and are commonly overlain by organic mud, muck, and papermill-sludge deposits. The shallow ground-water-flow system within the near-surface sand and silt deposits is presumed to be controlled largely by local topography, resulting in flow generally from west of the site to Hanson's Swamp on the east. Geophysical, hydrologic, and water-quality data indicate a direct hydraulic connection between Pond A and the shallow

Table 9. Organic analytical data for residential wells sampled April 28 through May 6, 1998 near the County Road A disposal site, Ashland County, Wisconsin

[All values reported in µg/L; MCL, maximum contaminant level; --, no established MCL; <, less than indicated detection limit; (J), estimated value]

Compound	MCL[a]	Res 1	Res 2	Res 3	Res 4	Res 5	Res 6
Chloromethane	--	< 1	< 1	< 1	< 1	< 1	< 1
Bromomethane	--	< 1	< 1	< 1	< 1	< 1	< 1
Vinyl Chloride	2	< 1	< 1	< 1	< 1	< 1	< 1
Chloroethane	--	< 1	< 1	< 1	< 1	< 1	< 1
Methylene Chloride	--	2 (J)	2 (J)	2 (J)	2 (J)	2 (J)	2 (J)
Acetone	--	< 5	< 5	< 5	< 5	< 5	< 5
Carbon Disulfide	--	< 1	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethene	--	< 1	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethane	--	< 1	< 1	< 1	< 1	< 1	< 1
1,2-Dichloroethene (total)	--	< 1	< 1	< 1	< 1	< 1	< 1
Chloroform	--	< 1	< 1	< 1	< 1	< 1	< 1
1,2-Dichloroethane	--	0.6 (J)	< 1	0.6 (J)	< 1	0.8 (J)	0.7 (J)
2-Butanone	--	< 5	< 5	< 5	< 5	< 5	< 5
1,1,1-Trichloroethane	200	< 1	< 1	< 1	< 1	< 1	< 1
Carbon Tetrachloride	5	< 1	< 1	< 1	< 1	< 1	< 1
Bromodichloromethane	--	< 1	< 1	< 1	< 1	< 1	< 1
1,2-Dichloropropane	5	< 1	< 1	< 1	< 1	< 1	< 1
cis-1,3-Dichloropropene	--	< 1	< 1	< 1	< 1	< 1	< 1
Trichloroethene	--	< 1	< 1	< 1	< 1	< 1	< 1
Dibromochloromethane	--	< 1	< 1	< 1	< 1	< 1	< 1
1,1,2-Trichloroethane	5	< 1	< 1	< 1	< 1	< 1	< 1
Benzene	5	< 1	< 1	< 1	< 1	< 1	< 1
trans-1,3-Dichloropropene	--	< 1	< 1	< 1	< 1	< 1	< 1
Bromoform	--	< 1	< 1	< 1	< 1	< 1	< 1
4-Methyl-2-Pentanone	--	< 5	< 5	< 5	< 5	< 5	< 5
2-Hexanone	--	< 5	< 5	< 5	< 5	< 5	< 5
Tetrachloroethene	--	< 1	< 1	< 1	< 1	< 1	< 1
1,1,2,2-Tetrachloroethane	--	< 1	< 1	< 1	< 1	< 1	< 1
Toluene	1,000	< 1	< 1	< 1	< 1	< 1	< 1
Chlorobenzene	100	< 1	< 1	< 1	< 1	< 1	< 1
Ethylbenzene	700	< 1	< 1	< 1	< 1	< 1	< 1
Styrene	100	< 1	< 1	< 1	< 1	< 1	< 1
Xylene (total)	10,000	< 1	< 1	< 1	< 1	< 1	< 1
Phenol	--	< 5	< 5	< 5	< 5	< 5	< 5
bis(2-Chloroethyl)ether	--	< 5	< 5	< 5	< 5	< 5	< 5
2-Chlorophenol	--	< 5	< 5	< 5	< 5	< 5	< 5
1,3-Dichlorobenzene	--	< 5	< 5	< 5	< 5	< 5	< 5
1,4-Dichlorobenzene	--	< 5	< 5	< 5	< 5	< 5	< 5
1,2-Dichlorobenzene	--	< 5	< 5	< 5	< 5	< 5	< 5
2-Methylphenol	--	< 5	< 5	< 5	< 5	< 5	< 5
2,2'-oxybis(1-chloropropane)	--	< 5	< 5	< 5	< 5	< 5	< 5
4-Methylphenol	--	< 5	< 5	< 5	< 5	< 5	< 5
N-Nitroso-di-n-propylamine	--	< 5	< 5	< 5	< 5	< 5	< 5
Hexachloroethane	--	< 5	< 5	< 5	< 5	< 5	< 5
Nitrobenzene	--	< 5	< 5	< 5	< 5	< 5	< 5

Table 9. Organic analytical data for residential wells sampled April 28 through May 6, 1998 near the County Road A disposal site, Ashland County, Wisconsin—Continued

[All values reported in µg/L; MCL, maximum contaminant level; --, no established MCL; <, less than indicated detection limit; (J), estimated value]

Compound	MCL[a]	Res 1	Res 2	Res 3	Res 4	Res 5	Res 6
Isophorone	--	< 5	< 5	< 5	< 5	< 5	< 5
2-Nitrophenol	--	< 5	< 5	< 5	< 5	< 5	< 5
2,4-Dimethylphenol	--	< 5	< 5	< 5	< 5	< 5	< 5
bis(2-Chloroethoxy)methane	--	< 5	< 5	< 5	< 5	< 5	< 5
2,4-Dichlorophenol	--	< 5	< 5	< 5	< 5	< 5	< 5
1,2,4-Trichlorobenzene	70	< 5	< 5	< 5	< 5	< 5	< 5
Naphthalene	--	< 5	< 5	< 5	< 5	< 5	< 5
4-Chloroaniline	--	< 5	< 5	< 5	< 5	< 5	< 5
Hexachlorobutadiene	--	< 5	< 5	< 5	< 5	< 5	< 5
4-Chloro-3-methylphenol	--	< 5	< 5	< 5	< 5	< 5	< 5
2-Methylnaphthalene	--	< 5	< 5	< 5	< 5	< 5	< 5
Hexachlorocyclopentadiene	50	< 5	< 5	< 5	< 5	< 5	< 5
2,4,6-Trichlorophenol	--	< 5	< 5	< 5	< 5	< 5	< 5
2,4,5-Trichlorophenol	--	< 20	< 20	< 20	< 20	< 20	< 20
2-Chloronaphthalene	--	< 5	< 5	< 5	< 5	< 5	< 5
2-Nitroaniline	--	< 20	< 20	< 20	< 20	< 20	< 20
Dimethylphthalate	--	< 5	< 5	< 5	< 5	< 5	< 5
Acenaphthylene	--	< 5	< 5	< 5	< 5	< 5	< 5
2,6-Dinitrotoluene	--	< 5	< 5	< 5	< 5	< 5	< 5
3-Nitroaniline	--	< 20	< 20	< 20	< 20	< 20	< 20
Acenaphthene	--	< 5	< 5	< 5	< 5	< 5	< 5
2,4-Dinitrophenol	--	< 20	< 20	< 20	< 20	< 20	< 20
4-Nitrophenol	--	< 20	< 20	< 20	< 20	< 20	< 20
Dibenzofuran	--	< 5	< 5	< 5	< 5	< 5	< 5
2,4-Dinitrotoluene	--	< 5	< 5	< 5	< 5	< 5	< 5
Diethylphthalate	--	< 5	< 5	< 5	< 5	< 5	< 5
4-Chlorophenyl-phenylether	--	< 5	< 5	< 5	< 5	< 5	< 5
Fluorene	--	< 5	< 5	< 5	< 5	< 5	< 5
4-Nitroaniline	--	< 20	< 20	< 20	< 20	< 20	< 20
4,6-Dinitro-2-methylphenol	--	< 20	< 20	< 20	< 20	< 20	< 20
N-Nitrosodiphenylamine (1)	--	< 5	< 5	< 5	< 5	< 5	< 5
4-Bromophenyl-phenylether	--	< 5	< 5	< 5	< 5	< 5	< 5
Hexachlorobenzene	1	< 5	< 5	< 5	< 5	< 5	< 5
Pentachlorophenol	1	< 20	< 20	< 20	< 20	< 20	< 20
Phenanthrene	--	< 5	< 5	< 5	< 5	< 5	< 5
Anthracene	--	< 5	< 5	< 5	< 5	< 5	< 5
Carbazole	--	< 5	< 5	< 5	< 5	< 5	< 5
Di-n-butylphthalate	--	< 5	< 5	< 5	< 5	< 5	< 5
Fluoranthene	--	< 5	< 5	< 5	< 5	< 5	< 5
Pyrene	--	< 5	< 5	< 5	< 5	< 5	< 5
Butylbenzylphthalate	--	< 5	< 5	< 5	< 5	< 5	< 5
3,3'-Dichlorobenzidine	--	< 5	< 5	< 5	< 5	< 5	< 5
Benzo(a)anthracene	--	< 5	< 5	< 5	< 5	< 5	< 5
Chrysene	--	< 5	< 5	< 5	< 5	< 5	< 5
bis(2-Ethylhexyl)phthalate	--	< 5	< 5	< 5	< 5	< 5	< 5

Table 9. Organic analytical data for residential wells sampled April 28 through May 6, 1998 near the County Road A disposal site, Ashland County, Wisconsin—Continued

[All values reported in µg/L; MCL, maximum contaminant level; -, no established MCL; <, less than indicated detection limit; (J), estimated value]

Compound	MCL[a]	Res 1	Res 2	Res 3	Res 4	Res 5	Res 6
Di-n-octylphthalate	--	< 5	< 5	< 5	< 5	< 5	< 5
Benzo(b)fluoranthene	--	< 5	< 5	< 5	< 5	< 5	< 5
Benzo(k)fluoranthene	--	< 5	< 5	< 5	< 5	< 5	< 5
Benzo(a)pyrene	0.2	< 5	< 5	< 5	< 5	< 5	< 5
Indeno(1,2,3-cd)pyrene	--	< 5	< 5	< 5	< 5	< 5	< 5
Dibenz(a,h)anthracene	--	< 5	< 5	< 5	< 5	< 5	< 5
Benzo(g,h,i)perylene	--	< 5	< 5	< 5	< 5	< 5	< 5
alpha-BHC	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
beta-BHC	--	< .01	< .01	< .01	< .01	< .01	< .01
delta-BHC	--	< .01	< .01	< .01	< .01	< .01	< .01
gamma-BHC (Lindane)	--	< .01	< .01	< .01	< .01	< .01	< .01
Heptachlor	0.4	< .01	< .01	< .01	< .01	< .01	< .01
Aldrin	--	< .01	< .01	< .01	< .01	< .01	< .01
Heptachlor epoxide	0.2	< .01	< .01	< .01	< .01	< .01	< .01
Endosulfan I	--	< .01	< .01	< .01	< .01	< .01	< .01
Dieldrin	--	< .02	< .02	< .02	< .02	< .02	< .02
4,4-DDE	--	< .02	< .02	< .02	< .02	< .02	< .02
Endrin	2	< .02	< .02	< .02	< .02	< .02	< .02
Endosulfan II	--	< .02	< .02	< .02	< .02	< .02	< .02
4,4-DDD	--	< .02	< .02	< .02	< .02	< .02	< .02
Endosulfan sulfate	--	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
4,4-DDT	--	< .02	< .02	< .02	< .02	< .02	< .02
Methoxychlor	40	< .10	< .10	< .10	< .10	< .10	< .10
Endrin ketone	--	< .02	< .02	< .02	< .02	< .02	< .02
Endrin aldehyde	--	< .02	< .02	< .02	< .02	< .02	< .02
alpha-Chlordane	2	< .01	< .01	< .01	< .01	< .01	< .01
gamma-Chlordane	2	< .01	< .01	< .01	< .01	< .01	< .01
Toxaphene	3	< 1	< 1	< 1	< 1	< 1	< 1
Aroclor-1016	--	< .20	< .20	< .20	< .20	< .20	< .20
Aroclor-1221	--	< .40	< .40	< .40	< .40	< .40	< .40
Aroclor-1232	--	< .20	< .20	< .20	< .20	< .20	< .20
Aroclor-1242	--	< .20	< .20	< .20	< .20	< .20	< .20
Aroclor-1248	--	< .20	< .20	< .20	< .20	< .20	< .20
Aroclor-1254	--	< .20	< .20	< .20	< .20	< .20	< .20
Aroclor-1260	--	< .20	< .20	< .20	< .20	< .20	< .20

[a] Primary Drinking Water Standard (U.S. Environmental Protection Agency, 2000).

ground-water system. Neutron logs indicated the bottom sediments of the ponds were saturated.

A water budget prepared for Pond A for selected periods in summer 1998 indicated seepage of pond water to shallow ground water at rates of 0.008 to 0.012 ft per day. In addition, a consistent downward gradient through the bottom of Pond A was measured, ranging from 0.24 to 0.38 ft per foot. During the same period, changes in the stage of Pond A were reflected in changes in the hydraulic head of the underlying sediments. The downward vertical gradient, which increased due to pond-stage rise with precipitation, decreased with time as the hydraulic head in the underlying sediment increased in response. The vertical hydraulic conductivity of the pond bottom sediments (estimated to be 0.021 to 0.050 ft per day) was sufficiently low to support the gradient, but not so low as to completely inhibit flow through the sediments.

The altitude and variation in water levels in well points WP-P2, WP-P3, WP-P4, and CAWP-7P indicate that Pond A was affecting the water table in adjacent areas. The relation between water levels in the pond and in adjacent shallow sediments is complex due to the physical evolution of the site.

Water-quality analyses indicate that inorganic and organic constituents have moved from the papermill sludge and/or ponds into the shallow ground-water-flow system within the site. Water samples from monitoring wells contained elevated concentrations (above maximum contaminant levels, where established) of sodium, aluminum, lead, antimony, and possibly cobalt, in addition to acetone and 2-butanone. All of these constituents except sodium and cobalt were identified in papermill samples. No analytical data for sodium or cobalt were found in previous reports. The more mobile organic compounds were detected at higher concentrations, and less mobile compounds were detected at trace concentrations. The future movement of the inorganic and organic constituents to ground water over time cannot be predicted without a detailed analysis of the partitioning of the compounds to the clay and soil-organic materials.

Analyses of water from residential wells in the vicinity showed considerably lower concentrations of inorganic constituents, with the exceptions of zinc and potassium, than were detected in the monitoring wells. Elevated concentrations of potassium and zinc, however, were consistent with concentrations measured previously in samples from other wells and springs on the reservation, which were presumably unaffected by papermill sludge disposal. None of the organic compounds identified in the papermill sludge were detected in water sampled from the residential wells.

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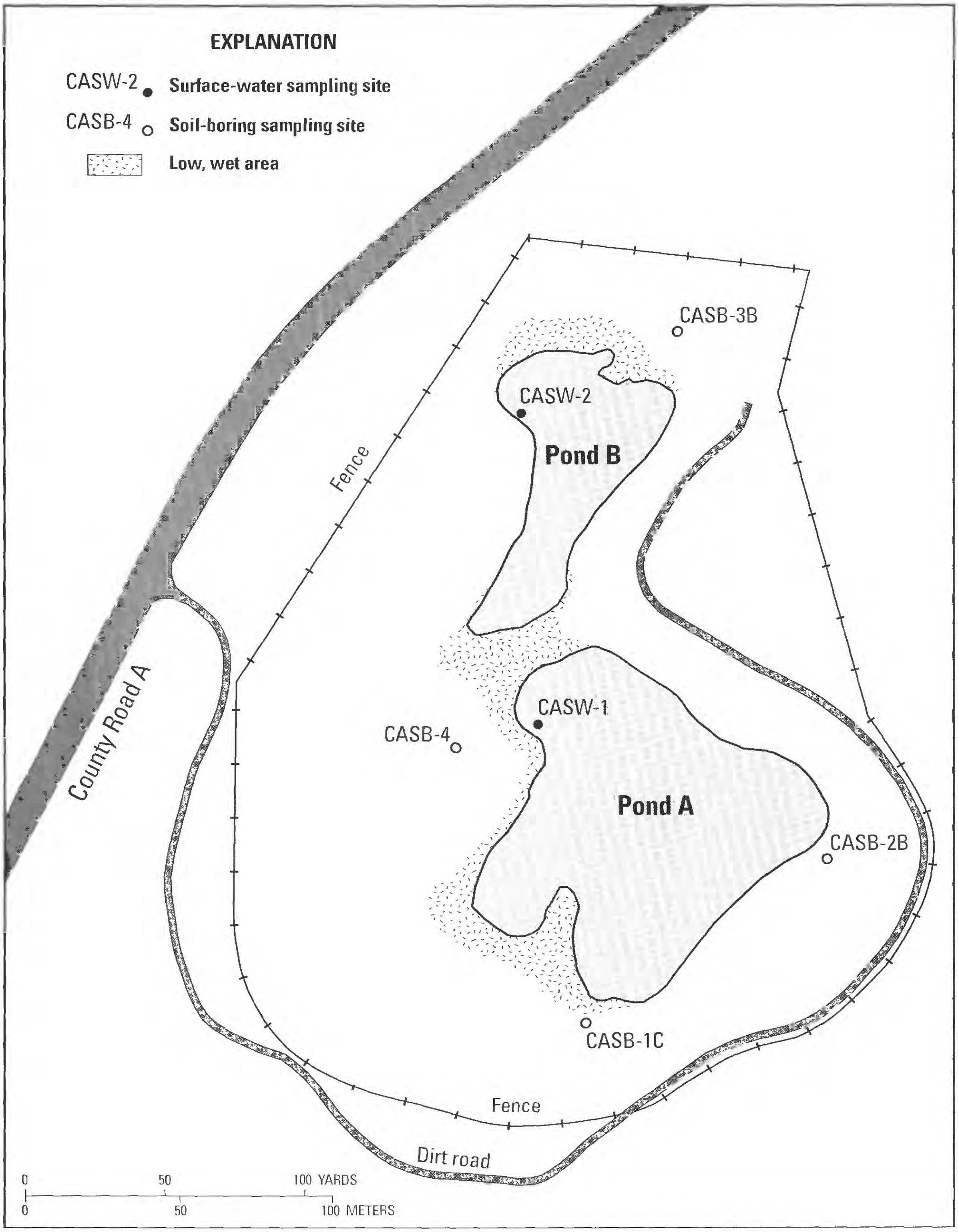
APPENDIXES A–C

Appendix A. Results of analysis of papermill sludge and surface-water samples, County Road A disposal site, Ashland County, Wisconsin.



Appendix A. Locations for selected surface-water and soil-boring samples.

Appendix A. Results of analysis of papermill sludge and surface-water samples, County Road A disposal site, Ashland County, Wisconsin (modified from Geraghty & Miller, Inc., 1996a, table 5-1, and Appendix M)

[J, estimated values; R, result was rejected; <, constituent was not detected at the method quanitation limit which follows the "< " sign; *, sample CASB3B:3-4 was a soil sample collected beneath the Sludge Sample CASB3B:2-3; µg/kg, micrograms per kilogram, equals parts per billion (ppb); pg/g, picograms per gram, equals parts per trillion (ppt); µg/L, micrograms per liter; pg/L, picograms per liter; Papermill sludge samples were also analyzed for PCBs and Pesticides. These constituents were not detected in papermill sludge samples]

Sample Identification Sample Date	Units	CASB1C:3-5 08/22/95	CASB2B:2-4 08/22/95	CASB3B:2-3 08/22/95	CASB3B:3-4* 08/22/95	CASB4:2-4 08/23/95
Volatile Organics						
2-Butanone	µg/kg	660 J	13,000 J	< 29,000 J	32 J	< 670 J
2-Hexanone	µg/kg	< 660 J	27,000 J	< 29,000 J	39 J	870 J
Acetone	µg/kg	< 660 J	6,300 J	6300 J	< 96	< 1,700 J
Ethylbenzene	µg/kg	< 66	< 1,800	< 2,900	< 5.8	120
Toluene	µg/kg	1,900	< 1,800	< 2,900	< 5.8	340
Xylenes (total)	µg/kg	< 66	< 1,800	< 2,900	< 5.8	32 J
Semi-Volatile Organics						
2-Methylnaphthalene	µg/kg	< 910	790	760 J	< 380	3500 J
4-Methylphenol	µg/kg	4,300	2,300	< 910	< 380	23,000
Benzo(a)anthracene	µg/kg	< 910	< 520	130 J	< 380	< 4,500
Benzo(a)pyrene	µg/kg	< 910	< 520	120 J	< 380	< 4,500
Benzo(b)fluoranthene	µg/kg	< 910	< 520	140 J	< 380	< 4,500
Butyl benzyl phthalate	µg/kg	< 910	260 J	< 910	< 380	< 4,500
Chrysene	µg/kg	< 910	< 520	140 J	< 380	< 4,500
Di-n-butyl phthalate	µg/kg	< 910	180	< 910	< 380	< 4,500
Fluoranthene	µg/kg	< 910	< 520	210 J	< 380	< 4,500
Fluorene	µg/kg	< 910	96 J	< 910	< 380	< 4,500
Naphthalene	µg/kg	< 910	< 520	210 J	< 380	< 4,500
Pyrene	µg/kg	< 910	< 520	180 J	< 380	< 4,500
bis(2-Ethylhexyl) phthalate	µg/kg	9,500	< 2,300	5,400	< 380	< 6,800
Dioxin/Furan Isomers						
Total TCDF	pg/g	390	62	84	< 0.25	120
2,3,7,8-TCDF"	pg/g	190	27	38	< .25	49
Total PeCDF	pg/g	31	14	8.7	< .14	15
2,3,4,7,8-PeCDF"	pg/g	3.2 J	2.5 J	< 2.0	< .078	< 2.1
1,2,3,7,8-PeCDF"	pg/g	3.9 J	< 0.95	< 1.2	< .049	< 1.9
Total HxCDF	pg/g	570	140	160	< .71	270
1,2,3,4,7,8-HxCDF"	pg/g	13	12	9.1	< .15	7.7
1,2,3,6,7,8-HxCDF"	pg/g	3.1 J	< 1.0	3.3 J	< .095	< 1.4
2,3,4,6,7,8-HxCDF"	pg/g	4.2 J	< 2.0	3.9 J	< .28	2.6J
1,2,3,7,8,9-HxCDF"	pg/g	< 0.31	< 0.22	< 0.22	< 0.054	0.19
Total HpCDF	pg/g	2,800	490	580	2.6	1,300
1,2,3,4,6,7,8-HpCDF"	pg/g	440	91	110	< 0.80	210
1,2,3,4,7,8,9-HpCDF"	pg/g	38	8.6	10	< 0.13	19
OCDF	pg/g	2,300	440	760	< 4.6	1,300
Total TCDD	pg/g	20	6.2	6.8	< 0.29	12
2,3,7,8-TCDD"	pg/g	14	4.8	6.3	< 0.11	8.6
Total PeCDD	pg/g	16	7.2	2.6	< 0.093	7.9
1,2,3,7,8-PeCDD"	pg/g	6.1	3.1 J	< 2.4	< 0.067	2.7J
Total HxCDD	pg/g	1,200	440	500	< 2.0	790
1,2,3,4,7,8-HxCDD"	pg/g	4.6 J	< 1.1	< 1.7	< 0.071	< 2.4
1,2,3,6,7,8-HxCDD"	pg/g	270	92	100	< 0.67	170
1,2,3,7,8,9-HxCDD"	pg/g	80	33	37	< 0.29	55
Total HpCDD	pg/g	8,900	1,200	1,500	10	3,900
1,2,3,4,6,7,8-HpCDD"	pg/g	4500	650	790	5.2	2,000
OCDD	pg/g	100,000	13,000	16,000	110	4,4000

Appendix A. Results of analysis of papermill sludge and surface-water samples, County Road A disposal site, Ashland County, Wisconsin (modified from Geraghty & Miller, Inc., 1996a, table 5-1, and Appendix M)—Continued

[J, estimated values; R, result was rejected; <, constituent was not detected at the method quanitation limit which follows the "< " sign; *, sample CASB3B:3-4 was a soil sample collected beneath the Sludge Sample CASB3B:2-3; µg/kg, micrograms per kilogram, equals parts per billion (ppb); pg/g, picograms per gram, equals parts per trillion (ppt); µg/L, micrograms per liter; pg/L, picograms per liter; Papermill sludge samples were also analyzed for PCBs and Pesticides. These constituents were not detected in papermill sludge samples]

Sample Identification Sample Date	Units	CASB1C:3-5 08/22/95	CASB2B:2-4 08/22/95	CASB3B:2-3 08/22/95	CASB3B:3-4* 08/22/95	CASB4:2-4 08/23/95
Inorganics						
Aluminum	µg/kg	12,900,000 J	3,910,000 J	5,560,000 J	6,880,000 J	5,360,000 J
Antimony	µg/kg	2090	1,010	1,460	1,140	1,920
Arsenic	µg/kg	5300	1,880	2,240	2,010	2,570
Barium	µg/kg	136,000	37,100	67,300	33,100	93,200
Chromium	µg/kg	75,900	15,400	31,100	13,400	37,900
Copper	µg/kg	239,000	29,200	72,700	7,960	49,100
Cyanide, Total (9012, Automated)	µg/kg	840	390	< 690	< 290	< 850
Iron	µg/kg	6,340,000 J	3,170,000 J	2,970,000 J	8,970,000 J	1,590,000 J
Lead	µg/kg	414,000 J	63,000 J	146,000 J	14,100 J	20,700 J
Magnesium	µg/kg	1470,000	< 787,000	< 1,390,000	2,460,000	< 1,700,000
Manganese	µg/kg	96,800 J	20,900 J	46,000	112,000 J	55,300
Nickel	µg/kg	20,800	7,340	< 11100	10,700	< 13,600
Potassium	µg/kg	< 1,380,000	< 787,000	< 1,390,000	711,000	< 17,00,000
Selenium	µg/kg	1,990	1,160	2150	< 1,140	< 1,700
Vanadium	µg/kg	58,200	13,000	< 13,900	27,600	< 17,000
Zinc	µg/kg	132,000	31,300	45,200	34,000	95,000
Solids, Percent	%	37.8	35.3	31.4	86.7	37.5

Sample Identification Sample Date	Units	CASW-01 11/18/95	Dup. CASW-01 CASW-99 11/18/95	CASW-02 11/18/95
Volatile Organic Compounds				
1,1,1-Trichloroethane	µg/L	< 1.0	< 1.0	< 1.0
1,1,2,2-Tetrachloroethane	µg/L	< 1.0	< 1.0	< 1.0
1,1,2-Trichloroethane	µg/L	< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	µg/L	< 1.0	< 1.0	< 1.0
1,1-Dichloroethene	µg/L	< 1.0	< 1.0	< 1.0
1,2-Dichloroethane	µg/L	< 1.0	< 1.0	<1.0
1,2-Dichloropropane	µg/L	< 1.0	< 1.0	< 1.0
2-Butanone	µg/L	< 10 J	< 10 J	< 10 J
2-Hexanone	µg/L	< 10 R	< 10 R	< 10 r
4-Methyl-2-pentanone	µg/L	< 10 J	< 10 J	< 10 J
Acetone	µg/L	< 10 J	3.8 J	< 10 J
Benzene	µg/L	< 1.0	< 1.0	< 1.0
Bromodichloromethane	µg/L	< 1.0	< 1.0	< 1.0
Bromoform	µg/L	< 1.0	< 1.0	< 1.0
Bromomethane	µg/L	< 1.0	< 1.0	< 1.0
Carbon disulfide	µg/L	< 1.0	< 1.0	< 1.0
Carbon tetrachloride	µg/L	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/L	< 1.0	< 1.0	< 1.0
Chloroethane	µg/L	< 1.0	< 1.0	< 1.0
Chloroform	µg/L	< 1.0	< 1.0	< 1.0
Chloromethane	µg/L	< 1.0	< 1.0	< 1.0
Dibromochloromethane	µg/L	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/L	< 1.0	< 1.0	< 1.0
Methylene chloride	µg/L	< 1.0	< 1.0	< 1.0
Styrene	µg/L	< 1.0	< 1.0	< 1.0
Tetrachloroethene	µg/L	< 1.0	< 1.0	< 1.0
Toluene	µg/L	< 1.0	< 1.0	< 1.0

Appendix A. Results of analysis of papermill sludge and surface-water samples, County Road A disposal site, Ashland County, Wisconsin (modified from Geraghty & Miller, Inc., 1996a, table 5-1, and Appendix M)—Continued

[J, estimated values; R, result was rejected; <, constituent was not detected at the method quanitation limit which follows the "< " sign; *, sample CASB3B:3-4 was a soil sample collected beneath the Sludge Sample CASB3B:2-3; µg/kg, micrograms per kilogram, equals parts per billion (ppb); pg/g, picograms per gram, equals parts per trillion (ppt); µg/L, micrograms per liter; pg/L, picograms per liter; Papermill sludge samples were also analyzed for PCBs and Pesticides. These constituents were not detected in papermill sludge samples]

Sample Identification		CASW-01	Dup. CASW-01 CASW-99	CASW-02
Sample Date	**Units**	**11/18/95**	**11/18/95**	**11/18/95**
Volatile Organic Compounds (con't)				
Trichloroethene	µg/L	< 1.0	< 1.0	< 1.0
Vinyl chloride	µg/L	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/L	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/L	< 1.0	< 1.0	< 1.0
cis-1,3-Dichloropropene	µg/L	< 1.0	< 1.0	< 1.0
trans-1,2-Dichloroethene	µg/L	< 1.0	< 1.0	< 1.0
trans-1,3-Dichloropropene	µg/L	< 1.0	< 1.0	< 1.0
Semi-Volatile Organic Compounds				
1,2,4-Trichlorobenzene	µg/L	< 10	< 11	< 10
1,2-Dichlorobenzene	µg/L	< 10	< 11	< 10
1,3-Dichlorobenzene	µg/L	< 10	< 11	< 10
1,4-Dichlorobenzene	µg/L	< 10	< 11	< 10
2,2'-Oxybis(1-Chloropropane)	µg/L	< 10	< 11	< 10
2,4,5-Trichlorophenol	µg/L	< 10	< 11	< 10
2,4,6-Trichlorophenol	µg/L	< 10	< 11	< 10
2,4-Dichlorophenol	µg/L	< 10	< 11	< 10
2,4-Dimethylphenol	µg/L	< 10	< 11	< 10
2,4-Dinitrophenol	µg/L	< 50	< 55	< 50
2,4-Dinitrotoluene	µg/L	< 10	< 11	< 10
2,6-Dinitrotoluene	µg/L	< 10	< 11	< 10
2-Chloronaphthalene	µg/L	< 10	< 11	< 10
2-Chlorophenol	µg/L	< 10	< 11	< 10
2-Methylnaphthalene	µg/L	< 10	< 11	< 10
2-Methylphenol	µg/L	< 10	< 11	< 10
2-Nitroaniline	µg/L	< 50 J	< 55	< 50 J
2-Nitrophenol	µg/L	< 10	< 11	< 10
3,3'-Dichlorobenzidine	µg/L	< 20	< 22	< 20
3-Nitroaniline	µg/L	< 50	< 55	< 50
4,6-Dinitro-2-methylphenol	µg/L	< 50	< 55	< 50
4-Bromophenyl phenyl ether	µg/L	< 10	< 11	< 10
4-Chloro-3-methylphenol	µg/L	< 10	< 11	< 10
4-Chloroaniline	µg/L	< 10	< 11	< 10
4-Chlorophenyl phenyl ether	µg/L	< 10	< 11	< 10
4-Methylphenol	µg/L	< 10	< 11	< 10
4-Nitroaniline	µg/L	< 50	< 55	< 50
4-Nitrophenol	µg/L	< 50 J	< 55 J	< 50 J
Acenaphthene	µg/L	< 10	< 11	< 10
Acenaphthylene	µg/L	< 10	< 11	< 10
Anthracene	µg/L	< 10	< 11	< 10
Benzo(a)anthracene	µg/L	< 10	< 11	< 10
Benzo(a)pyrene	µg/L	< 10	< 11	< 10
Benzo(b)fluoranthene	µg/L	< 10	< 11	< 10
Benzo(ghi)perylene	µg/L	< 10	< 11	< 10
Benzo(k)fluoranthene	µg/L	< 10	< 11	< 10
Butyl benzyl phthalate	µg/L	< 10	< 11	< 10
Carbazole	µg/L	< 10	< 11	< 10

Appendix A. Results of analysis of papermill sludge and surface-water samples, County Road A disposal site, Ashland County, Wisconsin (modified from Geraghty & Miller, Inc., 1996a, table 5-1, and Appendix M)—Continued

[J, estimated values; R, result was rejected; <, constituent was not detected at the method quanitation limit which follows the "< " sign; *, sample CASB3B:3-4 was a soil sample collected beneath the Sludge Sample CASB3B:2-3; µg/kg, micrograms per kilogram, equals parts per billion (ppb); pg/g, picograms per gram, equals parts per trillion (ppt); µg/L, micrograms per liter; pg/L, picograms per liter; Papermill sludge samples were also analyzed for PCBs and Pesticides. These constituents were not detected in papermill sludge samples]

Sample Identification Sample Date	Units	CASW-01 11/18/95	Dup. CASW-01 CASW-99 11/18/95	CASW-02 11/18/95
Semi-Volatile Organic Compounds (con't)				
Chrysene	µg/L	< 10	< 11	< 10
Di-n-butyl phthalate	µg/L	< 10	< 11	< 10
Di-n-octyl phthalate	µg/L	< 10	< 11	< 10
Dibenz(a,h)anthracene	µg/L	< 10	< 11	< 10
Dibenzofuran	µg/L	< 10	< 11	< 10
Diethyl phthalate	µg/L	< 10	< 11	< 10
Dimethyl phthalate	µg/L	< 10	< 11	< 10
Fluoranthene	µg/L	< 10	< 11	< 10
Fluorene	µg/L	< 10	< 11	< 10
Hexachlorocyclopentadiene	µg/L	< 10	< 11	< 10
Hexachloroethane	µg/L	< 10	< 11	< 10
Indeno(1,2,3-cd)pyrene	µg/L	< 10	< 11	< 10
Isophorone	µg/L	< 10	< 11	< 10
N-Nitrosodi-n-propylamine	µg/L	< 10	< 11	< 10
N-Nitrosodiphenylamine	µg/L	< 10	< 11	< 10
Naphthalene	µg/L	< 10	< 11	< 10
Nitrobenzene	µg/L	< 10	< 11	< 10
Pentachlorophenol	µg/L	< 50	< 55	< 50
Phenanthrene	µg/L	< 10	< 11	< 10
Phenol	µg/L	< 10	< 11	< 10
Pyrene	µg/L	< 10	< 11	< 10
bis(2-Chloroethoxy)methane	µg/L	< 10	< 11	< 10
bis(2-Chloroethyl) ether	µg/L	< 10	< 11	< 10
bis(2-Ethylhexyl) phthalate	µg/L	< 6.0	< 6.6	< 6.0
PCBs				
Aroclor 1260	µg/L	< 1.0	< 1.0	< 1.0
Furan Isomers				
TCDFs (total)	pg/L	< 2.7	< 2.1	< 24
2,3,7,8-TCDF	pg/L	< 2.7	< 2.1	< 4.0
PeCDFs (total)	pg/L	< 3.5	< 1.2	< 22
2,3,4,7,8-PeCDF	pg/L	< 1.3	< 0.73	< 6.8
1,2,3,7,8-PeCDF	pg/L	< 1.7	< 0.80	< 11
HxCDFs (total)	pg/L	< 4.3	< 2.8	< 23
1,2,3,4,7,8-HxCDF	pg/L	< 4.3	< 1.6	< 23
1,2,3,6,7,8-HxCDF	pg/L	< 1.7	< 0.54	< 9.1
2,3,4,6,7,8-HxCDF	pg/L	< 3.4	< 2.8	< 6.8
1,2,3,7,8,9-HxCDF	pg/L	< 1.3	< 0.99	< 3.5
HpCDFs (total)	pg/L	< 8.4	< 7.2	< 21
1,2,3,4,6,7,8-HpCDF	pg/L	< 6.7	< 3.8	< 15
1,2,3,4,7,8,9-HpCDF	pg/L	< 2.0	< 1 0	< 4.4
OCDF	pg/L	< 13	< 9.6	< 22
Dioxin Isomers				
TCDDs (total)	pg/L	< 1.2	< 0.74	< 2.0
2,3,7,8-TCDD	pg/L	< 1.2	< 0.74	< 2.0
PeCDDs (total)	pg/L	< 1.0	< 0.56	< 2.1

Appendix A. Results of analysis of papermill sludge and surface-water samples, County Road A disposal site, Ashland County, Wisconsin (modified from Geraghty & Miller, Inc., 1996a, table 5-1, and Appendix M)—Continued

[J, estimated values; R, result was rejected; <, constituent was not detected at the method quanitation limit which follows the "< " sign; *, sample CASB3B:3-4 was a soil sample collected beneath the Sludge Sample CASB3B:2-3; µg/kg, micrograms per kilogram, equals parts per billion (ppb); pg/g, picograms per gram, equals parts per trillion (ppt); µg/L, micrograms per liter; pg/L, picograms per liter; Papermill sludge samples were also analyzed for PCBs and Pesticides. These constituents were not detected in papermill sludge samples]

Sample Identification		CASW-01	Dup. CASW-01 CASW-99	CASW-02
Sample Date	**Units**	**11/18/95**	**11/18/95**	**11/18/95**
Dioxin Isomers (con't)				
1,2,3,7,8-PeCDD	pg/L	< 1.0	< 0.56	< 2.0
HxCDDs (total)	pg/L	< 7.4	< 7.6	< 16
1,2,3,4,7,8-HxCDD	pg/L	< 0.83	< 0.47	< 1.3
1,2,3,6,7,8-HxCDD	pg/L	< 2.7	< 2.4	< 5.1
1,2,3,7,8,9-HxCDD	pg/L	< 1.9	< 1.9	< 4.5
HpCDDs (total)	pg/L	63	61	85
1,2,3,4,6,7,8-HpCDD	pg/L	30 J	30 J	44 J
OCDD	pg/L	640	580	710
Inorganics				
Cadmium (Total)	µg/L	< 10.0	< 10.0	< 10.0
Chromium (Total)	µg/L	< 20.0	< 20.0	< 20.0
Copper (Total)	µg/L	< 10.0	< 10.0	< 12.5
Cyanide (Total)	µg/L	< 5.0 J	< 5.0	5.3 J
Lead (Total)	µg/L	< 3.0	< 3.0	< 3.0
Selenium (Total)	µg/L	< 5.0	< 5.0	< 5.0
Zinc (Total)	µg/L	< 50.0	< 50.0	98.5
Cadmium (Dissolved)	µg/L	< 10.0	< 10.0	< 10.0
Chromium (Dissolved)	µg/L	< 20.0	< 20.0	< 20.0
Copper (Dissolved	µg/L	< 10.0	< 10.0	< 10.0
Cyanide (Dissolved)	µg/L	< 5.0	< 5.0	< 5.0
Lead (Dissolved)	µg/L	< 3.0 J	< 3.0 J	< 3.0 J
Selenium (Dissolved)	µg/L	< 5.0	< 5.0	< 5.0
Zinc (Dissolved)	µg/L	< 50.0	< 50.0	< 50.0

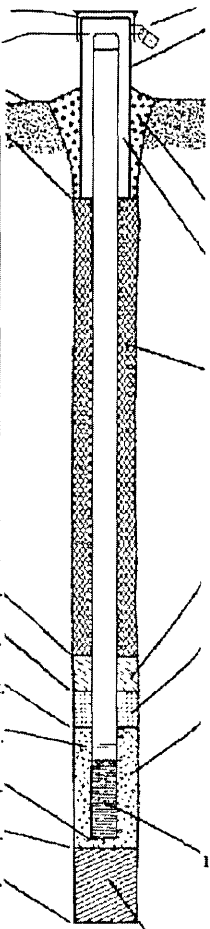
Appendix B. Well construction reports, County Road A disposal site, Ashland County, Wisconsin.

State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐ ____

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name Bad River County Road A	Local Grid Location of Well 0 ft. ☐ N. ☐ S. 0 ft. ☐ E. ☐ W.	Well Name CAMW-6A
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☒ Lat. 0 ° 0 ' 0 " Long. 0 ° 0 ' 0 or	Wis. Unique Well No. JU571 / DNR Well ID No.
Facility ID 0	St. Plane 0 ft. N, 0 ft. E. S/C/N	Date Well Installed 10 / 17 / 97 m m d d y y y y
Type of Well Well Code 11 / mw	Section Location of Waste/Source NW 1/4 of NW 1/4 of Sec. 35, T. 48 N, R. 3 ☒ E ☐ W	Well Installed By: Name (first, last) and Firm James Rauman US Geological Survey - WRD - Wisconsin Dist.
Distance from Waste/ Source 0 ft. / Enf. Stds. Apply ☐	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known Gov. Lot Number 0	



A. Protective pipe, top elevation 0 ft. MSL
B. Well casing, top elevation 640.63 ft. MSL
C. Land surface elevation 638 ft. MSL
D. Surface seal, bottom 0. ft. MSL or 4.8 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ 5 0
Hollow Stem Auger ☒ 4 1
Other ☐ ____

15. Drilling fluid used: Water ☐ 0 2 Air ☐ 0 1
Drilling Mud ☐ 0 3 None ☒ 9 9

16. Drilling additives used? ☐ Yes ☒ No
Describe ____

17. Source of water (attach analysis, if required):
____

E. Bentonite seal, top 0 ft. MSL or 0. ft.
F. Fine sand, top 631.6 ft. MSL or 6.4 ft.
G. Filter pack, top 631 ft. MSL or 7. ft.
H. Screen joint, top 630.6 ft. MSL or 7.4 ft.
I. Well bottom 620.1 ft. MSL or 17.9 ft.
J. Filter pack, bottom 620.1 ft. MSL or 17.9 ft.
K. Borehole, bottom 620.1 ft. MSL or 17.9 ft.
L. Borehole, diameter 8.25 in.
M. O.D. well casing 2.5 in.
N. I.D. well casing 2 in.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
   a. Inside diameter: 4. in.
   b. Length: 7. ft.
   c. Material: Steel ☒ 0 4
   Other ☐ ____
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe: ____
3. Surface seal: Bentonite ☐ 3 0
   Concrete ☒ 0 1
   Other ☐ ____
4. Material between well casing and protective pipe:
   Bentonite ☐ 3 0
   Other ☒ Concrete
5. Annular space seal: a. Granular/Chipped Bentonite ☒ 3 3
   b. 0 Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
   c. 0 Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
   d. 0 % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
   e. 0 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ 0 1
   Tremie pumped ☐ 0 2
   Gravity ☒ 0 8
6. Bentonite seal: a. Bentonite granules ☐ 3 3
   b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒ 3 2
   c. ____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
   a. R. W. Sidley 50
   b. Volume added 0.5 ft^3
8. Filter pack material: Manufacturer, product name & mesh size
   a. R. W. Sidley 30
   b. Volume added 3.25 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ 2 3
   Flush threaded PVC schedule 80 ☐ 2 4
   Other ☐ ____
10. Screen material: PVC
   a. Screen type: Factory cut ☐ 1 1
   Continuous slot ☒ 0 1
   Other ☐ ____
   b. Manufacturer Johnson
   c. Slot size: 0.01 in.
   d. Slotted length: 10 ft.
11. Backfill material (below filter pack): None ☒ 1 4
   Other ☐ ____

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm USGS WRD WI

Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

Appendix B. Well construction reports, County Road A disposal site, Ashland County, Wisconsin.

State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐ ________

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name: Bad River County Road A

Local Grid Location of Well: 0 ft. ☐ N. ☐ S. 0 ft. ☐ E. ☐ W.

Well Name: CAMW-6B

Facility License, Permit or Monitoring No.:

Local Grid Origin ☐ (estimated: ☐) or Well Location ☒

Lat. 0 ° 0 ' 0 " Long. 0 ° 0 ' 0 " or

St. Plane 0 ft. N, 0 ft. E. S/C/N

Wis. Unique Well No.: JU572

DNR Well ID No.:

Facility ID: 0

Date Well Installed: 10 / 16 / 97 (m m d d y y y y)

Type of Well: Well Code 12 / pz

Section Location of Waste/Source: NW 1/4 of NW 1/4 of Sec. 35, T. 48 N, R. 3 ☒ E ☐ W

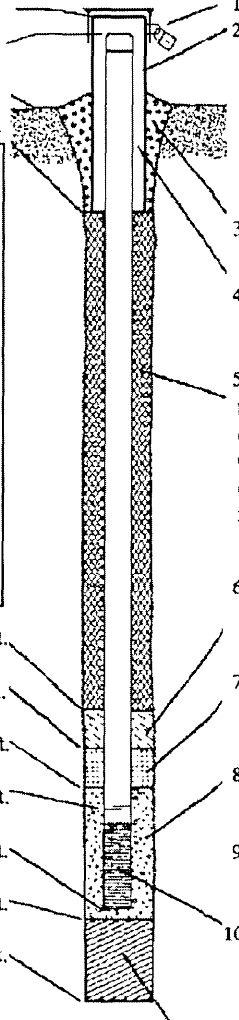
Well Installed By: Name (first, last) and Firm: James Rauman, US Geological Survey - WRD - Wisconsin Dist.

Distance from Waste/Source: 0 ft.

Enf. Stds. Apply ☐

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

Gov. Lot Number: 0



A. Protective pipe, top elevation 0 ft. MSL
B. Well casing, top elevation 640.8 ft. MSL
C. Land surface elevation 637.3 ft. MSL
D. Surface seal, bottom 0. ft. MSL or 5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ 5 0
Hollow Stem Auger ☒ 4 1
Other ☐ ▨

15. Drilling fluid used: Water ☐ 0 2 Air ☐ 0 1
Drilling Mud ☐ 0 3 None ☒ 9 9

16. Drilling additives used? ☐ Yes ☒ No

Describe

17. Source of water (attach analysis, if required):

E. Bentonite seal, top 0 ft. MSL or 0. ft.
F. Fine sand, top 618.3 ft. MSL or 19 ft.
G. Filter pack, top 617.3 ft. MSL or 20 ft.
H. Screen joint, top 615.8 ft. MSL or 21.5 ft.
I. Well bottom 605.3 ft. MSL or 32 ft.
J. Filter pack, bottom 605.3 ft. MSL or 32 ft.
K. Borehole, bottom 605.3 ft. MSL or 32 ft.
L. Borehole, diameter 8.25 in.
M. O.D. well casing 2.5 in.
N. I.D. well casing 2 in.

1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
  a. Inside diameter: 4. in.
  b. Length: 7. ft.
  c. Material: Steel ☒ 0 4
  Other ☐ ▨
  d. Additional protection? ☐ Yes ☒ No
  If yes, describe:

3. Surface seal: Bentonite ☐ 3 0
Concrete ☒ 0 1
Other ☐ ▨

4. Material between well casing and protective pipe:
Bentonite ☐ 3 0
Concrete Other ☒ ▨

5. Annular space seal: a. Granular/Chipped Bentonite ☒ 3 3
  b. 0 Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
  c. 0 Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
  d. 0 % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
  e. 0 Ft^3 volume added for any of the above
  f. How installed: Tremie ☐ 0 1
  Tremie pumped ☐ 0 2
  Gravity ☒ 0 8

6. Bentonite seal: a. Bentonite granules ☐ 3 3
  b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒ 3 2
  c. Other ☐ ▨

7. Fine sand material: Manufacturer, product name & mesh size
  a. R. W. Sidley 50 ▨
  b. Volume added 0.5 ft^3

8. Filter pack material: Manufacturer, product name & mesh size
  a. R. W. Sidley 30 ▨
  b. Volume added 3.25 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒ 2 3
Flush threaded PVC schedule 80 ☐ 2 4
Other ☐ ▨

10. Screen material: PVC ▨
  a. Screen type: Factory cut ☐ 1 1
  Continuous slot ☒ 0 1
  Other ☐ ▨
  b. Manufacturer Johnson
  c. Slot size: 0.01 in.
  d. Slotted length: 10 ft.

11. Backfill material (below filter pack): None ☒ 1 4
Other ☐ ▨

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: MR

Firm: USGS WRD WI

Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

Appendix B. Well construction reports, County Road A disposal site, Ashland County, Wisconsin—Continued.

State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name Bad River County Road A	Local Grid Location of Well 0 ft. ☐ N. ☐ S. 0 ft. ☐ E. ☐ W.	Well Name CAMW-8A
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☒ Lat. 0 ° 0 ' 0 " Long. 0 ° 0 ' 0 or	Wis. Unique Well No. JU573 — DNR Well ID No.
Facility ID 0	St. Plane 0 ft. N, 0 ft. E. S/C/N	Date Well Installed 10 / 16 / 97 m m d d y y y y
Type of Well Well Code 11 / mw	Section Location of Waste/Source NW 1/4 of NW 1/4 of Sec. 35, T. 48 N, R. 3 ☒ E ☐ W	Well Installed By: Name (first, last) and Firm James Rauman
Distance from Waste/Source 0 ft. — Enf. Stds. Apply ☐	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known Gov. Lot Number 0	US Geological Survey - WRD - Wisconsin Dist.

A. Protective pipe, top elevation 0 ft. MSL

B. Well casing, top elevation 644.56 ft. MSL

C. Land surface elevation 641.6 ft. MSL

D. Surface seal, bottom 0. ft. MSL or 4.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ 5 0
Hollow Stem Auger ☒ 4 1
Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐ 0 1
Drilling Mud ☐ 0 3 None ☒ 9 9

16. Drilling additives used? ☐ Yes ☒ No

Describe

17. Source of water (attach analysis, if required):

E. Bentonite seal, top 0 ft. MSL or 0 ft.

F. Fine sand, top 632.4 ft. MSL or 9.2 ft.

G. Filter pack, top 630.9 ft. MSL or 10.7 ft.

H. Screen joint, top 629.5 ft. MSL or 12.1 ft.

I. Well bottom 619.1 ft. MSL or 22.5 ft.

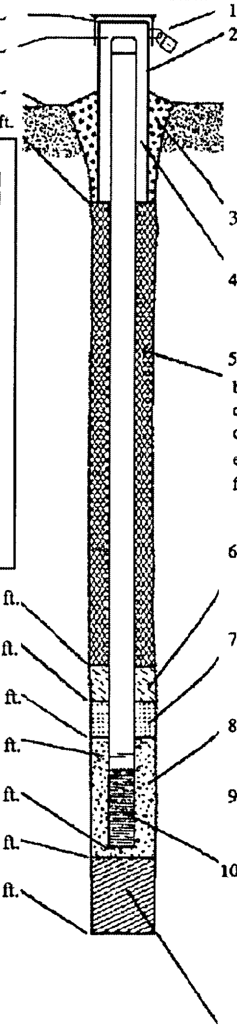
J. Filter pack, bottom 619.1 ft. MSL or 22.5 ft.

K. Borehole, bottom 619.1 ft. MSL or 22.5 ft.

L. Borehole, diameter 8.25 in.

M. O.D. well casing 2.5 in.

N. I.D. well casing 2 in.



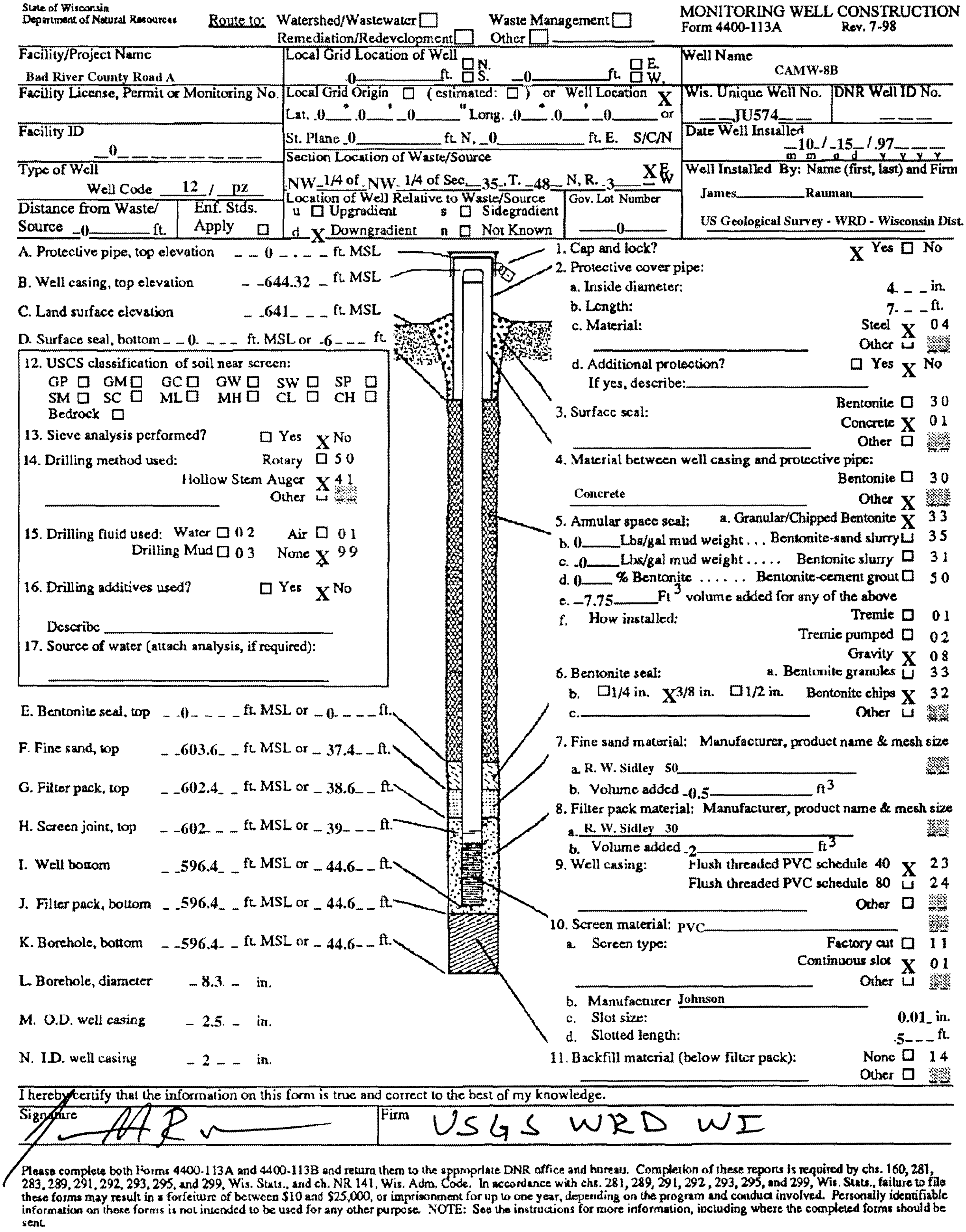
1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
   a. Inside diameter: 4 in.
   b. Length: 7 ft.
   c. Material: Steel ☒ 0 4
   Other ☐
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe:
3. Surface seal: Bentonite ☐ 3 0
   Concrete ☒ 0 1
   Other ☐
4. Material between well casing and protective pipe:
   Bentonite ☐ 3 0
   Concrete Other ☒
5. Annular space seal: a. Granular/Chipped Bentonite ☒ 3 3
   b. 0 Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
   c. 0 Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
   d. 0 % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
   e. 0 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ 0 1
   Tremie pumped ☐ 0 2
   Gravity ☒ 0 8
6. Bentonite seal: a. Bentonite granules ☐ 3 3
   b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒ 3 2
   c. Other ☒
7. Fine sand material: Manufacturer, product name & mesh size
   a. R. W. Sidley 50
   b. Volume added 0.5 ft^3
8. Filter pack material: Manufacturer, product name & mesh size
   a. R. W. Sidley 30
   b. Volume added 3.25 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ 2 3
   Flush threaded PVC schedule 80 ☐ 2 4
   Other ☐
10. Screen material: PVC
    a. Screen type: Factory cut ☐ 1 1
    Continuous slot ☒ 0 1
    Other ☐
    b. Manufacturer Johnson
    c. Slot size: 0.01 in.
    d. Slotted length: 10 ft.
11. Backfill material (below filter pack): None ☐ 1 4
    Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm USGS WRD WI

Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

Appendix B. Well construction reports, County Road A disposal site, Ashland County, Wisconsin—Continued.



State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐ ______

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name: Bad River County Road A

Local Grid Location of Well: 0 ft. ☐ N. ☐ S. 0 ft. ☐ E. ☐ W.

Well Name: CAMW-8B

Facility License, Permit or Monitoring No.

Local Grid Origin ☐ (estimated: ☐) or Well Location X

Lat. 0 ° 0 ' 0 " Long. 0 ° 0 ' 0 or

St. Plane 0 ft. N, 0 ft. E. S/C/N

Wis. Unique Well No. JU574

DNR Well ID No.

Facility ID: 0

Section Location of Waste/Source: NW 1/4 of NW 1/4 of Sec. 35, T. 48 N, R. 3 X E ☐ W

Date Well Installed: 10 / 15 / 97 (m m d d y y y y)

Type of Well: Well Code 12 / pz

Well Installed By: Name (first, last) and Firm: James Rauman, US Geological Survey - WRD - Wisconsin Dist.

Distance from Waste/Source 0 ft.

Enf. Stds. Apply ☐

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d X Downgradient n ☐ Not Known

Gov. Lot Number: 0

A. Protective pipe, top elevation 0 ft. MSL

B. Well casing, top elevation 644.32 ft. MSL

C. Land surface elevation 641 ft. MSL

D. Surface seal, bottom 0. ft. MSL or 6 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes X No

14. Drilling method used: Rotary ☐ 5 0; Hollow Stem Auger X 4 1; Other ☐

15. Drilling fluid used: Water ☐ 0 2; Air ☐ 0 1; Drilling Mud ☐ 0 3; None X 9 9

16. Drilling additives used? ☐ Yes X No

Describe ______

17. Source of water (attach analysis, if required): ______

E. Bentonite seal, top 0 ft. MSL or 0. ft.

F. Fine sand, top 603.6 ft. MSL or 37.4 ft.

G. Filter pack, top 602.4 ft. MSL or 38.6 ft.

H. Screen joint, top 602 ft. MSL or 39 ft.

I. Well bottom 596.4 ft. MSL or 44.6 ft.

J. Filter pack, bottom 596.4 ft. MSL or 44.6 ft.

K. Borehole, bottom 596.4 ft. MSL or 44.6 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.5 in.

N. I.D. well casing 2 in.

1. Cap and lock? X Yes ☐ No

2. Protective cover pipe:
   a. Inside diameter: 4. in.
   b. Length: 7. ft.
   c. Material: Steel X 0 4; Other ☐
   d. Additional protection? ☐ Yes X No
   If yes, describe: ______

3. Surface seal: Bentonite ☐ 3 0; Concrete X 0 1; Other ☐

4. Material between well casing and protective pipe: Bentonite ☐ 3 0; Concrete Other X

5. Annular space seal: a. Granular/Chipped Bentonite X 3 3
   b. 0 Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
   c. 0 Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
   d. 0 % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
   e. 7.75 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ 0 1; Tremie pumped ☐ 0 2; Gravity X 0 8

6. Bentonite seal: a. Bentonite granules ☐ 3 3
   b. ☐ 1/4 in. X 3/8 in. ☐ 1/2 in. Bentonite chips X 3 2
   c. ______ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
   a. R. W. Sidley 50
   b. Volume added 0.5 ft^3

8. Filter pack material: Manufacturer, product name & mesh size
   a. R. W. Sidley 30
   b. Volume added 2 ft^3

9. Well casing: Flush threaded PVC schedule 40 X 2 3; Flush threaded PVC schedule 80 ☐ 2 4; Other ☐

10. Screen material: PVC
   a. Screen type: Factory cut ☐ 1 1; Continuous slot X 0 1; Other ☐
   b. Manufacturer Johnson
   c. Slot size: 0.01 in.
   d. Slotted length: 5 ft.

11. Backfill material (below filter pack): None ☐ 1 4; Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature

Firm USGS WRD WI

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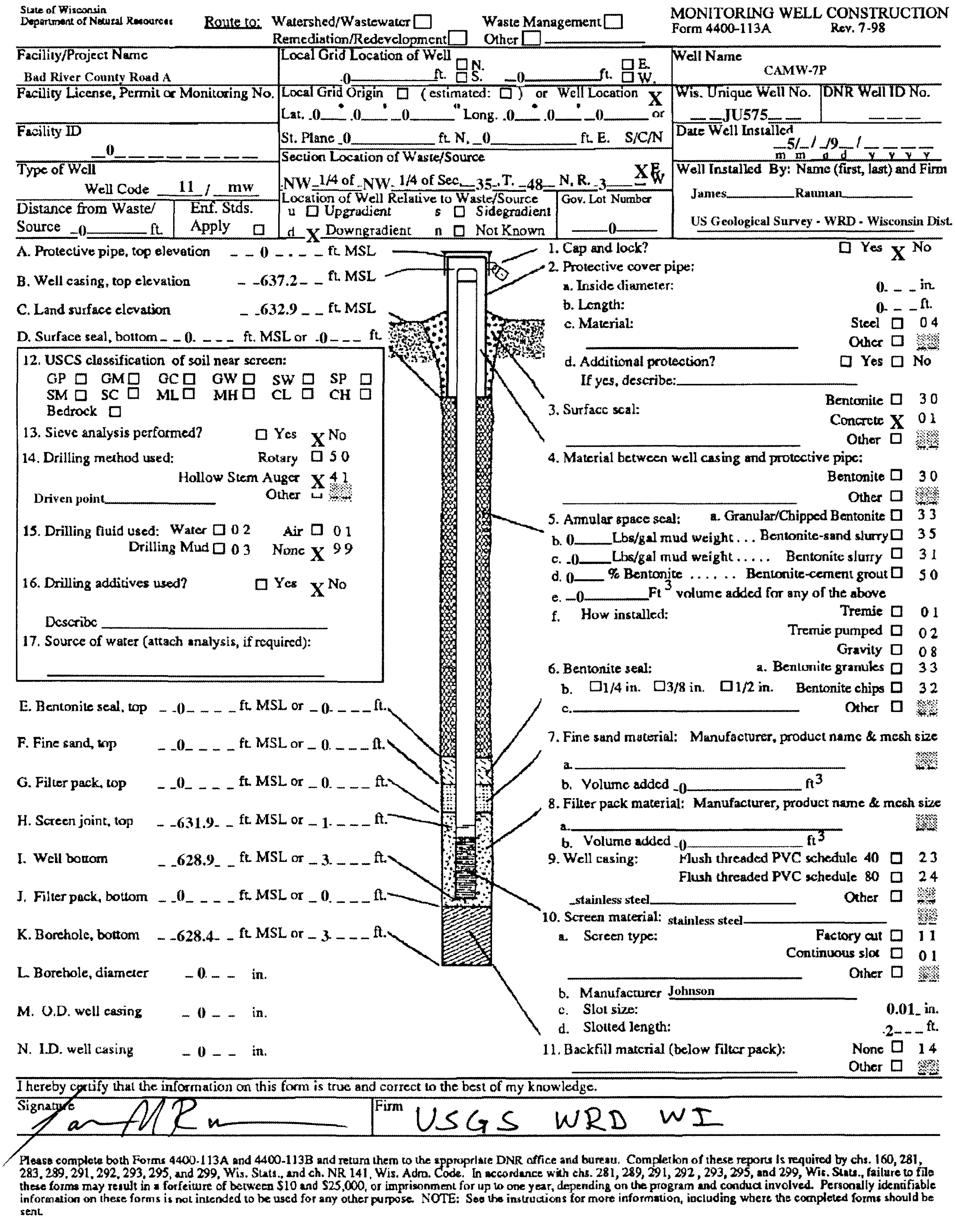
Appendix B. Well construction reports, County Road A disposal site, Ashland County, Wisconsin—Continued.



State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐ ______

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name: Bad River County Road A

Local Grid Location of Well: 0 ft. ☐ N. ☐ S. 0 ft. ☐ E. ☐ W.

Well Name: CAMW-7P

Facility License, Permit or Monitoring No.

Local Grid Origin ☐ (estimated: ☐) or Well Location X

Lat. 0 ° 0 ' 0 " Long. 0 ° 0 ' 0 or

St. Plane 0 ft. N, 0 ft. E. S/C/N

Wis. Unique Well No.: JU575

DNR Well ID No.

Facility ID: 0

Section Location of Waste/Source

NW 1/4 of NW 1/4 of Sec. 35, T. 48 N, R. 3 X E ☐ W

Date Well Installed: 5/ / 9 / (m m d d y y y y)

Type of Well: Well Code 11 / mw

Well Installed By: Name (first, last) and Firm: James Rauman, US Geological Survey - WRD - Wisconsin Dist.

Distance from Waste/Source 0 ft.

Enf. Stds. Apply ☐

Location of Well Relative to Waste/Source
u ☐ Upgradient s ☐ Sidegradient
d X Downgradient n ☐ Not Known

Gov. Lot Number: 0

A. Protective pipe, top elevation 0 ft. MSL

B. Well casing, top elevation 637.2 ft. MSL

C. Land surface elevation 632.9 ft. MSL

D. Surface seal, bottom 0. ft. MSL or 0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes X No

14. Drilling method used: Rotary ☐ 5 0
Hollow Stem Auger X 4 1
Other ☐ ▨
Driven point ______

15. Drilling fluid used: Water ☐ 0 2 Air ☐ 0 1
Drilling Mud ☐ 0 3 None X 9 9

16. Drilling additives used? ☐ Yes X No

Describe ______

17. Source of water (attach analysis, if required):

E. Bentonite seal, top 0 ft. MSL or 0. ft.

F. Fine sand, top 0 ft. MSL or 0. ft.

G. Filter pack, top 0 ft. MSL or 0. ft.

H. Screen joint, top 631.9 ft. MSL or 1. ft.

I. Well bottom 628.9 ft. MSL or 3. ft.

J. Filter pack, bottom 0 ft. MSL or 0. ft.

K. Borehole, bottom 628.4 ft. MSL or 3. ft.

L. Borehole, diameter 0. in.

M. O.D. well casing 0 in.

N. I.D. well casing 0 in.

1. Cap and lock? ☐ Yes X No

2. Protective cover pipe:
a. Inside diameter: 0. in.
b. Length: 0. ft.
c. Material: Steel ☐ 0 4
Other ☐ ▨
d. Additional protection? ☐ Yes ☐ No
If yes, describe: ______

3. Surface seal: Bentonite ☐ 3 0
Concrete X 0 1
Other ☐ ▨

4. Material between well casing and protective pipe:
Bentonite ☐ 3 0
Other ☐ ▨

5. Annular space seal: a. Granular/Chipped Bentonite ☐ 3 3
b. 0 Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
c. 0 Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
d. 0 % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
e. 0 Ft^3 volume added for any of the above
f. How installed: Tremie ☐ 0 1
Tremie pumped ☐ 0 2
Gravity ☐ 0 8

6. Bentonite seal: a. Bentonite granules ☐ 3 3
b. ☐1/4 in. ☐3/8 in. ☐1/2 in. Bentonite chips ☐ 3 2
c. ______ Other ☐ ▨

7. Fine sand material: Manufacturer, product name & mesh size
a. ______ ▨
b. Volume added 0 ft^3

8. Filter pack material: Manufacturer, product name & mesh size
a. ______ ▨
b. Volume added 0 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☐ 2 3
Flush threaded PVC schedule 80 ☐ 2 4
stainless steel Other ☐ ▨

10. Screen material: stainless steel ▨
a. Screen type: Factory cut ☐ 1 1
Continuous slot ☐ 0 1
Other ☐ ▨
b. Manufacturer Johnson
c. Slot size: 0.01 in.
d. Slotted length: 2 ft.

11. Backfill material (below filter pack): None ☐ 1 4
Other ☐ ▨

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature

Firm USGS WRD WI

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Appendix B. Well construction reports, County Road A disposal site, Ashland County, Wisconsin—Continued.

Appendix C. Meteorological data collected at the airport at Minocqua, Wisconsin, and estimates of evaporation for the period May 5 to August 18, 1998.

Hydrogeology and Ground-Water Quality of the County Road A Disposal Site on the Bad River Indian Reservation,
Ashland County, Wisconsin: 1997–98

WRIR 01–4082