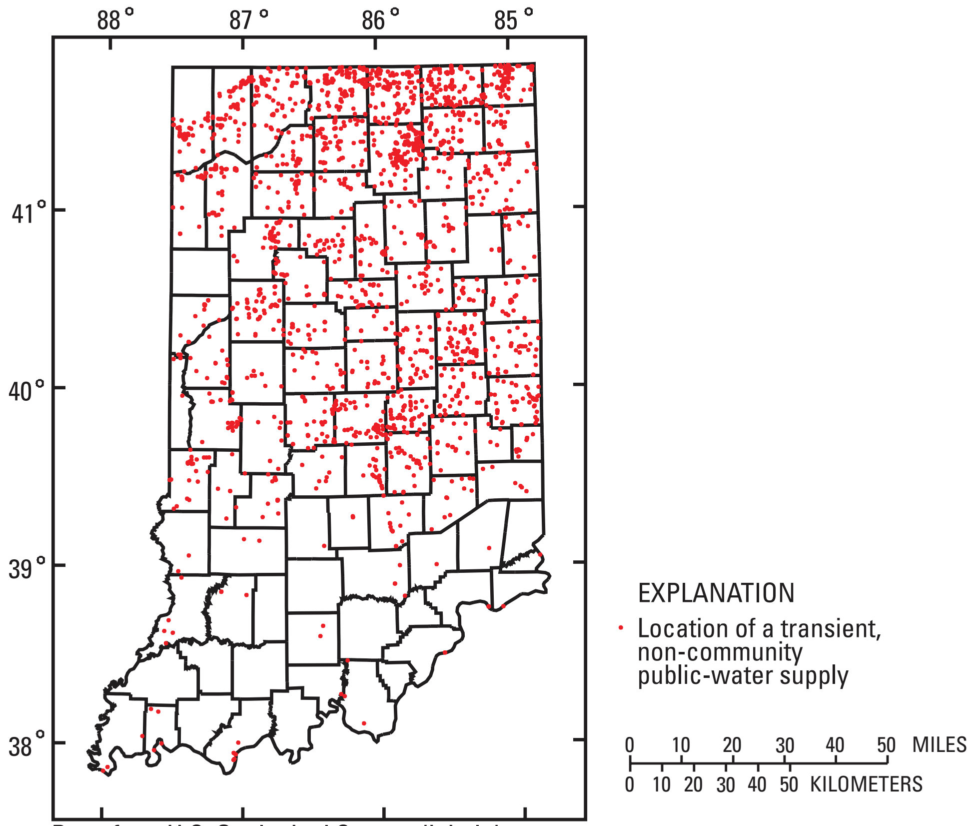
Prepared in cooperation with the Indiana Department of Environmental Management

Methods Used to Assess the Susceptibility to Contamination of Transient, Non-Community Public Ground-Water Supplies in Indiana



Base from U.S. Geological Survey digital data 1:100,000, 1983. Universal Transverse Mercator projection, Zone 16, North American Datum 1983

Scientific Investigations Report 2005–5059

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors, Abbreviations, and Datums

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
meter (m)	3.281	foot (ft)
mile (mi)	1.609	kilometer (km)
meter (m)	3.281	foot (ft)
	Mass	
kilogram (kg)	2.2046	pounds (lb)

Chemical concentrations and water temperature are given in metric units in milligrams per liter (mg/L). A milligram per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water.

Abbreviations

COC — Contaminant of concern

COCs —Contaminants of concern

DEM — Digital elevation model

GIS — Geographic information system

IDEM — Indiana Department of Environmental Management

IDNR — Indiana Department of Natural Resources

N — Nitrogen

NWIS — National Water Information System

PCS — Permit Compliance System

SIC — Standard Industrial Classification

SWA — Source-water assessment

SWAP — Source-Water Assessment Plan

TNC — Transient, non-community

TRI — Toxics Release Inventory

USEPA — U.S. Environmental Protection Agency

USGS — U.S. Geological Survey

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Methods Used to Assess the Susceptibility to Contamination of Transient, Non-Community Public Ground-Water Supplies in Indiana

By Leslie D. Arihood and David A. Cohen

Abstract

The Safe Water Drinking Act of 1974 as amended in 1996 gave each State the responsibility of developing a Source-Water Assessment Plan (SWAP) that is designed to protect public-water supplies from contamination. Each SWAP must include three elements: (1) a delineation of the source-water protection area, (2) an inventory of potential sources of contaminants within the area, and (3) a determination of the susceptibility of the public-water supply to contamination from the inventoried sources. The Indiana Department of Environmental Management (IDEM) was responsible for preparing a SWAP for all public-water supplies in Indiana, including about 2,400 small public ground-water supplies that are designated transient, non-community (TNC) supplies. In cooperation with IDEM, the U.S. Geological Survey compiled information on conditions near the TNC supplies and helped IDEM complete source-water assessments for each TNC supply.

The delineation of a source-water protection area (called the assessment area) for each TNC ground-water supply was defined by IDEM as a circular area enclosed by a 300-foot radius centered at the TNC supply well. Contaminants of concern (COCs) were defined by IDEM as any of the 90 contaminants for which the U.S. Environmental Protection Agency has established primary drinking-water standards. Two of these, nitrate as nitrogen and total coliform bacteria, are Indiana State-regulated contaminants for TNC water supplies. IDEM representatives identified potential point and nonpoint sources of COCs within the assessment area, and computer database retrievals were used to identify potential point sources of COCs in the area outside the assessment area.

Two types of methods—subjective and subjective hybrid—were used in the SWAP to determine susceptibility to contamination. Subjective methods involve decisions based upon professional judgment, prior experience, and (or) the application of a fundamental understanding of processes without the collection and analysis of data for a specific condition. Subjective hybrid methods combine subjective methods with quantitative hydrologic analyses.

The subjective methods included an inventory of potential sources and associated contaminants, and a qualitative description of the inherent susceptibility of the area around the TNC supply. The description relies on a classification of the hydrogeologic and geomorphic characteristics of the general area around the TNC supply in terms of its surficial geology, regional aquifer system, the occurrence of fine- and coarse-grained geologic materials above the screen of the TNC well, and the potential for infiltration of contaminants. The subjective hybrid method combined the results of a logistic regression analysis with a subjective analysis of susceptibility and a subjective set of definitions that classify the thickness of fine-grained geologic materials above the screen of a TNC well in terms of impedance to vertical flow. The logistic regression determined the probability of elevated concentrations of nitrate as nitrogen (greater than or equal to 3 milligrams per liter) in ground water associated with specific thicknesses of fine-grained geologic materials above the screen of a TNC well. In this report, fine-grained geologic materials are referred to as a geologic barrier that generally impedes vertical flow through an aquifer. A geologic barrier was defined to be thin for fine-grained materials between 0 and 45 feet thick, moderate for materials between 45 and 75 feet thick, and thick if the fine-grained materials were greater than 75 feet thick.

A flow chart was used to determine the susceptibility rating for each TNC supply. The flow chart indicated a susceptibility rating using (1) concentrations of nitrate as nitrogen and total coliform bacteria reported from routine compliance monitoring of the TNC supply, (2) the presence or absence of potential sources of regulated contaminants (nitrate as nitrogen and coliform bacteria) within the assessment area, and (3) the thickness of the geologic barrier above the TNC well screen. The possible susceptibility ratings were: "currently not susceptible," "moderately susceptible," or "susceptible," A rating of susceptible was automatically given to a TNC supply if there was a detection of coliform bacteria or a concentration of nitrate as nitrogen greater than 3 mg/L in any compliance-monitoring sample. Less than 2 percent (43) of the TNC supplies could not be rated because they were new and no compliance-monitoring data were available. Only one of the

TNC supplies was rated not currently susceptible, approximately 7 percent (164) were rated moderately susceptible, and approximately 91 percent (2,144) were rated susceptible. Of the 2,144 TNC supplies rated susceptible, approximately 79 percent (1,694) had a detection of coliform bacteria or a concentration of nitrate as nitrogen greater than 3 mg/L in at least one compliance-monitoring sample.

Introduction

Amendments made in 1996 to the Safe Drinking Water Act of 1974 required a Source-Water Assessment Plan (SWAP) to be developed by each State under the direction of the U.S. Environmental Protection Agency (USEPA) (U.S. Environmental Protection Agency, 1997, p. 2-1). A SWAP is designed to protect public-water supplies from contamination. A SWAP must include three elements: (1) a delineation of the source-water protection area, (2) an inventory of potential sources of contaminants within the area, and (3) a determination of the susceptibility of the public-water supply to the sources inventoried (U.S. Environmental Protection Agency, 1997, p. 2-12). The inventory of potential sources identifies sites that may release any of the 90 contaminants for which the USEPA has established primary drinking-water standards (Indiana Department of Environmental Management, 2000, Appendix E; U.S. Environmental Protection Agency, 2002). In the remainder of this report, these 90 contaminants will be referred to as the "contaminants of concern" (COCs), with a single contaminant of concern abbreviated as "COC." Under the guidelines of Indiana's SWAP, a source-water assessment (SWA) must be prepared for all large and small public-water supplies that use surface water and (or) ground water as their source. The Indiana Department of Environmental Management (IDEM) is responsible for administering the SWAP for Indiana. Part of their responsibility is to explain the methods used to accomplish the goals of each element of the SWAP.

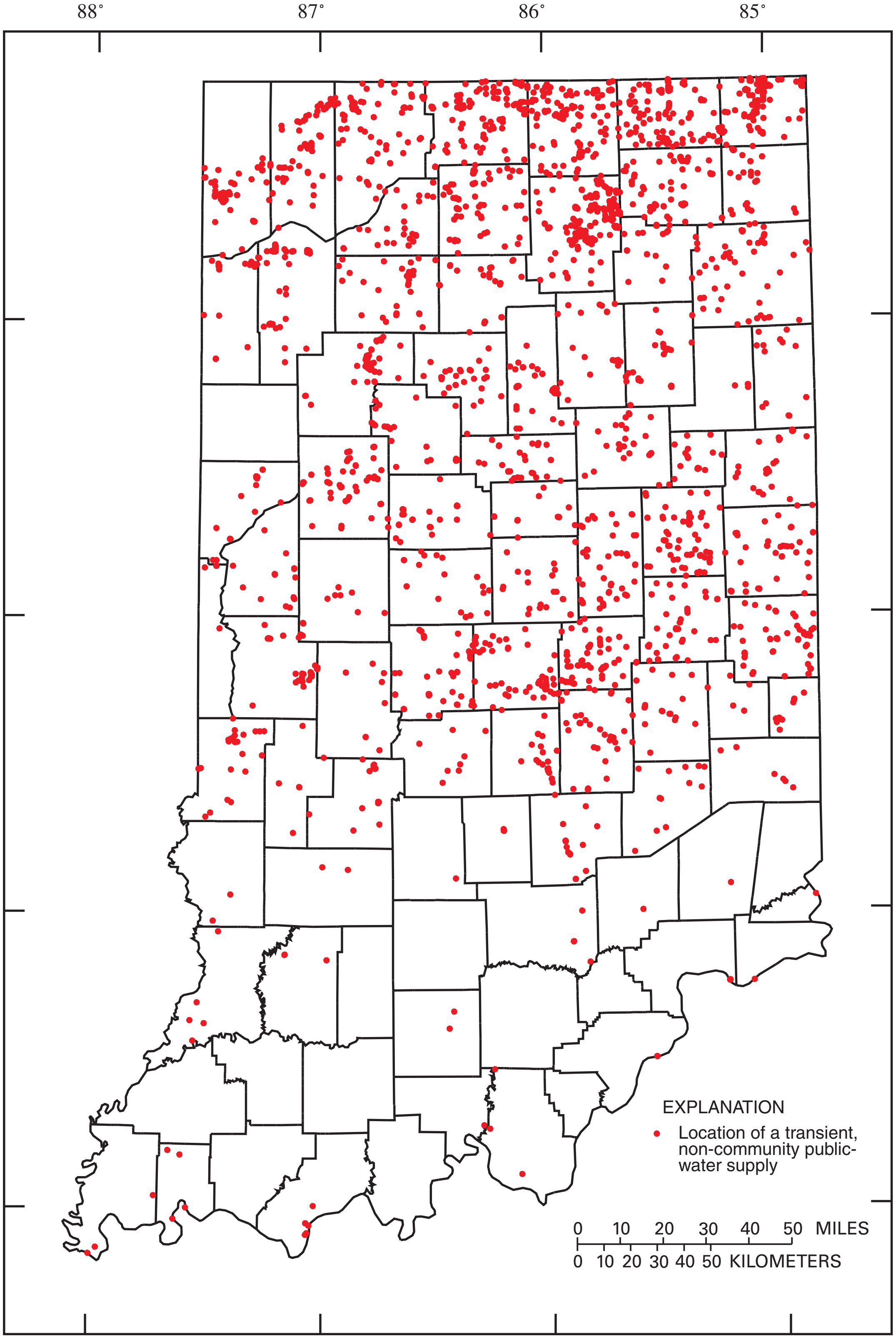
Indiana's Source-Water Assessment Plan

The U.S. Geological Survey (USGS), in cooperation with the IDEM, compiled data and provided technical assistance in the preparation of SWAs for the small public ground-water supplies designated as transient, non-community (TNC) supplies. TNC supplies include facilities using low pump-rate ground-water supplies and serving people who remain at the facility for short periods. Examples of TNC supplies are motels, gasoline stations, churches, golf-course clubhouses, and restaurants. As of 1999, there were approximately 2,400 such facilities in Indiana (Indiana Department of Environmental Management, 2000, p. 31) (fig. 1). A school would not be classified as a TNC supply because the public (students and staff) remain at the facility all day for many days in any given year.

The IDEM's approach to the preparation of a SWA for TNC supplies is based upon the three elements required by USEPA in a SWAP. The delineation of a source-water-protection area (hereinafter referred to as assessment area) was defined by IDEM to be the circular area within a 300-ft radius centered at the TNC supply well (Indiana Department of Environmental Management, 2000, p. 31). A potential source of COCs was defined by IDEM as an activity, facility, location, or land use associated with the handling, usage, storage, or generation of any COCs (Indiana Department of Environmental Management, 2000, p. 20, 24, 27). The potential sources of COCs generally were classified as either point sources (above-ground storage tanks, dry cleaning stores, utility substations) or nonpoint sources (agricultural cropland, camp grounds, golf courses).

Susceptibility has been defined by IDEM as the potential for a public-water system to draw water contaminated by inventoried sources of COCs that would pose concern for water operators or consumers (Indiana Department of Environmental Management, 2000, p. 19). The IDEM requested that the analysis of susceptibility for a TNC supply include consideration of several conditions present in the assessment area, such as (1) land use; (2) the presence or absence of low-permeability geologic materials; (3) general aquifer characteristics, including ground-water flow direction; and (4) presence and proximity of potential sources of COCs to the well, with particular emphasis on potential sources of nitrate as nitrogen and coliform bacteria, which are the only COCs that are regulated for TNC supplies in Indiana (Indiana Department of Environmental Management, 2000, p. 19, 31; Indiana Administrative Code, 2006), and are hereafter referred to as "regulated COCs" in this report. These conditions were assessed and used by the USGS in a susceptibility analysis for the TNC supplies.

In cooperation with the IDEM, the USGS compiled information about conditions near the TNC supplies to perform a susceptibility analysis for the nearly 2,400 TNC supplies in Indiana. The information consisted of a compilation of potential sources and associated regulated COCs, land use, surficial and subsurface geologic materials, regional aquifer descriptions, land slope, and ground-water level data. The information was used with qualitative and quantitative methods to assess the susceptibility of each TNC supply to contamination and to prepare 2-page reports for distribution by the IDEM to the general public.



Base from U.S. Geological Survey digital data 1:100,000. 1983
Universal Transverse Mercator projection, Zone 16, North American Datum 1983

Figure 1. Transient, non-community public-water supplies in Indiana.

Purpose and Scope

This report describes the details of the methods and terminology used by the IDEM and the USGS to complete a susceptibility analysis for about 2,400 TNC ground-water supplies. The report includes details of methods used to provide general, qualitative assessments of susceptibility as well as methods used to obtain a specific susceptibility rating. The report distinguishes the methods according to their use of professional judgment and quantitative hydrologic analysis.

Methods Used to Assess the Susceptibility to Contamination

Some methods were used to describe susceptibility of TNC supplies qualitatively without specifying a degree of susceptibility, and other methods were used to classify susceptibility into one of three susceptibility ratings. The qualitative description of susceptibility used subjective methods, and the rating of susceptibility used both subjective and subjective hybrid methods.

Subjective methods are those in which professional judgment is used to delineate assessment areas, classify conditions, and analyze susceptibility. For example, the assessment area for a TNC supply was subjectively chosen by the IDEM as a fixed radius of 300 ft around the well. The IDEM considers this area sufficiently large to include the area contributing water to the well in most cases, given what generally is known about ground-water travel times in Indiana (Indiana Department of Environmental Management, 2000, p. 28, 31). The term "subjective" should not infer a concept of inferior or potentially incorrect analysis. Subjective methods involve decisions that are made on the basis of prior experience and (or) application of a fundamental understanding of processes without the collection and analysis of data for a specific condition (Focazio and others, 2002). The SWAP could not be completed without subjective decisions.

Subjective hybrid methods combine subjective methods with quantitative hydrologic analyses. For example, a logistic regression analysis was used to quantify a relation between the concentration of nitrate as nitrogen in ground water and the thickness of fine-grained geologic materials above a well screen. Interpretations based upon this quantitative relation, in combination with qualitative information, were used to subjectively assign each TNC supply to one of three susceptibility ratings. Focazio and others (2002) provide additional details regarding the definition and use of subjective and subjective hybrid methods in assessing ground-water susceptibility to contamination. An example of the application of these methods to a specific site is provided in Appendix 1, which contains the source-water-assessment report for a gasoline service station in Marion County, Indiana.

Methods Used to Qualitatively Describe Susceptibility

Two subjective methods were used to qualitatively describe susceptibility to contamination for the TNC ground-water supplies. The first method determined the presence of potential sources of contaminants in and around the assessment area and identified COCs that may be associated with each of these sources. The second subjective method provided a description of susceptibility based upon hydrogeologic and geomorphic characteristics in the general area of the TNC supply.

Presence of Potential Sources and Associated Contaminants of Concern

During on-site visits to each TNC supply, IDEM representatives identified potential point and nonpoint sources of COCs within the assessment area. Point sources were located using mapping-grade global positioning equipment, and nonpoint sources were visually estimated as a percentage of the assessment area. The relation between potential contaminant sources in the assessment area and specific COCs was based upon a reference prepared by the USEPA called "Potential Sources of Drinking-Water Contamination Index" (U.S. Environmental Protection Agency, 2004, Appendix 2) that lists potential contaminant sources and associated COCs .

Potential point sources outside the assessment area, but within the area of the figures in the SWA reports for the TNC supplies, were identified by a geographic-information-system (GIS) retrieval from 22 computerized databases (table 1).

Many of the records in these databases contained a Standard Industrial Classification (SIC) code that describes the type of facility or activity associated with the potential point source (Office of Management and Budget, 1987). Identification of associated COCs with these potential sources was based upon information obtained from the Toxics Release Inventory (TRI) (U.S. Environmental Protection Agency, 1999) and the Permit Compliance System (PCS) (Joe Lewis, Data Management Branch, U.S. Environmental Protection Agency, written commun., October 26, 1999) databases. The TRI and PCS databases include records that identify a SIC code representing a type of facility or activity and COCs that are associated with that type of facility or activity. Records from both databases were combined to form a table (the TRI-PCS table) that relates SIC codes to associated COCs. For records of potential point sources outside an assessment area that contained a SIC code, the TRI-PCS table was used to identify associated COCs.

For records of potential point sources outside the assessment area that did not have a SIC code, an attempt was made to use the available computerized information in those records to match an appropriate category in the USEPA reference

"Potential Sources of Drinking-Water Contamination Index" (U.S. Environmental Protection Agency, 2004, Appendix 2) to identify associated COCs. For example, if the computerized record for a potential point source outside the assessment area lacked a SIC code, but had the name "XYZ Gas Station #63," then this potential point source would be associated with the COCs listed for the category "Gas Stations" in the Appendix 2 reference. There were some identified potential point sources outside the assessment area that could not be associated with any COCs, either because their SIC codes were not associated with any COCs in the TRI-PCS table, or, if the computer record did not contain a SIC code, the remaining computerized information was insufficient to allow a matching category to be identified in the USEPA reference.

All potential point sources were included in a table associated with the SWA report for the TNC supply (Appendix 1). The table included the following information: name and type of potential point source; location method; data source, either from an on-site visit inside the assessment area or from a computer database retrieval outside the assessment area; associated regulated COCs; and all associated COCs. Potential nonpoint sources, their respective estimated percentage of the assessment area, associated regulated COCs, and all associated COCs, were included in a second table associated with the SWA report for the TNC supply (Appendix 1).

The COCs listed in the tables may not always be present at a given potential source, and the list of contaminants may not include all contaminants that could be present. Both tables were accessed via a hyperlink in the SWA report. Additionally, all potential point sources of contamination were plotted on figure 2 of the SWA report for the TNC supply (Appendix 1). A larger number of potential sources of COCs can indicate a greater susceptibility of the water supply to contaminant releases. The information regarding the presence of potential sources of regulated COCs was used as a factor in the subjective hybrid method described in the section "Methods Used to Determine a Susceptibility Rating."

Hydrogeologic and Geomorphic Descriptions

The second subjective method used in the SWAP was a qualitative description of the inherent susceptibility to contamination of the general area around the TNC supply. The description was not meant to provide a specific susceptibility rating for a TNC supply, but to provide additional information about general susceptibility. The qualitative description relied on hydrogeologic and geomorphic characteristics of the assessment and surrounding area. For example, if an area is underlain by thick clays, the vertical movement of contaminants is restricted by the low hydraulic conductivity typically associated with the fine-grained materials contained in the clay (Freeze and Cherry, 1979, p. 29). The presence of fine-grained geologic materials above an aquifer is considered by IDEM to provide some degree of protection from contamination by surface contaminants—the thicker the fine-grained materials the greater the degree of protection (Indiana Department of Environmental Management, 2000, p. 18-19). Five hydrogeologic and geomorphic characteristics were used to qualitatively describe the susceptibility of the assessment area: typical geologic materials above the TNC well screen, surficial geology, regional aquifer system, land slope, and ground-water flow direction (Appendix 1). The following paragraphs explain the susceptibility interpretations based on these characteristics and present the text used in the SWA reports for the TNC supplies. The order of presentation of the material parallels the order used in the TNC reports.

The geologic materials above the TNC well screen are the most influential in determining the well's inherent sensitivity to surface contaminants. Fine-grained geologic materials, which IDEM generally refers to as a low-permeability clay layer or an aquitard (Indiana Department of Environmental Management, 2000, p. 19), provide the most protection from surface contaminants. A list of the most typical geologic materials above the TNC well screen were determined by an analysis of drillers' logs of local water wells from the computerized well-log database maintained by the Indiana Department of Natural Resources (IDNR) (Indiana Department of Natural Resources, 2006). The water-well logs provide a description of the occurrence and thickness of geologic materials that the driller encountered as each well was being drilled. The well logs within a 2-mi radius of the TNC supply well were compiled to determine the geologic materials typically encountered and the thickness of each type of material. A file listing unique geologic materials and the total thickness of each was generated that represents the most typical geologic materials between the land surface and the bottom of the TNC well. The file was sorted by thickness, and the geologic materials having the three greatest thicknesses were provided in the TNC report. For example, the three most abundant lithologies above the TNC well screen described in Appendix 1 are clay, gravel, and shale. Determining the most abundant geologic materials above the TNC well screen is dependent upon the depth of the TNC well, which was not always known. Well depths for TNC wells with unknown depths were estimated using a conservative method that should underestimate the actual well depth for a given TNC well. The following method was used to estimate a well depth:

1. Records of domestic water wells within a 5-mi radius of the TNC supply were selected. Records of industrial, irrigation, or other high-capacity wells within that radius were not included in the selection because they were expected to be deeper than a typical TNC well. If there were fewer than 100 well records in the 5-mi radius, the radius was expanded until at least 100 records were selected.

2. The selected well records were sorted by the depth of each well.

Table 1. Electronic data sets for identifying potential point sources of contamination outside the assessment area for a transient, non-community public-water supply.

[USEPA, U.S. Environmental Protection Agency; IDEM–OLQ, Indiana Department of Environmental Management–Office of Land Quality; IAC, Indiana Administrative Code; IC, Indiana Code; UST, underground storage tank; IDEM–OWQ, Indiana Department of Environmental Management–Office of Water Quality; NPL, National Priorities List; RCRA, Resource Conservation and Recovery Act; IGS, Indiana Geological Survey; USEPA–BASINS, U.S. Environmental Protection Agency–Better Assessment Science Integrating Point and Nonpoint Sources]

Data set name/description	Data source[1]	Description of potential point sources of contamination included in data set
Envirofacts Data for Indiana	USEPA-Envirofacts	Compilation of information on USEPA regulated facilities.
Inventory of Transfer Stations in Indiana	IDEM–OLQ	Transfer Stations — transfer of solid waste from one collection vehicle to another that later is disposed at a State-approved solid-waste permitted facility, as defined by 329 IAC 11-2-47.
Inventory of Composting Facilities in Indiana	IDEM–OLQ	Composting Facilities — leaf-, limb-, or grass-collection sites where a compost product is created, as defined by IC 13-20-10.
Inventory of Confined Feeding Operations in Indiana	IDEM–OLQ	Confined Feeding Operations — a swine, chicken, turkey, beef, or dairy agri-business that has large enough numbers of animals that IDEM regulates for environmental concerns, as defined by IC 13-18-10.
Inventory of USTs in Indiana	IDEM–OLQ	USTs — the UST program is responsible for registering all regulated USTs. Regulated USTs are those USTs that have 10 percent or more of the tank and piping buried beneath the ground and contain a regulated substance, which includes either petroleum products or hazardous substances.
Inventory of Leaking USTs in Indiana	IDEM–OLQ	Leaking USTs — known sites with leaking USTs. Regulated USTs contain regulated substances including petroleum and hazardous substances such as those typically found at gasoline stations, fleet-fueling facilities, and industrial sites.
Inventory of Construction/ Demolition Sites in Indiana	IDEM–OLQ	Construction/Demolition Sites — a permitted State-licensed facility that accepts solid waste in the form of anything that is attached to a house during construction or demolition, as defined by IAC 329 10-2-36.
Inventory of Open Dumps in Indiana	IDEM–OLQ	Open Dumps — Sites that are not regulated and are illegal dump sites of solid waste, as defined by IAC 10-2-28 329 and IAC 10-2-128.
National Pollutant Discharge Elimination System Facilities in Indiana	IDEM–OWQ	National Pollutant Discharge Elimination System Facilities — all available records listed in Indiana associated with "Active" surface-water discharges from regulated wastewater-discharge sites. It consists of State-permitted wastewater-facility-related information.
National Pollutant Discharge Elimination System Pipes in Indiana	IDEM–OWQ	National Pollutant Discharge Elimination System Pipes — includes all "active" records listed in Indiana associated with permitted surface-water discharge points. It consists of regulated wastewater outfall or end-of-pipe related information that originated from sites/facilities in the data set "National Pollutant Discharge Elimination System Facilities"
Inventory of Septage Sites in Indiana	IDEM–OLQ	Septage Sites — permitted septage (septic-tank waste) sites where the waste is land applied, as defined by 327 IAC 7, 327 IAC 7-6, and 327 IAC 7-7.
Inventory of Tire Sites in Indiana	IDEM–OLQ	Tire Sites — sites which contain tires—either for processing, storage, or transport—as well as some illegal tire dumps, as defined by IC 13-11-2-251, IC 13-11-2-252, and IC 13-11-250.5.
Inventory of Superfund Sites in Indiana	IDEM–OLQ	Superfund Sites — USEPA evaluates and prioritizes these sites for placement on the NPL as "Superfund Sites" eligible for extensive, long-term cleanup action under the Superfund Program.
Inventory of Treatment, Storage, and Disposal Sites in Indiana	IDEM–OLQ	Treatment, Storage, and Disposal Sites — facilities that may treat, store, generate and (or) dispose of hazardous waste, non-hazardous industrial waste, and solid waste.

Table 1. Electronic data sets for identifying potential point sources of contamination outside the assessment area for a transient, non-community public-water supply.—Continued

[USEPA, U.S. Environmental Protection Agency; IDEM–OLQ, Indiana Department of Environmental Management–Office of Land Quality; IAC, Indiana Administrative Code; IC, Indiana Code; UST, underground storage tank; IDEM–OWQ, Indiana Department of Environmental Management–Office of Water Quality; NPL, National Priorities List; RCRA, Resource Conservation and Recovery Act; IGS, Indiana Geological Survey; USEPA–BASINS, U.S. Environmental Protection Agency–Better Assessment Science Integrating Point and Nonpoint Sources]

Data set name/description	Data source[1]	Description of potential point sources of contamination included in data set
Inventory of Voluntary Remediation Sites in Indiana	IDEM–OLQ	Voluntary Remediation Sites — sites where a voluntary cleanup of hazardous and petroleum wastes is conducted with IDEM oversight, and at the conclusion of the cleanup a Certificate of Completion from IDEM and a Covenant Not To Sue from the Governor's office is awarded. The Covenant Not To Sue is a release of liability that bars enforcement action from the State and third party law suits relating to the cleanup. The covenant runs with the land so all subsequent owners of the property also receive liability protection.
Inventory of Restricted Waste Sites in Indiana	IDEM–OLQ	Restricted Waste Sites — sites that accept only specific types of solid waste that fall into three select categories, as defined by IAC 329 10-2-159.
Inventory of State Cleanup Sites in Indiana	IDEM–OLQ	State Cleanup Sites — sites currently administered under the State Cleanup Section. Similar to the Federal Superfund Program, these abandoned or uncontrolled hazardous-waste sites in Indiana are evaluated for extensive, long-term cleanup action.
Inventory of Industrial-Waste Sites in Indiana	IDEM–OLQ	Industrial-Waste Sites — facilities that generate and (or) manage hazardous waste, non-hazardous industrial waste, and solid waste. The majority are Large Quantity Generators (facilities that generate more than 1,000 kilograms—about 2,200 lbs.—of hazardous waste per month). Treatment, Storage, and Disposal facilities that may treat, store, generate and (or) dispose hazardous waste, non-hazardous industrial waste, and solid waste. Small Quantity Generators (facilities that generate less than 1,000 kilograms—about 2,200 lbs. —but more than 100 kilograms—about 220 lbs. —of hazardous waste per month), or Conditionally Exempt Small Quantity Generators (facilities that generates less than 100 kilograms—about 220 lbs. —of hazardous waste per month) are included if the location has significant environmental issues.
Inventory of Active Permitted Solid-Waste Sites	IDEM–OLQ	Active Permitted Solid-Waste Sites — sites that have received a solid-waste-facility permit issued under either 329 IAC 10 (land-disposal facilities) or 329 IAC 11 (processing facilities), have finished construction, and are actively receiving waste.
Inventory of Corrective-Action Sites in Indiana	IDEM–OLQ	Corrective Action Sites — facilities that are subject to RCRA corrective action. These are facilities that meet any of the following conditions: operating under a hazardous-waste permit, an interim status facility, and lawsuit against any handler.
Inventory of Oil and Gas Wells in Indiana	IGS	Oil and Gas Wells — producing oil and gas wells; gas-storage wells; and abandoned gas, oil, and gas-storage wells.
Inventory of Mines and Quarries in Indiana	USEPA–BASINS	Mines and Quarries — Includes above ground and underground mines or quarries and processing facilities for coal, limestone, building stone, sand and gravel, clay, gypsum, perlite, and other materials.

[1]Data-source references:
USEPA Envirofacts (U.S. Environmental Protection Agency, 2001a)
IDEM-OLQ (Greg Overtoom, Indiana Department of Environmental Management, Office of Land Quality, written commun., June 20, 2002; Shane Moore, Indiana Department of Environmental Management, Office of Land Quality, written commun., 2004)
IDEM-OWQ (Jeff Ewick, Indiana Department of Environmental Management, Office of Water Quality, written commun., February 5, 2003)
IGS (Indiana Geological Survey, 2004)
USEPA–BASINS (U.S. Environmental Protection Agency, 2001b)

3. The estimated depth of the TNC well was chosen such that the depths of 75 percent of the selected well records were greater than the estimated depth.

The surficial geology at and around a TNC supply well can be classified for the purpose of susceptibility by texture. The relation between surficial geologic materials and susceptibility was based upon the capability of surface materials to limit the infiltration of water into the ground and thereby reduce the transport of any associated contaminants. The surficial geology of Indiana has been mapped using 49 different geologic classifications (Gray, 1989). The classifications are too numerous to use directly in measuring infiltration capacity; therefore, the classifications were grouped into similar geologic materials. For example, the 14 different tills were grouped into a class simply called till. This process was repeated until the surficial geologic materials were grouped into 5 general texture classifications (table 2). The specific texture groups within the assessment area were determined, and text describing the textures was included in the SWA report for the TNC supply. The following paragraphs contain the text used to describe each texture group and their relation to susceptibility. The texture groups in the following paragraphs are identified by bold type.

Fine-grained surficial geologic materials, such as clay and silt, tend to slow the movement of and provide a filtering action to water entering the ground. Compared to clay or silt, **coarse-grained** surficial geologic materials, such as sand and gravel, allow more surface water to infiltrate and provide less filtering action to water entering the ground. **Mixtures of sands and silts** have protective properties between clays (less infiltration of water and greater filtering of particulates) and coarser sands or gravels (more infiltration and less filtering). **Fine-grained soils that form on bedrock** at the ground surface tend to slow the infiltration of, and provide a filtering action to, water entering the ground. However, local fractures in the upper part of the bedrock, when present at or very close to the land surface, can facilitate entry of surface contaminants into the ground water. Fine-grained soils also develop on **karst** areas, but the overriding factor controlling infiltration in **karst** areas is the development of solution channels. Surface water and associated contaminants can readily enter the ground in **karst** areas through sinkholes or through thin soils overlaying subsurface channels.

Table 2. Classification, by texture, of surficial geologic materials in Indiana.

Texture classification	Associated surficial geologic materials
Fine-grained	Till; silt complex; terra rosa; overburden and artificial fill; lake silt and clay; muck, peat, and marl; loess
Coarse-grained	Outwash; ice-contact deposits; lake and beach sand; dune and blanket sand
Mixtures of sands and silts	Alluvium; sand and silt
Fine-grained soils formed on bedrock	Devonian to Mississippian black shale; Mississippian limestone; Silurian and Devonian limestone and dolomite; siltstone and shale; mixed sandstone, shale, limestone, and coal; Ordovician shale and limestone
Karst	Karst

The composition of regional aquifers can provide general information about how well the aquifers are protected from contamination. Regional aquifers have been defined as geologic deposits formed by the same process and containing sufficient saturated permeable material to yield quantities of potable water adequate at least for domestic purposes (Fenelon and others, 1994). An example of a regional aquifer would be glacial drift containing discontinuous deposits of sand or sand and gravel, herein referred to as the Discontinuous Buried Sand and Gravel Regional Aquifers. Regional aquifers have been mapped for major Indiana watersheds (Fenelon and others, 1994). The complete extents of the unconsolidated regional aquifers are shown in figure 2, and the extents of the consolidated regional aquifers are shown in figure 3.

The susceptibility of regional aquifers to surface contaminants can be assessed according to their depth from the land surface and their areal extent. Generally, the deeper and the less aerially extensive the aquifer, the more the aquifer is protected from a point source of contaminants. Some of the regional aquifers of Indiana have been named to convey these two characteristics. The regional aquifers within the assessment area for a TNC supply were determined, and text describing the aquifers was included in the report for the TNC supply. More than one regional aquifer may lie beneath the assessment area because regional aquifers can overlap. The following paragraphs contain the text used to describe each regional aquifer and its susceptibility to surface contaminants. The regional aquifers are identified by bold type.

The Surficial Sand and Gravel Regional Aquifers consist of sand or sand and gravel that is areally continuous in at least one direction for several miles. The aquifer materials were deposited by glacial meltwater and present-day stream deposition. The aquifers range in thickness from 5 to 175 ft and are covered by less than 10 ft of clay, silt, and fine sand. The thin layer of fine-grained material over the aquifer makes it more vulnerable to contaminant sources than most other regional aquifers.

The Discontinuous Surficial Sand and Gravel Regional Aquifers consist of sand or sand and gravel that is areally continuous for less than 1 mi. The aquifer material was deposited as layers of outwash, drift, and till at the edge of melting glacial ice. The aquifers range in thickness from 5 to 100 ft and are covered by less than 10 ft of clay, silt, and fine sand. The thin layer of fine-grained deposits over the aquifer material makes it more vulnerable to contamination sources than most other regional aquifers, although its discontinuous nature limits the area in which contaminants would enter the aquifer.

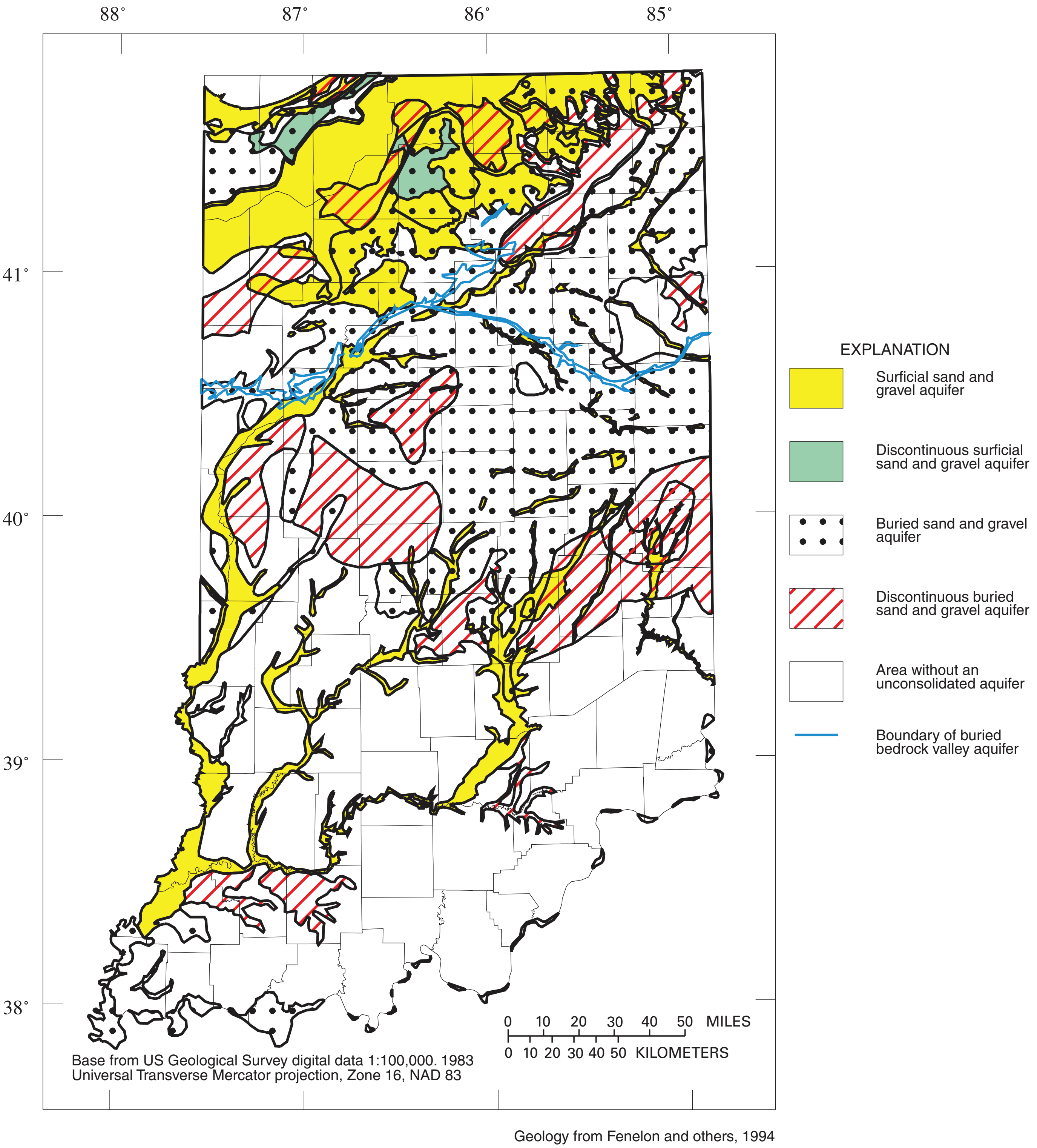


Figure 2. Location and extent of unconsolidated regional aquifers in Indiana.

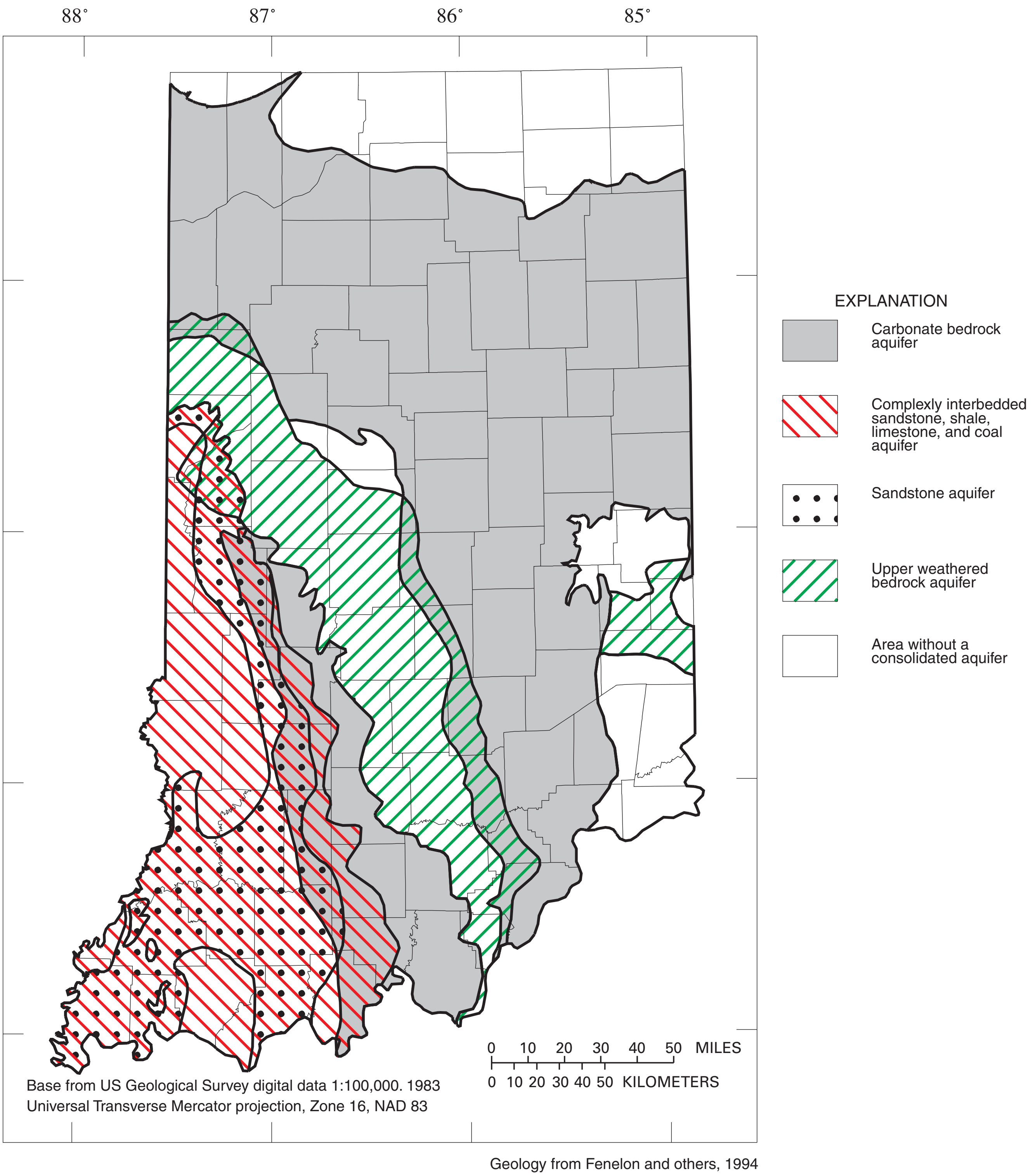


Figure 3. Location and extent of consolidated regional aquifers in Indiana.

The Buried Sand and Gravel Regional Aquifers consist of sand or sand and gravel that is areally continuous in at least one direction for several miles. The aquifer materials originated from glacial meltwater as either outwash fans (aerial deposits) or channel deposits. The aquifers range in thickness from 5 to 225 ft and are covered by 10 ft or more of clay, silt, and fine sand. The overlying fine-grained materials are typically much more than 10 ft in thickness outside the river valleys. In the uplands, the aquifer is typically covered by tens of feet of low-permeability till, which provides protection from point and nonpoint contaminant sources.

The Discontinuous Buried Sand and Gravel Regional Aquifers consist of sand or sand and gravel lenses that are areally continuous in at least one direction from 1 to 5 mi. The aquifer is commonly reported by water-well drillers because the lenses of aquifer material may be present at multiple depths within the glacial till. The aquifer lenses range in thickness from 5 to 80 ft, and are typically covered by tens of feet of fine-grained glacial till. The till provides protection from point and nonpoint contaminant sources.

The Buried Bedrock Valley Regional Aquifer consists of glacial deposits of sand and gravel that filled the preglacial Teays River valley over multiple glacial periods. The aquifer can be as much as 200 ft in thickness and is deeply buried beneath glacial till. The thick cover of fine-grained till provides considerable protection from contaminant sources at ground surface.

The Carbonate Bedrock Regional Aquifer consists of limestone and dolomite deposits that underlie over half of the State. The upper 100 ft of the formation contains voids from weathering and dissolution of rock material along fractures, bedding planes, and joints. The voids can provide conduits for contaminants to spread through the aquifer. In the northern two-thirds of the State, the aquifer is overlain by fine-grained glacial till that provides protection from contaminant sources at ground surface.

The Sandstone Regional Aquifer consists of sheet or channel deposits of cemented sands that extend over several miles. The aquifer ranges in thickness from 20 to 250 ft. The low permeability of sandstone and the low permeability of materials that may overly the sandstone provide protection from contaminants at ground surface.

The Complexly Interbedded Sandstone, Shale, Limestone, and Coal Regional Aquifer, as the name implies, is a mixture of bedrock deposits. Shale constitutes the majority of the unit, but each rock type is limited in areal extent. The sandstones, coals, and limestones are typically less than 10 ft in thickness, yet they are the most productive part of the aquifer. The water-bearing zones of the aquifer are protected from contamination by the large proportion of shale in the aquifer.

The Upper Weathered Bedrock Regional Aquifer consists of shale and siltstone that developed solution channels within the upper 150 ft of bedrock because of the weathering process before glaciation. In the northern two-thirds of the State, the aquifer is overlain by fine-grained glacial till that provides protection from contaminants.

Areas without a consolidated or unconsolidated aquifer have geologic materials that cannot yield sufficient water for even domestic purposes. An example is an area of shale of Ordovician age in the southeast corner of the State; the shale is softer than other shales (Fenelon and others, 1994, p. 191). As such, joints and fractures cannot be sustained in this rock. Without joints and fractures, usable amounts of water cannot be obtained from this shale, and ground-water supplies usually are not developed in this area. If supplies were developed, then the entry of contaminants into the formation would be impeded by the general lack of a pathway (fractures) for the contaminant to enter the formation.

The slope of the land surface affects the potential for infiltration of contaminated surface waters. Specifically, the lower the slope, the lower the potential for surface runoff and the greater the potential for infiltration. The Natural Resource Conservation Service and the Purdue University Agricultural Experiment Station classified land slopes for Indiana into five slope ranges: 0–2 percent, 2–6 percent, 6–18 percent, 18–35 percent, and greater than 35 percent (U.S. Department of Agriculture, 1977). They also describe the geomorphic characteristics associated with the slopes in terms of land-surface topography. The average slope within the 300-ft radius of the TNC supply was determined using a 30-m digital elevation model (DEM) (U.S. Geological Survey, 2000), and the slope was assigned to a slope range. Text describing the slope range was included in the SWA report for each TNC supply. The following list contains the text used in the reports to describe each slope range and its relation to susceptibility; the slope ranges are identified by bold type.

0–2 percent slope: Land surface is essentially flat, which maximizes the probability for potential contaminants to infiltrate into ground-water supplies.

2–6 percent slope: Land surface has a slightly rolling topography and opportunity exists for potential contaminants to infiltrate into ground-water supplies.

6–18 percent slope: Land surface has rolling topography, which encourages surface runoff and less infiltration of potential contaminants into ground-water supplies, compared to more mildly sloping areas.

18–35 percent slope: Land surface is steeply sloped, and surface runoff is likely. Infiltration of potential contaminants at any one point into ground-water supplies is reduced compared to milder slopes.

Greater than 35 percent slope: Land surface is very steeply sloped, and the potential for surface runoff of potential contaminants is greatest compared to other locations in Indiana. Conversely, it has the least probability for infiltration of potential contaminants to ground-water supplies.

A final qualitative description of the potential for susceptibility is the display of ground-water-altitude contours shown in figure 3 of the TNC reports. The ground-water flow direction relative to potential contaminant sites and the TNC supply is perpendicular to the contours in the direction of decreasing water-level altitude. The water-level contours were generated from over 100,000 water-level data values recorded by water-well drillers on well logs submitted to the IDNR from approximately the 1960's to 2002 (Indiana Department of Natural Resources, 2006).

Water-level altitude data were calculated from the each IDNR well log by subtracting the reported depth to water from the land-surface altitude at the well. Both data values were potential sources of error in the calculation, and both were checked for accuracy. Any land-surface value that varied by more than 15 ft from the elevation interpolated from the 30-m DEM was removed from the data set, along with the associated water-level altitude before determining water-level contours. A water-level surface was developed from the remaining water-level altitude data by the use of a kriging interpolator available in ARC-INFO, version 8.3 (Environmental Systems Research Institute, 2003). Water-level surface altitudes were then compared to the individual point values of water-level altitude to determine if any point values varied greatly from the surface. If point values varied from the interpolated surface by more than 20 ft, then the point values were considered to be in error relative to the entire data set and were removed. A final water-level surface was reconstructed from the remaining point values. Contours shown in figure 3 of the TNC reports were generated using the final water-level surface developed from the reduced data set. The values of 15 and 20 ft were chosen as cut-off values for their respective elevation and water-level data sets because they represented values that separated more common values from outliers.

Water-level data from all seasons of the year, all years, and all well depths were used in the kriging to obtain a long-term average water level. This type of water-level surface has been shown to be useful in determining regional ground-water flow directions (Fowler and Arihood, 1998, sheet 1). The ground-water flow directions inferred from the contours are a general indicator of long-term regional flow directions over all depths for which data were available. The water levels may not accurately reflect water levels in the aquifer from which a given TNC supply obtains water because they represent a regional condition and may contain measurement error. The contours shown in figure 3 of the TNC reports are intended to alert the public to the potential for ground-water flow to deliver contaminants to a TNC supply and to encourage further, site-specific flow-direction analysis.

Methods Used to Determine a Susceptibility Rating

The method for assigning a susceptibility rating to a TNC supply included qualitative analysis of susceptibility and subjective decisions combined with a quantitative (statistical) method. The combination of subjective and quantitative methods is called a subjective hybrid method (Focazio and others, 2002).

The susceptibility rating for TNC supplies is based on three factors:

1. Elevated concentrations of nitrate as nitrogen and the presence or absence of total-coliform bacteria reported in routine compliance monitoring of the TNC supply.
2. Presence or absence of potential sources of regulated COCs for TNC supplies within the assessment area, as reported by IDEM representatives during on-site visits.
3. Presence and thickness of a geologic barrier to contamination.

For this evaluation of susceptibility, the detection of coliform bacteria or a concentration of greater than 3 mg/L of nitrate as nitrogen in the analyses of any compliance-monitoring sample from a TNC well was considered an indicator that contaminants could reach the TNC well screen. The presence of total coliform as an indicator is based on the Indiana maximum permissible level of nondetect for total-coliform bacteria in drinking-water supplies obtained from ground water (Indiana Administrative Code, 2006). The value of greater than 3.0 mg/L nitrate as nitrogen as an indicator was derived from a sensitivity classification scheme for nitrate sources based on concentrations in ground water (Madison and Brunett, 1984, p. 95) (table 3). For the remainder of this report, nitrate and nitrate plus nitrite are reported in concentration as nitrogen.

Table 3. Classification of nitrate source based upon range of concentration in ground water.

[mg/L, milligrams per liter; N, nitrogen; USEPA, U.S. Environmental Protection Agency; MCL, maximum contaminant level]

Range of concentrations of nitrate or nitrate plus nitrite	Nitrate source as an indicator of sensitivity classification
Less than 0.2 mg/L as N	Assumed to represent natural background conditions
0.21 to 3.0 mg/L as N	Transitional; Concentrations that may or may not represent human influence
3.1 to 10 mg/L as N	May indicate elevated concentrations resulting from human activity
Greater than 10 mg/L as N	Exceeds USEPA MCL for nitrate

Source: Madison and Brunett, 1984, p. 95.

The presence or absence of potential sources of regulated COCs within the assessment area was determined during site visits by IDEM representatives as described in the section "Presence of Potential Sources and Associated Contaminants of Concern."

The term "geologic barrier" is used by IDEM in their source-water assessment plan (Indiana Department of Environmental Management, 2000, p. 19) and is a convenient way to refer to the relative protection afforded by fine-grained geologic materials above the TNC well screen. Ground-water contamination can occur when surface contaminants are able to travel vertically through overlying geologic materials to the pumped aquifer. Fine-grained geologic materials, such as clay, silt, and shale, provide resistance to vertical flow and can slow the movement of contaminants greatly, as compared to coarser-grained geologic materials. Also, fine-grained geologic materials can filter out many particle-bound contaminants and facilitate chemical reactions that change the contaminant properties of many substances. For example, concentrations of nitrate are lowest in aquifers within low-permeability clay-rich tills (Mueller and others, 1995, p. 25). The report by Mueller and others (1995) attributed the low concentrations of nitrate to decreased water infiltration through fine-grained soils and tills to the aquifers and to denitrification of nitrate in low-oxygen environments. The capability of clays and silts to provide flow resistance, filtering, and beneficial chemical reactions has lead to IDEM's use of "geologic barrier" as a descriptor in the SWA reports for TNC supplies. The greater the thickness of fine-grained geologic materials, the more effective the geologic barrier becomes at diminishing infiltration rates and decreasing the probability of contamination in an underlying aquifer. Therefore, determining the total thickness of fine-grained geologic materials above a TNC well screen is part of Indiana's susceptibility analysis.

The thickness of fine-grained geologic materials above the well screen for the TNC supply could be estimated using the geologic records from the IDNR well-log database (Indiana Department of Natural Resources, 2006). The IDNR database contained records for more than 134,000 wells, and it was not practical within the scope of this project to match the records for an individual well log to a corresponding TNC supply well. Therefore, well logs near (2-mi radius) the TNC supply well were used to estimate a thickness of fine-grained geologic materials above the well screen. At least three wells logs had to be available within 2 mi of the TNC supply well to provide sufficient data to interpolate a fine-grained thickness near the TNC supply. The wells had to surround the TNC supply and represent most of the same vertical section of geologic materials as encountered by the TNC well. Of the approximately 2,400 TNC supplies, only 83 (3 percent) were lacking at least 3 surrounding wells, and a thickness estimate of fine-grained geologic materials could not be determined. About 75 percent of the TNC supplies had 20 or more surrounding wells on which to base an estimate of fine-grained thickness.

The thickness of fine-grained geologic materials above the TNC well screen was dependent upon the depth of the TNC well, which was not always known. Well depths for TNC wells with unknown depths were estimated as described in the section "Hydrogeologic and Geomorphic Descriptions." A computer program read well-log information for the wells near the TNC supply down to the depth (estimated or actual) of the TNC well. The thickness of fine-grained geologic materials was summed for each well, and the total thickness was assigned to the well for subsequent mapping of thickness. The total-thickness values were interpolated with an ARC-INFO procedure called inverse distance weighting (Environmental Systems Research Institute, 2003) to obtain a spatially continuous distribution of fine-grained geologic-material thickness around the TNC supply. After the thickness was interpolated, the thickness value at the location of the TNC supply was determined. The maximum potential calculated thickness for the fine-grained geologic materials was set to be equal to the depth of the well minus 3 ft to account for the well screen.

To determine the fine-grained thickness above a TNC well screen, the geologic records were classified as fine or coarse grained. Geologic records in the IDNR database first were classified according to the corresponding lithology descriptions and codes used in the USGS National Water Information System (NWIS) database (Babcock and others, 2005), then each NWIS code was classified as either fine or coarse grained. The lithology descriptions and their classifications are recorded in table 4.

A quantitative relation was developed between thickness of fine-grained geologic material above the TNC well screen and reduction in the susceptibility to contamination. The relation describes the decrease in concentrations of contaminants with increasing thickness of fine-grained geologic materials. Concentrations of nitrate were used to represent the decrease in concentrations of contaminants with increasing thickness of fine-grained geologic materials.

The nitrate data were obtained from the NWIS database maintained by the USGS and from the Indiana Department of Natural Resources (2000). Well sites in NWIS were included in the data set if they contained a well depth and at least one analysis of nitrate or nitrate plus nitrite. If analyses of multiple samples were available for a given well, then only the analysis of the most recent sample was retained for this data set. The nitrate analyses from the IDNR were part of a data set representing ambient ground-water chemistry collected during water-resource assessments (Indiana Department of Natural Resources, 2000); these data are further described as the IDNR water-resources assessment data set in Risch and Cohen (1995, tables 1 and 2, p. 7). The NWIS data included 1,019 wells with a well depth and a nitrate analysis for the period June 3, 1954 to March 3, 2005, and the IDNR data included 892 wells with a well depth and a nitrate analysis for the period June 4, 1985 to November 26, 1985 (Appendix 3).

The combined NWIS and IDNR data (Appendix 3) included analyses of filtered and unfiltered ground-water samples; no differentiation was made between the analyses of water samples collected using either of these procedures. Analytical values for nitrate were used where available; other-

Table 4. U.S. Geological Survey National Water Information System lithologies and texture category for use in estimating thickness of fine-grained geologic materials above a well screen.

National Water Information System lithology description[1]	National Water Information System lithology code[1]	Categorized as fine-grained geologic material
Basalt	BSLT	Yes
Boulders	BLDR	No
Boulders and sand	BLSD	No
Boulders, silt, and clay	BLSC	Yes
Chert	CHRT	Yes
Clay	CLAY	Yes
Clay some sand	CLSD	Yes
Claystone	CLSN	Yes
Coal	COAL	No
Cobbles	COBB	No
Cobbles and sand	COSD	No
Cobbles, silt, and clay	COSC	Yes
Conglomerate	CGLM	No
Dolomite	DLMT	No
Drift	DRFT	No
Evaporite	EVPR	Yes
Granite	GRNT	Yes
Gravel	GRVL	No
Gravel and clay	GRCL	Yes
Gravel, cemented	GRCM	Yes
Gravel, sand, and silt	GRDS	Yes
Gravel, silt, and clay	GRSC	Yes
Gypsum	GPSM	Yes
Hard pan	HRDP	Yes
Igneous (undifferentiated)	IGNS	Yes
Limestone	LMSN	No
Limestone and Dolomite	LMDM	No
Loam	LOAM	Yes
Loess	LOSS	Yes
Marl	MARL	Yes
Muck	MUCK	Yes
Mud	MUD	Yes
Other	OTHR	No
Overburden	OBDN	No
Peat	PEAT	Yes
Quartzite	QRTZ	Yes
Rock	ROCK	No
Rubble	RBBL	No
Sand	SAND	No
Sand and clay	SDCL	Yes
Sand and gravel	SDGL	No
Sand and silt	SDST	Yes
Sand, gravel, and clay	SGVC	Yes
Sand, some clay	SNCL	Yes
Sandstone	SNDS	No
Sandstone and shale	SDSL	Yes
Schist	SCST	Yes
Sedimentary (undifferentiated)	SDMN	No
Shale	SHLE	Yes
Silt	SILT	Yes
Silt and clay	STCL	Yes
Siltstone	SLSN	Yes
Slate	SLTE	Yes
Soil	SOIL	Yes
Till	TILL	Yes

[1]Source: Babcock and others, 2005, p. 105–113.

wise, analytical values for nitrate plus nitrite were used. The inclusion of nitrite in the analysis was not considered to be a source of meaningful error. Hem (1989, p. 124) reported that nitrite as nitrogen is seldom present in concentrations large enough to affect the ionic balance of nitrogen species in natural waters. Nolan and Hitt (2003, p. 7) indicate that concentrations of nitrite as nitrogen in ground-water samples collected by the National Water-Quality Assessment Program (which includes samples collected in Indiana) typically are negligible; therefore, concentrations of nitrate plus nitrite are referred to as concentrations of nitrate for the remainder of this discussion. If the analytical value was reported as being less than a detection limit, then a value equal to one-half of the detection limit was used in evaluating the relation between nitrate and fine-grained thickness.

The relation between the concentration of nitrate for a well and the thickness of fine-grained geologic materials above the well screen required an estimate of fine-grained thickness at the sampled well. An estimate of the thickness of fine-grained geologic materials above the screen of each well with a concentration of nitrate was calculated in the same manner as previously described for the TNC wells. At least three wells within a 2-mi radius surrounding the sampled well were required to estimate a fine-grained thickness. For the entire data set, approximately 88 percent (1,684 wells) had fine-grained-thickness estimates based on from 10 to 347 surrounding wells; less than 1 percent (14 wells) had fine-grained-thickness estimates based on three surrounding wells.

The relation between concentration of nitrate and thickness of fine-grained geologic materials above the well screen is shown in figure 4. The plot depicts a downward trend in concentration of nitrate with increasing fine-grained thickness. The trend was quantified with a statistical procedure called logistic regression.

A logistic regression procedure (SAS Institute, 1999) was used to quantify the relation between concentration of nitrate and thickness of fine-grained geologic materials above the well screen. The process of logistic regression uses a critical value for a condition to predict the probability of encountering the condition based upon one or more independent variables.

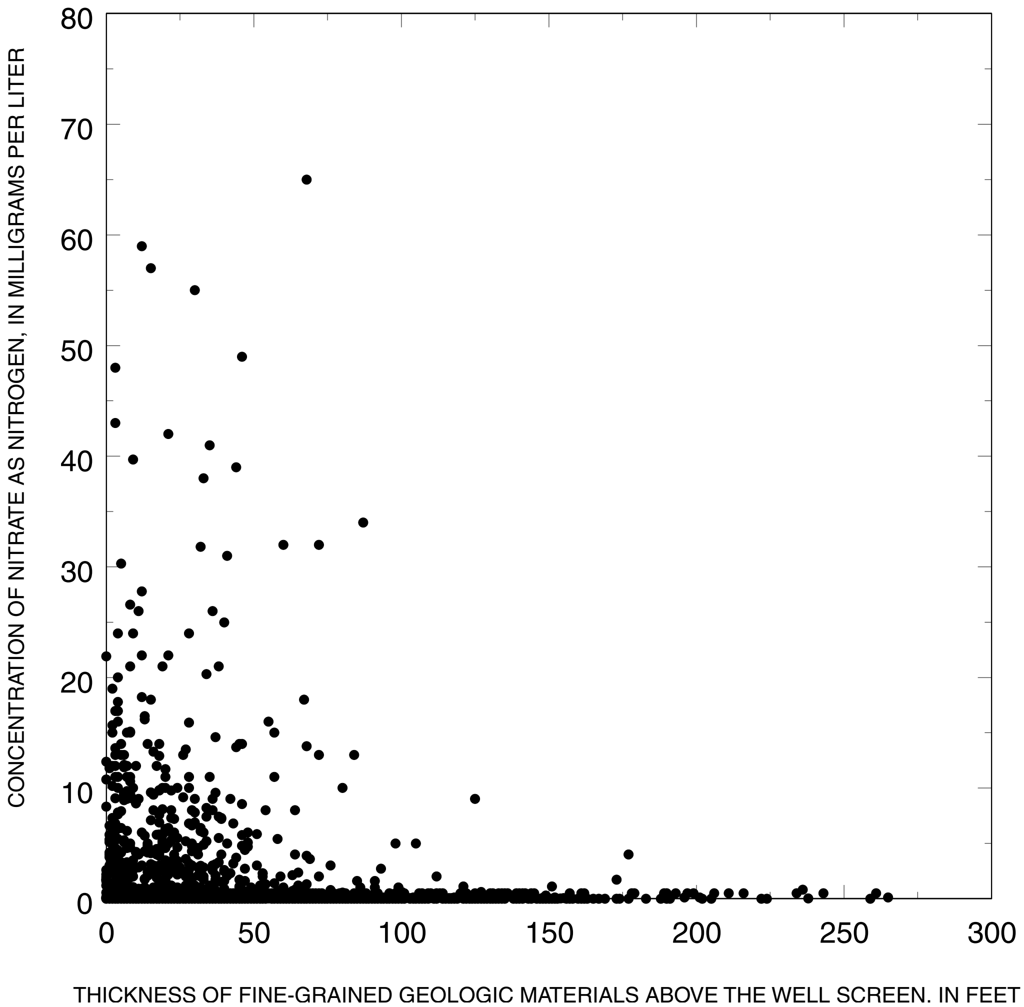


Figure 4. Relation between concentrations of nitrate as nitrogen in ground water and the thickness of fine-grained geologic materials above the well screen in Indiana.

Values above or below the critical value define the condition. The condition used for this logistic regression was the state of water quality and the critical value was a concentration of nitrate of 3 mg/L as N or greater. Values greater than or equal to 3.1 mg/L as N indicate that nitrate in the aquifer may be from a surface contaminant (see table 3), but the value used in logistic regression was rounded to 3 mg/L as N for simplicity. The logistic-regression analysis related concentration of nitrate to thickness of fine-grained geologic material and yielded a probability of nitrate concentration being greater than or equal to 3 mg/L as N, based on the thickness of fine-grained geologic material above the well screen. The probability plot of concentration of nitrate being equal to or greater than 3 mg/L as N is shown in figure 5. Additional details about logistic regression can be found in Helsel and Hirsch (1995).

The quality of the regression can be measured in terms of the statistical significance of the regression parameters and by the equation's predictive ability. Table 5 provides the statistical analysis of the coefficients from the regression. The standard errors associated with the coefficient estimates are small relative to their values, and the *p* values (probability of the coefficient being zero) are less than 0.01 percent, which is highly significant. The predictive ability of the regression equation can be measured by Somers' D (SAS Institute, 1999, p. 1955), which measures the rank correlation between the observed and predicted responses. That is, Somers' D measures how consistently the increase in thickness of fine-grained geologic materials above the well screen corresponds to a decrease in concentration of nitrate for the observed data. The range of the Somers' D statistic is from -1 (no predictive ability) to 1 (perfect predictive ability); Somers' D for the regression is 0.438. Based upon these statistics, the regression equation adequately

Table 5. Statistical characteristics of the logistic regression.

Variable	Coefficients	Standard error of the parameters	*p* value
Intercept	-0.7732	0.0976	0.0001
Fine-grained thickness	-0.0290	0.0029	0.0001

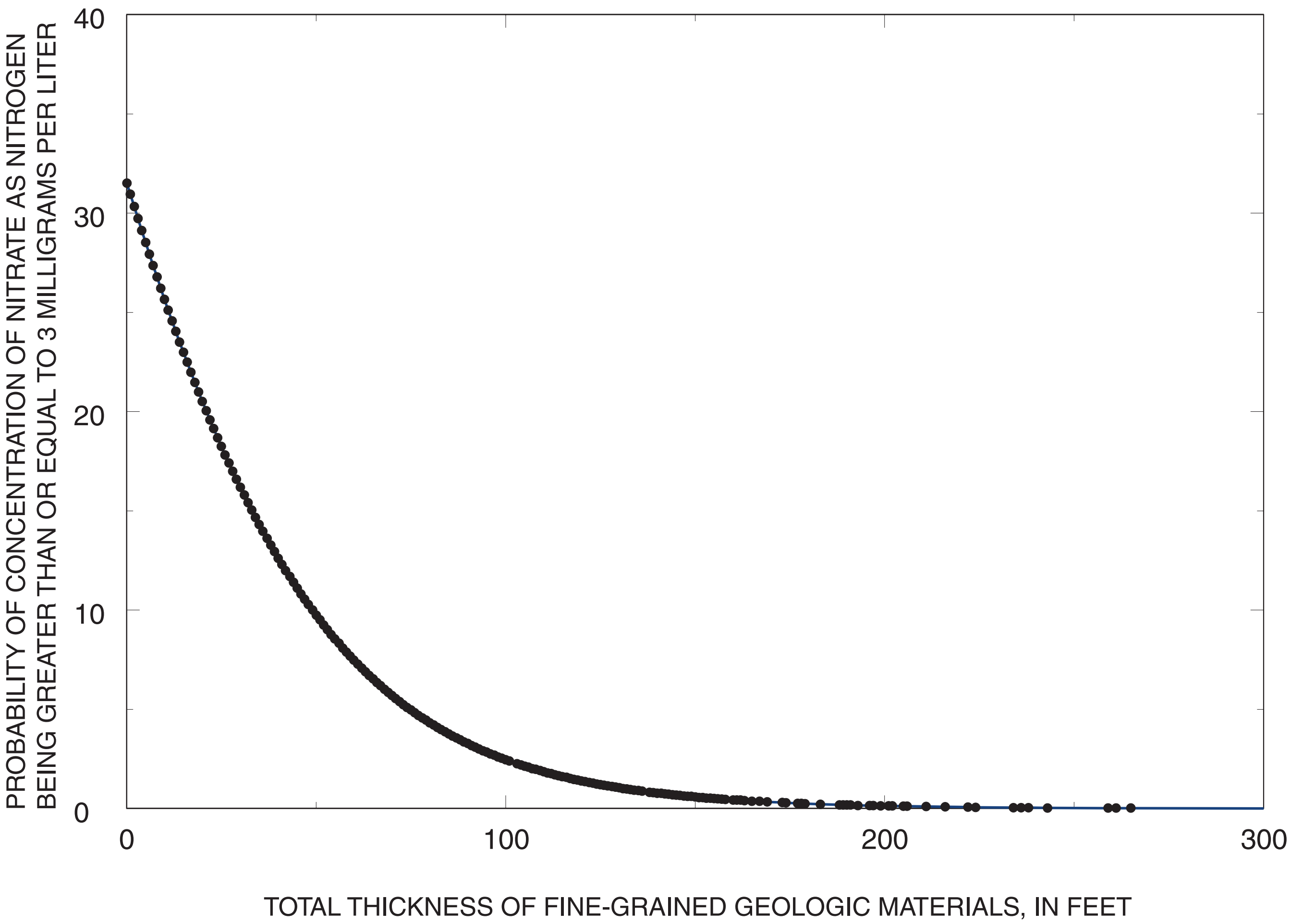


Figure 5. Probability of nitrate as nitrogen in ground water being greater than or equal to 3 milligrams per liter for various thicknesses of fine-grained geologic materials above the well screen in Indiana.

estimates the probability of concentrations of nitrate in relation to total thickness of fine-grained geologic materials above the well screen.

The thickness of the geologic barrier at the TNC supply is the third of three factors that was used to determine a susceptibility rating for the TNC supply. The application of these factors to determine a susceptibility rating is illustrated in the flow chart (or decision tree) shown in figure 6.

The flow chart was used to determine a susceptibility rating for each TNC supply using the data compiled during the study. Each box of the flow chart represents the general conditions around the water supply relative to the three factors described previously. The chart is divided into four sections. The first section categorizes whether regulated contaminants are absent or present in the drinking water. This section has two possibilities:

1. There were no detections of elevated concentrations of nitrate (greater than 3 mg/L as N), and there were no detections of bacteria during compliance monitoring of water samples from the TNC supply.
2. Elevated concentrations of nitrate (greater than 3 mg/L as N) were detected and (or) bacteria were detected during compliance monitoring of water samples from the TNC supply; at least one of these conditions was present.

The second section categorizes potential sources of regulated contaminants (bacteria and nitrate) as absent or present in the assessment area. This section has two possibilities:

1. No potential sources of regulated contaminants were identified within the assessment area during on-site visits to the TNC supply.
2. One or more potential sources of regulated contaminants within the assessment area were identified during on-site visits to the TNC supply.

The third section characterizes the thickness of fine-grained geologic materials (geologic barrier) into one of three categories:

1. THIN or NOT DETERMINED—The thickness of the geologic barrier is 45 ft or less or is unknown.

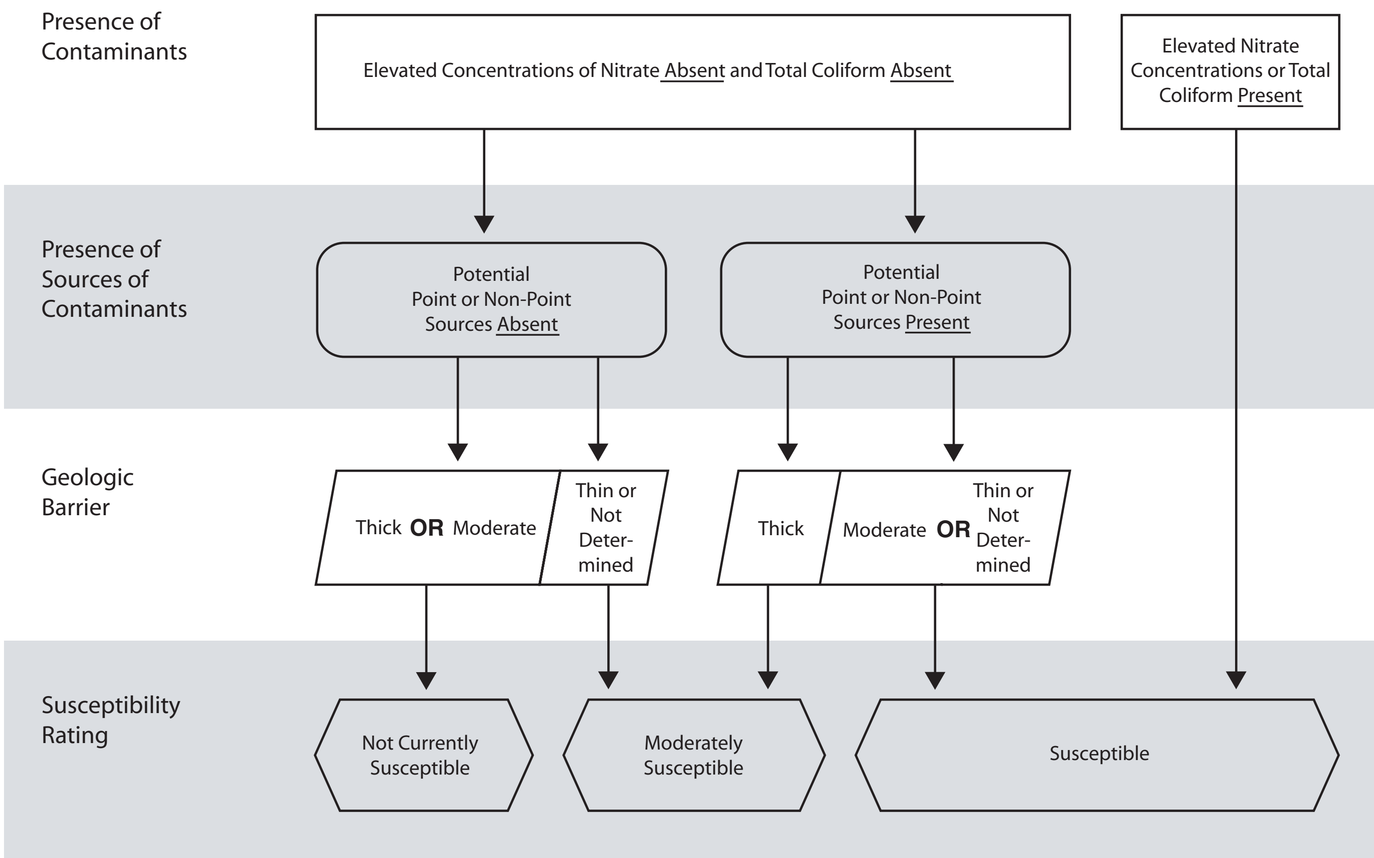


Figure 6. Process for determining the susceptibility rating of transient, non-community ground-water supplies in Indiana.

2. MODERATE—The thickness of the geologic barrier ranges from greater than 45 to less than or equal to 75 ft.
3. THICK—The thickness of the geologic barrier is greater than 75 ft.

The definitions for a thin (less than or equal to 45 ft), moderate (greater than 45 ft to less than or equal to 75 ft), and thick (greater than 75 ft) geologic barrier were derived from a qualitative analysis of the probability plot in figure 5. The probability of elevated concentration of nitrate verses thickness of fine-grained geologic materials is redrawn in figure 7 with additional information that helps to clarify choices for the thickness definitions. In figure 7*A*, a significant break in the steepest part of the slope occurs at about 45 ft. A single steep slope, as indicated by the red line, could be assigned to the probability plot from 0 to 45 ft of thickness. An incremental change in thickness from 0 to 45 ft represents a relatively large change in the probability of elevated nitrate, compared to other thickness ranges, and the probability of elevated nitrate is considered to be the most sensitive to a change in thickness within this range. Thicknesses from 0 to 45 ft have a large effect on the probability of elevated nitrate; therefore, thicknesses in this range are considered to be thin for the purpose of the flow chart.

At 75 ft (figure 7*B*), the probability of elevated nitrate is about 5 percent. Five percent is commonly used as an acceptable error percent, as in the 95 percent confidence interval. Alternatively, when the probability of an event is less than 5 percent, then the risk of the event occurring is commonly considered acceptable. In the context of the flow chart, when the thickness of fine-grained geologic materials becomes greater than 75 ft, the risk of elevated concentrations of nitrate (and associated contamination) becomes 5 percent or less. At probabilities of 5 percent or less, the geologic barrier is considered to be thick and generally protective. Thicknesses greater than 45 ft, but less than or equal to 75 ft, are considered to be moderate thicknesses and represent intermediate protection.

The fourth section of the flow chart characterizes the susceptibility of a TNC supply as one of three susceptibility ratings based on the three factors that indicate conditions around the public-water supply. The ratings are as follows:

1. NOT CURRENTLY SUSCEPTIBLE—This rating is assigned if all the factors above generally represent a lesser potential for contamination of the TNC supply by regulated contaminants. For example, no sources of contamination are present and the geologic barrier is thick.
2. MODERATELY SUSCEPTIBLE—This rating is assigned if the factors above are a mix of conditions that represent both a lesser potential for contamination and a greater potential for contamination of the TNC supply by regulated contaminants. For example, point and nonpoint sources could be absent, but the geologic barrier is thin.
3. SUSCEPTIBLE—This rating is assigned if elevated concentrations of nitrate or bacteria were detected during compliance monitoring, or the factors represent a greater potential for contamination of the TNC supply by regulated contaminants. For example, if point or nonpoint sources are present and the geologic barrier is thin, then the water supply is rated susceptible.

The susceptibility rating can be determined by choosing the boxes in the flow chart (fig. 6) that best describe the conditions around the water supply and following the arrows down to the final susceptibility rating. If compliance-monitoring data on nitrate or bacteria data are not available, then the susceptibility of the TNC supply to contamination could not be determined because no information was available for the first section of the flow chart. Less than 2 percent (43) of the TNC supplies could not be rated because they were new and no compliance-monitoring data were available. Only one of the TNC supplies was rated not currently susceptible, approximately 7 percent (164) were rated moderately susceptible, and approximately 91 percent (2,144) were rated susceptible. Of the 2,144 TNC supplies rated susceptible, approximately 79 percent (1,694) had a detection of coliform bacteria or a concentration of nitrate as nitrogen greater than 3 mg/L in at least one compliance-monitoring sample.

Summary

Methods were developed to delineate assessment areas, inventory potential sources and associated contaminants, and analyze the susceptibility of transient, non-community (TNC) ground-water public supplies to contamination. Two types of methods were used: subjective and subjective hybrid. Subjective methods use professional judgment to analyze conditions and decide levels of classification. Subjective hybrid methods combine subjective decisions with quantitative hydrologic analyses.

Subjective methods were used to delineate the assessment areas for TNC supplies, inventory potential sources and associated contaminants, and qualitatively describe the susceptibility of the TNC supply. The Indiana Department of Environmental Management (IDEM) defined a 300-feet (ft) radius around the TNC supply as the assessment area for the well. The regulated contaminants for Indiana TNC supplies are nitrate as nitrogen and bacteria as total coliform. Potential sources of contaminants were determined by on-site visits within the assessment area and by data-base retrievals from computerized databases for the area outside the assessment area. A U.S. Environmental Protection Agency reference and information in the Toxics Release Inventory and Permit Compliance System databases were used to associate specific contaminants with identified potential sources. A qualitative description of the inherent susceptibility of the general area around the TNC supply was made based upon five hydrogeologic and geomorphic characteristics of the general area: typical geologic materials above the TNC well screen, surficial

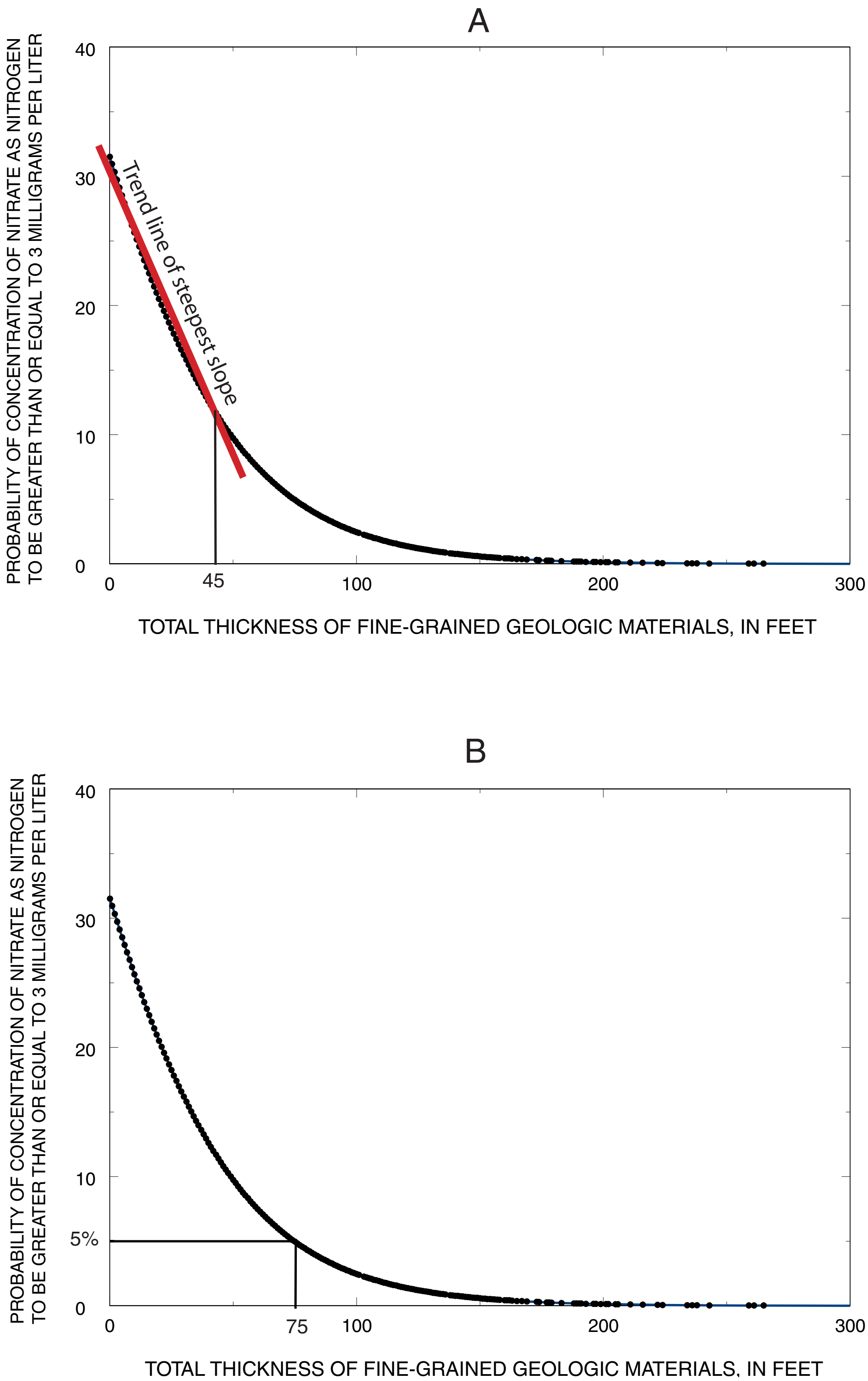


Figure 7. Intervals in which thickness of fine-grained geologic materials is considered thin, moderate, and thick. (A) From 0 to 45 feet fine-grained thickness is considered thin. (B) The 75-feet thickness is considered the transition between moderate and thick.

geology, regional aquifer system, land slope, and ground-water flow direction.

A subjective hybrid method was used in determining a susceptibility rating. The subjective hybrid method combined the results of a logistic regression analysis with subjective analyses of susceptibility and subjective definitions for low, moderate, and thick geologic barriers. The logistic regression determined the probability of elevated concentrations of nitrate (greater than or equal to 3 milligrams per liter as nitrogen (mg/L as N)) in ground-water associated with specific thicknesses of fine-grained geologic materials (geologic barrier) above the pumped aquifer. The geologic barrier was defined to be thin for thicknesses between 0 and 45 ft, moderate for thicknesses greater than 45 and less than or equal to 75 ft, and thick if greater than 75 ft. Characteristics of the probability plot and a 5 percent probability of elevated concentration of nitrate in ground-water were used to determine the definitions of thickness ranges for the geologic barrier.

Information collected for a TNC supply and the assessment area was used with a flow chart to determine a susceptibility rating. Each tier of the flow chart represented potential conditions in and around the TNC supply well. The first tier of the flow chart accounted for the exceedance of IDEM's drinking-water standards for regulated contaminants of concern (COCs) in monitoring samples from the TNC water supply. The second tier accounted for the presence or absence of potential sources of COCs in the assessment area. The third tier accounts for the presence and thickness of a geologic barrier. Lastly, a susceptibility rating of currently not susceptible, moderately susceptible, or susceptible is determined based upon the values applied to the three tiers. A rating of susceptible was automatically given to a TNC supply with a detection of coliform bacteria or a concentration of nitrate greater than 3 mg/L as N. Less than 2 percent (43) of the TNC supplies could not be rated because they were new and no compliance-monitoring data were available. Only one of the TNC supplies was rated not currently susceptible, approximately 7 percent (164) were rated moderately susceptible, and approximately 91 percent (2,144) were rated susceptible. Of the 2,144 TNC supplies rated susceptible, approximately 79 percent (1,694) had a detection of coliform bacteria or a concentration of nitrate greater than 3 mg/L as N in at least one compliance-monitoring sample.

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Appendixes 1–3

1. Example Transient, Non-Community Source-Water Assessment Report
2. Potential Sources of Drinking-Water Contamination Index
3. Concentrations of Nitrate and Thickness of Fine-Grained Geologic Materials Above the Well Screen in Indiana

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report

Source Water Assessment
Public Water Supply ID# XXXXXXX
Service Station #XX

Public Water Supply ID# XXXXXXX
Service Station #XX
Transient Non-community
Name of County
Name of City, Indiana

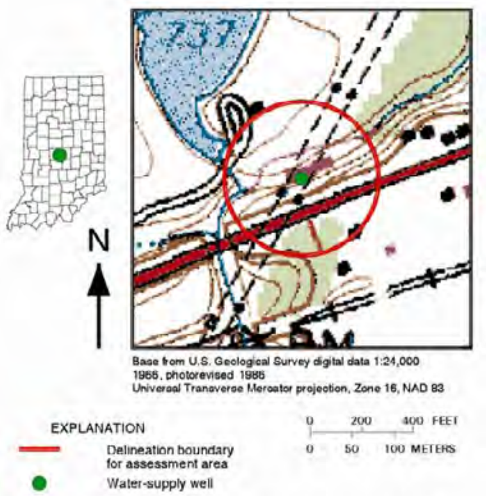

Figure 1. Location of the source water assessment area for Public Water Supply XXXXXXX.

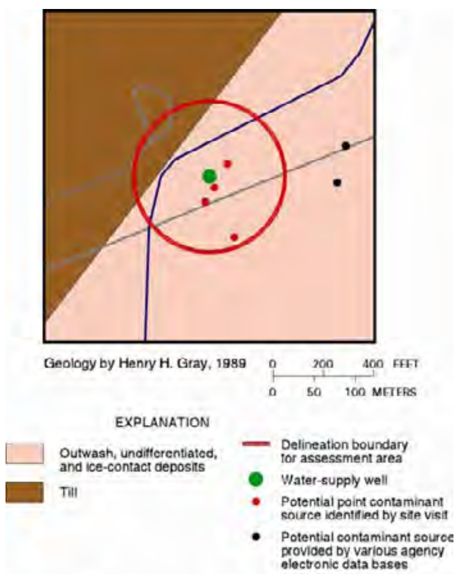

Figure 2. Location of potential point contaminant source(s) and surface geology.

Safe Drinking Water Is Important. In 1996, Congress amended the Safe Drinking Water Act to provide funds for state agencies to perform source water assessments. The Indiana Source Water Assessment Plan defines the approach and strategy for promoting clean and safe drinking water, and for performing individual source water assessments for Indiana's public drinking-water supplies. The assessments evaluate the safety of ground- and surface-water public drinking-water supplies, including that for Service Station #XX. The Indiana Department of Environmental Management (IDEM) has collected information from the assessment area, the area within a 300-ft radius around the well supplying water to Service Station #XX (figure 1). The U.S. Geological Survey has compiled this information and provided other state-wide environmental data. These data include available water-quality data, potential sources of contaminants, geologic information, and other environmental factors that may affect the potential for the drinking-water supply to become contaminated. This report summarizes these findings and includes several links for related information.

Water-Supply Information. The date that the well supplying water to Service Station #XX was drilled is not known. Based upon similar wells in the surrounding area, the estimated depth of the well is 45 feet, and the rated capacity of the well is not known. The three most abundant geologic materials above the water-bearing zone (typically called an aquifer) in order of thickness are clay, gravel, and shale. Water is disinfected and softened and treated to remove inorganics before being served to an average of 300 people per day. Additional information about this drinking-water supply can be seen in the public water supply data table.

What are the Potential Sources of Regulated Contaminants? Regulated contaminants in ground water for transient non-community drinking-water supplies may occur if potential sources of these contaminants are present. The regulated contaminants for transient non-community water supplies are bacteria (total coliform) and nitrate. The possibility that these contaminants are locally present near Service Station #XX is indicated by land-use information and by data collected during on-site visits to this public drinking-water supply. Potential contaminant sources within the assessment area that may contribute to increased concentrations of bacteria and nitrate include pasture and septic systems. A potential contaminant source within the assessment area that may contribute to increased concentrations of nitrate is an area of lawn grass, golf course, or urban park. Data on bacteria and nitrate concentrations collected from drinking water supplied by Service Station #XX can be seen in the bacteria and nitrate tables.

What Are Other Potential Contaminant Sources? For this source water assessment, a potential contaminant source is any activity, facility, or location that stores, handles, generates, or is associated with any of the ninety State-listed drinking water contaminants. Potential contaminant sources were identified by checking contaminant-related data bases and by on-site visits to the water system. Six land uses and four facilities (figures 2 and 3) that have the potential to be sources of non-regulated contaminants were found within the assessment area and two such facilities were found outside the assessment area and within the area of figure 2. For a list of potential contaminants associated with the local land uses see the nonpoint-source contaminants table. A list of potential contaminants associated with facilities can be seen in the point-source contaminants table.

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Source Water Assessment
Public Water Supply ID# XXXXXXX
Service Station #XX

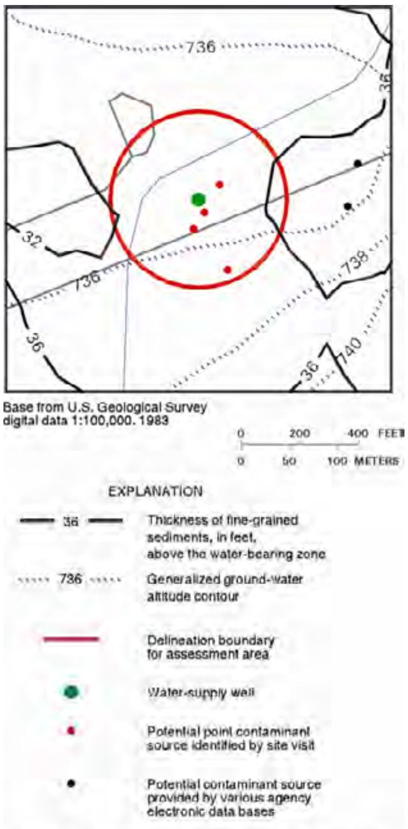

Figure 3. Total thickness of fine-grained sediments above the water-bearing zone and ground-water altitude contours.

What Is The Effect Of The Environmental Setting?

The environmental setting around the drinking-water supply is an important factor influencing susceptibility to contamination. The following is a brief description of the environment as it relates to drinking-water supply susceptibility. The assessment area is mostly overlain by coarse-grained surficial geologic materials. Compared to clay or silt, these materials allow more surface water to infiltrate and provide less filtering action to water and potential contaminants entering the ground. This drinking-water supply lies within the Buried Sand And Gravel and Upper Weathered Bedrock regional aquifer systems. The general topography in the area around the drinking-water supply is slightly rolling, and opportunity exists for spills to infiltrate into ground-water supplies. The general direction of ground-water flow is perpendicular to the ground-water altitude contours and in the direction of decreasing contour values in figure 3. Ground water also may locally flow radially toward the drinking-water supply during pumping.

What Is The Potential That Regulated Contaminants May Reach This Water Supply?

The potential for contamination is evaluated using (1) the detection of elevated nitrate concentrations and the presence of bacteria, (2) the presence of potential contaminant sources, and (3) the presence and thickness of a geologic barrier. The combination of these three factors provides an indication of the potential for a public drinking-water supply to be contaminated. Elevated concentrations of bacteria have been found in the drinking water supplied by Service Station #XX. One land use and two facilities within the assessment area have the potential to contribute bacteria to this drinking-water supply. Two land uses and two facilities within the assessment area have the potential to contribute nitrate to this drinking-water supply. For Service Station #XX, it was found that the thickness of the geologic barrier above the water-bearing zone is generally thin. The combination of these factors suggest this drinking-water supply is susceptible to contamination. In some cases a potential source of contaminants is classified as both a land use and a facility, for example a residence with a septic system.

How Can I Act On This Information?

Promoting a clean and safe drinking-water supply is a primary goal of the Source Water Assessment program. The previous sections provide background information that may help interested parties in developing a source water protection program. The information will help to:

(1) Increase local awareness of the source of drinking water
(2) Recognize the factors affecting drinking-water quality
(3) Focus available resources on sites and areas of greatest concern
(4) Make land-use decisions compatible with maintaining clean water

For more information on developing a local source water protection program or with questions or comments regarding this source water assessment contact the IDEM Drinking Water Branch at 800-451-6027.

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Bacteria Data from the Indiana Department of Environmental Management Compliance Database for the Public-Water Supply PWSID XXXXXXX, Service Station #XX

[NOTE(S): —, data not available]

Date	Sample type	Presence or absence of *Escherichia coli* (E.coli)	Presence or absence of fecal coliform	Presence or absence of total coliform
1/18/1995	Distribution sample	—	—	Absent
4/7/1995	Distribution sample	—	—	Absent
10/11/1995	Distribution sample	—	—	Absent
1/4/1996	Distribution sample	—	—	Absent
6/7/1996	Distribution sample	—	—	Absent
11/14/1996	Distribution sample	—	Absent	Present
11/14/1996	Distribution sample	—	Absent	Present
11/14/1996	Distribution sample	—	Absent	Present
11/14/1996	Distribution sample	—	Absent	Present
12/4/1996	Distribution sample	—	Absent	Present
4/1/1997	Distribution sample	—	—	Absent
4/1/1997	Distribution sample	—	—	Absent
4/14/1997	Distribution sample	—	—	Absent
6/16/1997	Distribution sample	—	—	Absent
7/23/1997	Distribution sample	—	—	Absent
9/12/1997	Routine sample	—	Absent	Absent
12/8/1997	Routine sample	—	Absent	Absent
3/24/1998	Routine sample	—	Absent	Absent
6/17/1998	Routine sample	—	Present	Present
6/22/1998	Check sample	—	Absent	Absent
9/21/1998	Routine sample	—	Absent	Absent
12/8/1998	Routine sample	—	Absent	Absent
3/9/1999	Routine sample	—	Absent	Absent
6/2/1999	Routine sample	—	Absent	Absent
9/14/1999	Routine sample	—	Absent	Absent
12/9/1999	Routine sample	—	Absent	Absent
3/7/2000	Routine sample	—	Absent	Absent

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Bacteria Data from the Indiana Department of Environmental Management Compliance Database for the Public-Water Supply PWSID XXXXXXX, Service Station #XX

[NOTE(S): —, data not available]

Date	Sample type	Presence or absence of *Escherichia coli* (E.coli)	Presence or absence of fecal coliform	Presence or absence of total coliform
6/7/2000	Routine sample	—	Absent	Absent
9/11/2000	Routine sample	—	Absent	Absent
12/6/2000	Routine sample	—	Absent	Absent
1/4/2001	Routine sample	—	Absent	Absent
1/5/2001	Routine sample	—	Absent	Absent
3/5/2001	Routine sample	—	Absent	Absent
4/5/2001	Routine sample	—	Absent	Absent
4/6/2001	Routine sample	—	Absent	Absent
6/5/2001	Routine sample	—	Absent	Absent
7/10/2001	Routine sample	—	Absent	Absent
7/10/2001	Routine sample	—	Absent	Absent
12/17/2001	Routine sample	—	Absent	Absent
5/9/2002	Routine sample	—	Absent	Absent
8/27/2002	Routine sample	—	Absent	Absent
11/14/2002	Routine sample	Absent	Absent	Present
11/21/2002	Check sample	—	Absent	Absent
11/21/2002	Check sample	—	Absent	Absent
11/21/2002	Check sample	—	Absent	Absent
11/21/2002	Check sample	—	Absent	Absent
3/10/2003	Routine sample	—	—	Absent
6/18/2003	Routine sample	—	—	Absent
9/30/2003	Routine sample	—	—	Absent
3/8/2004	Routine sample	—	—	Absent
6/14/2004	Routine sample	—	—	Absent
9/29/2004	Routine sample	—	—	Absent
12/9/2004	Routine sample	—	—	Absent

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Nitrate and Nitrite Data from the Indiana Department of Environmental Management Compliance Database for the Public-Water Supply PWSID XXXXXXX, Service Station #XX

[NOTE(S): —, data not available; <MRL, actual concentration less than the reporting limit of the method used to determine the concentration]

Date	Entry point	Sample type	Nitrate (as N) (milligrams per liter)	Nitrate plus nitrite (as N) (milligrams per liter	Nitrite (as N) (milligrams per liter)
12/9/1994	EP001	Routine sample	0.01	—	—
10/13/1995	EP001	Routine sample	0.5	—	0.005
9/18/1996	EP001	Routine sample	0.12	—	0.03
9/12/1997	EP001	Routine sample	1.14	—	0.04
9/21/1998	EP001	Routine sample	0.22	—	0.04
9/14/1999	EP001	Routine sample	0.01	—	—
9/11/2000	EP001	Routine sample	0	—	—
9/18/2001	EP001	Routine sample	0	—	—
9/16/2002	EP001	Routine sample	0	—	—
12/8/2004	EP001	Routine sample	0 <MRL	0 <MRL	0 <MRL

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Inventory of Potential Point Sources of Contaminants of Concern near the Public-Water Supply PWSID XXXXXXX, Service Station #XX.

Name	Type of activity	Location method	Data source	Potential regulated contaminants of concern associated with this type of activity. Listed contaminants may or may not be present.	Potential contaminants of concern associated with this type of activity. Listed contaminants may or may not be present.
SERVICE STATION XX	GAS STATIONS (SEE ALSO ABOVE GROUND/ UNDERGROUND STORAGE TANKS, MOTOR-VEHICLE DRAINAGE WELLS), RETAIL OPERATIONS, SEPTIC SYSTEMS	OFFSET GPS	INSIDE ASSESSMENT AREA, SITE VISIT	BACTERIA AND NITRATE	1,1,1-TRICHLOROETHANE OR METHYL CHLOROFORM, 1,2-DICHLOROETHANE OR ETHYLENE DICHLORIDE, 2,4-D, ALACHLOR, ARSENIC, ATRAZINE, BARIUM, BENZENE, CADMIUM, CARBOFURAN, CIS 1,2-DICHLOROETHYLENE, COLIFORM, *CRYPTOSPORIDIUM*, DALAPON, DICHLOROMETHANE OR METHYLENE CHLORIDE, DIQUAT, *GIARDIA LAMBLIA*, GLYPHOSATE, LEAD, MERCURY, NITRATE, NITRITE, OXAMYL (VYDATE), PICLORAM, SIMAZINE, STYRENE, SULFATE, TETRACHLOROETHYLENE OR PERCHLORETHYLENE (PERC), TOLUENE, TRANS 1,2-DICHLOROETHYLENE, TRICHLOROETHYLENE (TCE), VINYL CHLORIDE, VIRUSES (ENTERIC)
RESIDENTIAL AREA	FLEET/TRUCKING/BUS TERMINALS, SEPTIC SYSTEMS	OFFSET GPS	INSIDE ASSESSMENT AREA, SITE VISIT	BACTERIA AND NITRATE	1,1,1-TRICHLOROETHANE OR METHYL CHLOROFORM, 1,2-DICHLOROBENZENE OR O-DICHLOROBENZENE, 1,2-DICHLOROETHANE OR ETHYLENE DICHLORIDE, 1,4-DICHLOROBENZENE OR P-DICHLOROBENZENE, 2,4-D, ACRYLAMIDE, ALACHLOR, ARSENIC, ATRAZINE, BARIUM, BENZENE, BENZO(A)PYRENE, CADMIUM, CARBOFURAN, CARBON TETRACHLORIDE, CHLOROBENZENE, CIS 1,2-DICHLOROETHYLENE, COLIFORM, *CRYPTOSPORIDIUM*, CYANIDE, DALAPON, DI(2-ETHYLHEXYL) PHTHLATE, DICHLOROMETHANE OR METHYLENE CHLORIDE, DIQUAT, EPICHLOROHYDRIN, *GIARDIA LAMBLIA*, GLYPHOSATE, HEPTACHLOR EPOXIDE, LEAD, MERCURY, METHOXYCHLOR, NITRATE, NITRITE, OXAMYL (VYDATE), PENTACHLOROPHENOL, PICLORAM, PROPYLENE DICHLORIDE OR 1,2-DICHLOROPROPANE, SELENIUM, SIMAZINE, STYRENE, SULFATE, TETRACHLOROETHYLENE OR PERCHLORETHYLENE (PERC), TOLUENE, TOXAPHENE, TRANS 1,2-DICHLOROETHYLENE, TRICHLOROETHYLENE (TCE), VINYL CHLORIDE, VIRUSES (ENTERIC), XYLENE (MIXED ISOMERS)

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Inventory of Potential Point Sources of Contaminants of Concern near the Public-Water Supply PWSID XXXXXXX, Service Station #XX.—Continued

Name	Type of activity	Location method	Data source	Potential regulated contaminants of concern associated with this type of activity. Listed contaminants may or may not be present.	Potential contaminants of concern associated with this type of activity. Listed contaminants may or may not be present.
WASHINGON ST. - US 40	TRANSPORTATION CORRIDORS (E.G., ROADS, RAILROADS)	OFFSET GPS	INSIDE ASSESSMENT AREA, SITE VISIT		DALAPON, PICLORAM, SIMAZINE, SODIUM, SODIUM CHLORIDE, TURBIDITY
EAST FORK WHITE LICK CREEK	WATER BODY	OFFSET GPS	INSIDE ASSESSMENT AREA, SITE VISIT		NONE KNOWN
SERVICE STATION 22	AUTOMOBILE, BODY/ REPAIR SHOPS	GPS (PSEUDO RANGE) DIFFERENTIAL	OUTSIDE ASSESSMENT AREA, FROM ELECTRONIC DATA BASES		1,1,1-TRICHLOROETHANE, ARSENIC, BARIUM, BENZENE, CADMIUM, CHLOROBENZENE (MONOCHLOROBENZENE), CIS-1,2-DICHLOROETHYLENE, COPPER, DICHLOROMETHANE, FLUORIDE, LEAD, MERCURY, P-DICHLOROBENZENE, TETRACHLOROETHYLENE, TRANS-1,2-DICHLOROETHYLENE, TRICHLOROETHYLENE, XYLENES (TOTAL)
LOCAL AIRPORT	UNDERGRND STORAGE TANK/LEAKY UNDERGRND STORAGE TANK	ADDRESS MATCHING-HOUSE NUMBER	OUTSIDE ASSESSMENT AREA, FROM ELECTRONIC DATA BASES		ARSENIC, BARIUM, BENZENE, CADMIUM, CIS-1,2-DICHLOROETHYLENE, DICHLOROMETHANE, LEAD, P-DICHLOROBENZENE, TETRACHLOROETHYLENE, TRANS-1,2-DICHLOROETHYLENE, TRICHLOROETHYLENE

Appendix 1. Example Transient, Non-Community Source-Water Assessment Report—Continued

Inventory of Potential Nonpoint Sources of Contaminants of Concern near the Public-Water Supply PWSID XXXXXXX, Service Station #XX.—Continued

Well number	Land use	Percent of the area within 300 feet of the well	Potential regulated contaminants of concern associated with this land use. Listed contaminants may or may not be present.	Potential contaminants of concern associated with this land use. Listed contaminants may or may not be present.
1	PAVED	40		DALAPON, PICLORAM, SIMAZINE, SODIUM, SODIUM CHLORIDE, TURBIDITY
1	LAWN GRASS	25	NITRATE ONLY	2,4-D, ARSENIC, ATRAZINE, BENZENE, CARBOFURAN, CHLOROBENZENE, DALAPON, DIQUAT, GLYPHOSATE, LEAD, METHOXYCHLOR, NITRATE, NITRITE, PICLORAM, SIMAZINE, TURBIDITY
1	COMMERCIAL BUILDING	15		1,1,1-TRICHLOROETHANE OR METHYL CHLOROFORM, 1,2-DICHLOROBENZENE OR O-DICHLOROBENZENE, 1,2-DICHLOROETHANE OR ETHYLENE DICHLORIDE, 2,4-D, BARIUM, BENZENE, CADMIUM, COPPER, DIAZINON, DICHLOROMETHANE OR METHYLENE CHLORIDE, DIQUAT, ETHYLBENZENE, GLYPHOSATE, LEAD, MERCURY, SELENIUM, SIMAZINE, TETRACHLOROETHYLENE OR PERCHLORETHYLENE (PERC), TRICHLOROETHYLENE (TCE), VINYL CHLORIDE, XYLENE (MIXED ISOMERS)
1	GRAVEL	10		DALAPON, PICLORAM, SIMAZINE, SODIUM, SODIUM CHLORIDE, TURBIDITY
1	WATER	5		NONE KNOWN
1	PASTURE	5	BACTERIA AND NITRATE	COLIFORM, *CRYPTOSPORIDIUM*, *GIARDIA LAMBLIA*, NITRATE, NITRITE, SULFATE, TURBIDITY, VIRUSES (ENTERIC)

Appendix 2. Potential Sources of Drinking-Water Contamination Index.

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
Commercial / industrial	
Above-ground storage tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or p-Dichlorobenzene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Automobile, Body Shops/Repair Shops	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, 1,4-Dichlorobenzene or p-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Boat Repair/Refinishing/Marinas	Benzene, Cadmium, cis-1,2-Dichloroethylene, Coliform, *Cryptosporidium*, Dichloromethane or Methylene Chloride, *Giardia Lamblia*, Lead, Mercury, Nitrate, Nitrite, trans-1,2-Dichloroethylene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Vinyl Chloride, Viruses
Cement/Concrete Plants	Barium, Benzene, Dichloromethane or Methylene Chloride, Ethyl Benzene, Lead, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Xylene (Mixed Isomers)
Chemical/Petroleum Processing	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthalate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Ethyl Benzene, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor, Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Construction/Demolition	Arsenic, Asbestos, Benzene, Cadmium, Chloride, Copper, Cyanide, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluorides, Lead, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Turbidity, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Dry Cleaners/Dry Cleaning	Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane
Dry Goods Manufacturing	Barium, Benzene, Cadmium, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthalate, Lead, 1,1,1-Trichloroethane or Methyl Chloroform, Polychlorinated Biphenyls, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Electrical/Electronic Manufacturing	Aluminum (Fume or Dust), Antimony, Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride, 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthalate, Ethyl Benzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Thallium, Toluene, Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)

Appendix 2. Potential Sources of Drinking-Water Contamination Index.—Continued

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
	Commercial / industrial—Continued
Fleet/Trucking/Bus Terminals	Arsenic, Acrylamide, Barium, Benzene, Benzo(a)pyrene, Cadmium, Chlorobenzene, Cyanide, Carbon Tetrachloride, 2,4-D, 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthalate, Epichlorohydrin, Heptachlor (and Epoxide), Lead, Mercury, Methoxychlor, Pentachlorophenol, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Toxaphene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Food Processing	Arsenic, Benzene, Cadmium, Copper, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Funeral Services/Taxidermy	Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Total Coliforms, Viruses
Furniture Repair/Manufacturing	Barium, 1,2-Dichloroethane or Ethylene Dichloride, Dichloromethane or Methylene Chloride, Ethyl Benzene, Lead, Mercury, Selenium, Trichloroethylene (TCE)
Gas Stations (see also above ground/underground storage tanks, motor-vehicle drainage wells)	cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE)
Graveyards/Cemeteries	Dalapon, Lindane, Nitrate, Nitrite, Total Coliforms, Viruses.
Hardware/Lumber/Parts Stores	Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Chlorobenzene, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl)adipate, Di(2-ethylhexyl) phthalate, 1,4-Dichlorobenzene or p-Dichlorobenzene, Ethyl Benzene, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Xylene (Mixed Isomers)
Historic Waste Dumps/Landfills	Atrazine, Alachlor, Carbofuran, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Diquat, Dalapon, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Sulfate, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene(TCE)
Home Manufacturing	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Carbon Tetrachloride, 1,2-Dichlorobenzene or o-Dichlorobenzene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthalate, Ethyl Benzene, Lead, Mercury, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Turbidity, Xylene (Mixed Isomers)
Industrial Waste Disposal Wells	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Ammonia, Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthalate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor, Oxamyl (Vydate), Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)

Appendix 2. Potential Sources of Drinking-Water Contamination Index.—Continued

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
Commercial / industrial—Continued	
Junk/Scrap/Salvage Yards	Barium, Benzene, Copper, Dalapon, cis-1,2-Dichloroethylene, Diquat, Glyphosate, Lead, Polychlorinated Biphenyls, Sulfate, Simazine, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Machine Shops	Arsenic, Aluminum (Fume or Dust), Barium, Benzene, Boric Acid, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride 2,4-D, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthalate, Ethyl Benzene, Fluoride, Hexachlorobenzene, Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Xylene (Mixed Isomers), Zinc (Fume or Dust)
Metal Plating/Finishing/Fabricating	Antimony, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Chromium, Copper, Cyanide, 1,4-Dichlorobenzene or p-Dichlorobenzene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Ethyl Benzene, Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), , Thallium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Military Installations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Hexachlorobenzene, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), , Toluene, Trichloroethylene (TCE)
Mines/Gravel Pits	Lead, Selenium, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Turbidity
Motor Pools	cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride
Motor Vehicle Waste Disposal Wells (gas stations, repair shops) See Underground Injection Control website for more information about these sources (U.S. Environmental Protection Agency, 2006e)	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, 1,4-Dichlorobenzene or p-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Office Building/Complex	Barium, Benzene, Cadmium, Copper, 2,4-D, Diazinon, 1,2-Dichlorobenzene or o-Dichlorobenzene, Dichloromethane or Methylene Chloride, Diquat, 1,2-Dichloroethane or Ethylene Dichloride, Ethyl Benzene, Glyphosate, Lead, Mercury, Selenium, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)

Appendix 2. Potential Sources of Drinking-Water Contamination Index.—Continued

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
	Commercial / industrial—Continued
Photo Processing/Printing	Acrylamide, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,1-Dichloroethylene or Vinylidene Chloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthalate, 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Heptachlor epoxide, Hexachlorobenzene, Lead, Lindane, Mercury, Methoxychlor, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Toluene, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Synthetic / Plastics Production	Antimony, Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthalate, Ethyl Benzene, Hexachlorobenzene, Lead, Mercury, Methyl Chloroform or 1,1,1-Trichloroethane, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perk), Toluene,, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
RV/Mini Storage	Arsenic, Barium, Cyanide, 2,4-D, Endrin, Lead, Methoxychlor
Railroad Yards/Maintenance/Fueling Areas	Atrazine, Barium, Benzene, Cadmium, Dalapon, 1,4-Dichlorobenzene or p-Dichlorobenzene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE).
Research Laboratories	Arsenic, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Endrin, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), Thallium, Thiosulfates, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
	Residential / municipal
Retail Operations	Arsenic, Barium, Benzene, Cadmium, 2,4-D, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane, Vinyl Chloride
Underground Storage Tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or p-Dichlorobenzene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE)
Wood Preserving/Treating	cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Lead, Sulfate
Wood/Pulp/Paper Processing	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Copper, Dichloromethane or Methylene Chloride, Dioxin, 1,2-Dichloroethane or Ethylene Dichloride, Ethyl Benzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Xylene (Mixed Isomers)

Appendix 2. Potential Sources of Drinking-Water Contamination Index.—Continued

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
Residential / municipal—Continued	
Airports (Maintenance/Fueling Areas)	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, cis-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Ethyl Benzene, Lead, Mercury, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Apartments and Condominiums	Atrazine, Alachlor, Coliform, *Cryptosporidium*, Dalapon, Diquat, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Camp Grounds/RV Parks	Benomyl, Coliform, *Cryptosporidium*, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Isopropanol, Nitrate, Nitrite, Picloram, Sulfate, Simazine, Turbidity, Vinyl Chloride, Viruses
Cesspools - Large Capacity (see UIC for more information)	Atrazine, Alachlor, Carbofuran, Coliform, *Cryptosporidium*, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Drinking Water Treatment Facilities	Atrazine, Benzene, Cadmium, Cyanide, Fluoride, Lead, Polychlorinated Biphenyls, Toluene, Total Trihalomethanes, 1,1,1-Trichloroethane or Methyl Chloroform
Gas Pipelines	cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene or TCE
Golf Courses and Urban Parks	Arsenic, Atrazine, Benzene, Chlorobenzene, Carbofuran, 2,4-D, Diquat, Dalapon, Glyphosate, Lead, Methoxychlor, Nitrate, Nitrite, Picloram, Simazine, Turbidity
Housing developments	Atrazine, Alachlor, Coliform, *Cryptosporidium*, Carbofuran, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Landfills/Dumps	Arsenic, Atrazine, Alachlor, Barium, Benzene, Cadmium, Carbofuran, cis-1,2-Dichloroethylene, Diquat, Glyphosate, Lead, Lindane, Mercury, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Selenium, Simazine, Trichloroethylene (TCE)
Public Buildings (e.g., schools, town halls, fire stations, police stations) and Civic Organizations	Arsenic, Acrylamide, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 2,4-D, 1,2-Dichlorobenzene or o-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Endothall, Endrin, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Lead, Lindane, Mercury, Methoxychlor, Selenium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Septic Systems	Atrazine, Alachlor, Carbofuran, Coliform, *Cryptosporidium*, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Sewer Lines	Coliform, *Cryptosporidium*, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Stormwater infiltration basins/injection into wells (UIC Class V), runoff zones	Atrazine, Alachlor, Coliform, *Cryptosporidium*, Carbofuran, Chlorine, Diquat, Dalapon, *Giardia Lamblia,* Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Nitrosamine, Oxamyl (Vydate), Phosphates, Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Transportation Corridors (e.g., Roads, railroads)	Dalapon, Picloram, Simazine, Sodium, Sodium Chloride, Turbidity

Appendix 2. Potential Sources of Drinking-Water Contamination Index.—Continued

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
Residential / municipal—Continued	
Utility Stations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Cyanide, 2,4-D, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Toluene, 1,1,2,2- Tetrachloroethane, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Waste Transfer /Recycling	Coliform, *Cryptosporidium*, *Giardia Lamblia*, Nitrate, Nitrite, Vinyl Chloride, Viruses
Wastewater Treatment Facilities/Discharge locations (incl. land disposal and underground injection of sludge)	Cadmium, Coliform, *Cryptosporidium*, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluoride, *Giardia Lamblia*, Lead, Mercury, Nitrate, Nitrite, Tetrachloroethylene or Perchlorethylene (Perc) Selenium, Sulfate, Trichloroethylene (TCE), Vinyl Chloride, Viruses
Agricultural / rural	
Auction Lots/Boarding Stables	Coliform, *Cryptosporidium*, *Giardia Lamblia*, Nitrate, Nitrite, Sulfate, Viruses
Animal Feeding Operations/ Confined Animal Feeding Operations	Coliform, *Cryptosporidium*, *Giardia Lamblia*, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Bird Rookeries/Wildlife feeding /migration zones	Coliform, *Cryptosporidium*, *Giardia Lamblia*, Nitrate , Nitrite , Sulfate, Turbidity, Viruses
Crops - Irrigated and Non-irrigated	Benzene, 2,4-D, Dalapon, Dinoseb, Diquat, Glyphosate, Lindane, Lead, Nitrate, Nitrite , Picloram, Simazine, Turbidity
Dairy operations	Coliform, *Cryptosporidium*, *Giardia Lamblia*, Nitrate , Nitrite, Sulfate, Turbidity, Viruses
Drainage Wells, Lagoons and Liquid Waste Disposal - Agricultural	Atrazine, Alachlor, Coliform, *Cryptosporidium*, Carbofuran, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Managed Forests/Grass Lands	Atrazine, Diquat, Glyphosate, Picloram, Simazine, Turbidity
Pesticide/Fertilizer Storage Facilities	Atrazine, Alachlor, Carbofuran, Chlordane, 2,4-D, Diquat, Dalapon, 1,2-Dibromo-3-Chloropropane or DBCP, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, 2,4,5-TP (Silvex)
Rangeland/Grazing lands	Coliform, *Cryptosporidium*, *Giardia Lamblia*, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Residential Wastewater lagoons	Atrazine, Alachlor, Carbofuran, Coliform, *Cryptosporidium*, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Rural Homesteads	Atrazine, Alachlor, Carbofuran, Coliform, *Cryptosporidium*, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses

Appendix 2. Potential Sources of Drinking-Water Contamination Index.—Continued

[UIC, Underground injection control; Vet, Veterinary; RV, recreational vehicle]

Potential source	Contaminant of concern
Miscellaneous sources	
Abandoned drinking water wells (conduits for contamination)	Atrazine, Alachlor, Coliform, *Cryptosporidium*, Carbofuran, Diquat, Dalapon, *Giardia Lamblia*, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Naturally Occurring	Arsenic, Asbestos, Barium, Cadmium, Chromium, Coliform, Copper, *Cryptosporidium*, Fluoride, *Giardia Lamblia*, Iron, Lead, Manganese, Mercury, Nitrate, Nitrite, Radionuclides, Selenium, Silver, Sulfate, Viruses, Zinc (Fume or Dust)
Underground Injection Control (UIC) Wells CLASS I - deep injection of hazardous and non-hazardous wastes into aquifers separated from underground sources of drinking water	U.S. Environmental Protection Agency (2006a)
UIC Wells CLASS II deep injection wells of fluids associated with oil/gas production (for more detailed list of sites click here)	U.S. Environmental Protection Agency (2006b)
UIC Wells CLASS III re-injection of water/steam into mineral formations for mineral extraction	U.S. Environmental Protection Agency (2006c)
UIC Wells CLASS IV - officially banned. Inject hazardous or radioactive waste into or above underground sources of drinking water	U.S. Environmental Protection Agency (2006d)
UIC Wells Class V (Shallow injection wells)	U.S. Environmental Protection Agency (2006e)

Source: U.S. Environmental Protection Agency (2004)

Appendix 3. Concentrations of Nitrate and Thickness of Fine-Grained Geologic Materials Above the Well Screen in Indiana

Appendix 3 data are available in an Excel data base spreadsheet and a tab-delimited file for download:
Tab-delinited URL: http://pubs.usgs.gov/sir/2005/5059/htdocs/Appendix_3.txt
Excel data base spreadsheet URL: http://pubs.usgs.gov/sir/2005/5059/htdocs/Appendix_3.xls

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Arihood, L.D., and Cohen, D.A.—**Methods Used to Assess the Susceptibility to Contamination of Transient, Non-Community Public Ground-Water Supplies in Indiana** —Scientific Investigations Report 2005–5059