Wellhead Protection Plan

Prepared For

The City of West Carrollton

As Part of a Cooperative Between
The Cities of West Carrollton and Miamisburg

Prepared by

CH2M HILL

Dayton, Ohio

December 1993

Reader's Guide

This document describes the City of West Carrollton's work to date to develop and implement a comprehensive program to protect its vital groundwater resources from degradation. Each reader may have a different level of interest in this program. The following suggests how each reader may best match the desired level of detail with his or her level of interest.

1. Limited interest: Read the Executive Summary only.
2. Detailed interest: Read the entire main text.
3. Comprehensive interest: Read the entire main text and the appendices.

Contents

Tables

Figures

Executive Summary

The City of West Carrollton's Public Works Department operates a municipal wellfield that draws groundwater from a buried valley aquifer to meet the City's water supply needs. Because of the relatively shallow depth to groundwater in the area and the absence of a near surface low permeability layer, the City's groundwater supply (the only source of drinking water) is potentially vulnerable to a variety of contamination threats. Because of known groundwater contamination incidents, the existence of numerous potential contaminant sources, and recent regulatory requirements, West Carrollton has begun to develop protection plans for its groundwater resources. This report describes the work performed to date by the City of West Carrollton and its consultant (CH2M HILL) to meet the objectives of Ohio's Wellhead Protection Program (Ohio Environmental Protection Agency 1992).

The report contains seven sections (and four appendixes that provide detailed information):

Section 1 describes the regulatory framework that guides the work and introduces the general components of a wellhead protection program.

Section 2 and Appendix A describe the methods used to delineate a wellhead protection area around the City's wellfield.

Section 3 and Appendix B present the results of the inventory of known contamination incidents and potential contaminant sources.

Section 4 and Appendix C present the recommended groundwater monitoring plan and sampling and analysis plan.

Section 5 and Appendix D describe the contingency plans that may be invoked in the event of contamination in a City monitoring or production well, or that may be invoked in an emergency (such as a contaminant spill) that could threaten groundwater quality.

Section 6 outlines the possible elements of an overall management strategy that the City could use to fully develop and implement its wellhead protection program.

Section 7 summarizes the recommendations made in the preceding sections.

Wellhead Protection Area Delineation

The source of West Carrollton's water is the Great Miami Buried Valley Aquifer System, which is an extensive sand and gravel aquifer designated in 1988 by the U.S. Environmental Protection Agency as a sole source aquifer under the federal Safe Drinking Water Act. This designation affords extra protection to the aquifer under federal and state regulations.

Conceptual Model of Hydrogeology

Delineating wellhead protection areas in complex hydrogeologic environments like the Great Miami Buried Valley Aquifer System requires the use of sophisticated methods such as numerical (mathematical) computer modeling. Before numerical modeling can be performed, a conceptualization of the area's hydrogeologic setting must be developed. A conceptual model is a theoretical formulation that describes the assumed hydrogeologic conditions (for example, stratigraphic units, boundaries to groundwater flow) to be modeled. The conceptual model of the project area's hydrogeology includes the following:

- A bedrock valley that was scoured by glacial events and subsequently filled with permeable, water-bearing glacial outwash (sand and gravel) deposits up to 200 feet thick
- A low permeability glacial till (clay-rich material) layer that locally divides the outwash deposits into an upper and lower aquifer and that allows water to leak vertically between the two aquifers
- Recharge to the groundwater system that occurs primarily through infiltration of surface water flow and precipitation

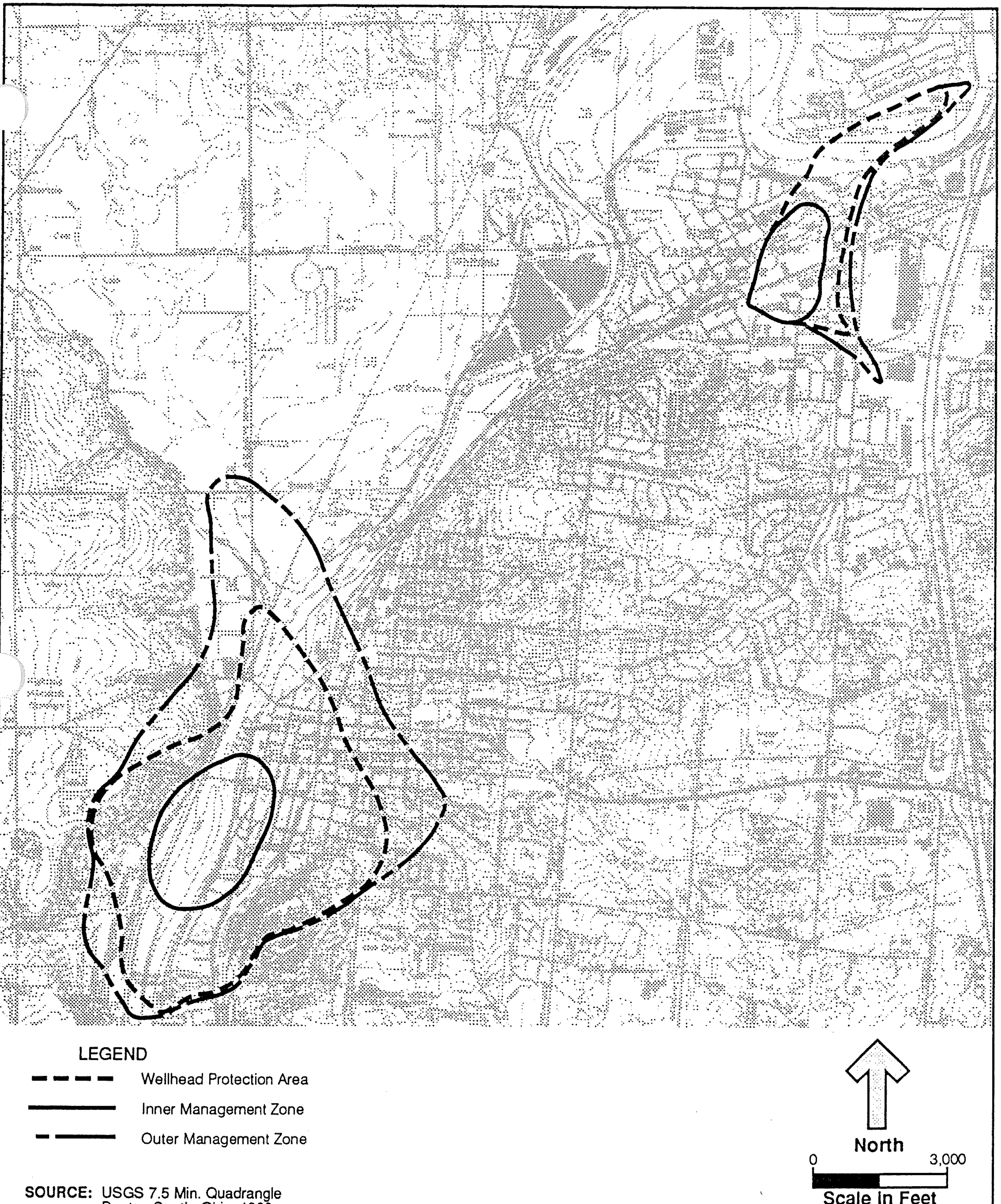
Numerical Model

Numerical models allow the assignment of discrete parameter values to separate blocks of the model grid to represent the hydrogeologic system and the heterogeneity in the actual groundwater system. Constructing and using such models allows for predictions to be made in the way that a hydrogeologic system will respond to stresses such as pumping at a municipal wellfield. For this project, CH2M HILL constructed a three-dimensional model using the U.S. Geological Survey MODFLOW code to simulate pumping conditions and responses caused by groundwater extractions from West Carrollton and other nearby groundwater users.

Capture Zone Analysis of Wellhead Protection Areas

Capture zone analysis is one of the most sophisticated processes of delineating wellhead protection areas. Following construction and verification of the numerical model, CH2M HILL used the U.S. Geological Survey MODPATH code (and output from MODFLOW runs) to estimate groundwater pathlines for 1-, 5-, and 10-year times-of-travel. These pathlines (and the delineated area encompassing them) estimate the areas from which the West Carrollton wellfield will draw water in the time period of interest.

The Ohio Environmental Protection Agency's Wellhead Protection Program recommends that water suppliers delineate protection areas for 1- and 5-year times-of-travel so that zones from which groundwater could potentially move to the City's wellfield over 1- and 5-year periods are included. More stringent protection measures are envisioned for the smaller (1 year) protection area. Figure ES-1 shows the resulting protection areas.



SOURCE: USGS 7.5 Min. Quadrangle Dayton South, Ohio, 1966, Photorevised 1981.

Figure ES-1
Miamisburg and West Carrollton Inner Management Zone, Wellhead Protection Areas, and Outer Management Zones
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

Potential Contamination Sources

A potential contamination source survey is intended to identify potential pollution sources and subsequently assist in the development of groundwater monitoring and contingency plans. Using a variety of information sources, a total of 20 sites that contain potential groundwater contaminant sources were located within the West Carrollton 1- and 5-year wellhead protection areas. Of these 20 sites, one has known groundwater contamination problems. The sites were ranked as to their probable pollution risk according to the Ohio Environmental Protection Agency's suggested categorization (Ohio EPA 1992) (with the exception that known contamination cases are, by definition, high risk sites).

Groundwater Monitoring Plan

Based on the locations of potential contaminant sources and known contamination incidents, six additional monitoring wells at five locations are proposed to complete the initial groundwater monitoring network. The groundwater monitoring plan outlines a 2-year cycle of groundwater sampling (for a variety of inorganic and organic constituents) and water level measurements.

Groundwater quality sampling allows the tracking of water quality changes that might necessitate actions to mitigate contamination problems that pose threats to the City's water supply system. Frequent water level measurements will assist in estimating and tracking groundwater flow directions (and changes in direction with time). Information on flow directions is critical when evaluating where contamination may originate.

Contingency Plans

Contingency plans consist of multiple actions that may be implemented if substantial changes in groundwater quality occur in a monitoring or production well, or if an emergency (such as a contaminant spill) occurs that could adversely affect groundwater quality. Different actions would be taken depending on whether contaminants are detected in a monitoring well or production well.

The wellhead protection contingency plan should be integrated into (and expand) the City's existing contingency plan for emergency operations in response to threats to its water supply. For example, when it is complete, the wellhead protection contingency plan will identify both short-term (emergency) and long-term alternative water supplies, as well as the funding mechanisms for financing them.

The City may need to invoke its wellhead protection plan if analytical results from either a monitoring or production well shows concentrations above a trigger concentration (referred to as a preventive action limit, or PAL). PALs for organic constituents are defined as concentrations greater than 10 percent of a constituent's maximum contaminant level (MCL) as defined by the U.S. Environmental Protection Agency; PALs for inorganic constituents are defined as concentrations greater than 50 percent of a constituent's MCL. Depending on the types, locations, and concentrations of contaminants, necessary actions may range from simply increasing the monitoring frequency to abandoning and replacing a production well in conjunction with remedial actions.

An emergency response team (under the supervision of the City Fire Chief) should be formed to deal specifically with emergencies that may involve an immediate threat to the City's water supply. Examples of these emergencies include tanker truck accidents, railroad accidents, storage tank ruptures, and fires. Actions of the wellfield emergency response team should be coordinated with the City's existing emergency response plan for protecting its water supply. To respond appropriately in an emergency, the officials involved in decisionmaking must understand the sensitivity of the wellfield to contamination and the magnitude of costs involved in remediating groundwater contamination once it has occurred.

Management Strategy

The City of West Carrollton should consider developing and implementing a comprehensive management strategy to control both existing and potential sources of groundwater contamination (as recommended by Ohio's Wellhead Protection Program). Major components of this management strategy would include:

- Formation of a planning committee to assist in wellhead protection plan development and implementation
- Identification and evaluation of possible groundwater protection measures (for example, prohibition of certain activities through zoning mechanisms, prescribing operating standards to regulate high risk activities) and evaluating the ease of implementing these measures
- Preparation of a water supply plan to project long-term water needs in conjunction with possible actions that the City could take to protect likely water supply areas well in advance of the actual installation of new production wells
- Development and implementation of a public participation and education program to fully involve affected parties in wellhead protection activities

GLOSSARY

Aquifer—Saturated rock or sediment that is permeable enough to transmit significant quantities of water to wells and/or springs.

Buried Valley Aquifer—An aquifer formed by the scouring and subsequent infilling of a pre-existing bedrock valley with water bearing sediments during glacial events.

Capture Zone—The portion of an aquifer contributing water to a well.

Chain of Custody—Signed documentation that details sample handling from the time of sample collection to sample analysis.

Conceptual Model—A theoretical formulation that describes the assumed hydrogeological conditions (stratigraphic units, boundary conditions, etc.) that form the basis for a numerical model.

Confining Low-Permeability Layer—A layer or zone of generally low permeability underlying or overlying more permeable aquifer material that a retards the vertical movement of groundwater.

Discharge—The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.

Esker—A long, narrow ridge of sand and gravel situated in the middle of a more heterogeneous glacial deposit.

Great Miami Buried Valley Aquifer System—A system of buried valley aquifers that contain portions of the Great Miami, Little Miami, and Mill Creek Basins of Ohio and the Whitewater River Basin in Indiana.

Groundwater, Confined—Water within an aquifer that is under greater than atmospheric pressure due to an overlying layer that has a low hydraulic conductivity.

Groundwater Divide—A boundary on a potentiometric surface across which negligible groundwater flow occurs.

Groundwater, Unconfined—Water within an aquifer that has a water table.

Hazardous Waste—Any garbage; refuse; sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; or other discarded material, including solid, liquid, semisolid or hazardous gas—containing material resulting from industrial, commercial, mining or agricultural operations or from community activities that because of its quantity, concentration or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed. The term hazardous waste does not include some materials that are specifically exempted from that classification.

Hydraulic Conductivity—A measure of the ease with which an aquifer transmits water.

Hydraulic Gradient—The change in head (groundwater elevation) divided by the change in distance in a given direction.

Inner Management Zone (IMZ)—WHP Area defined by a one-year capture zone. This zone often requires more stringent management controls than the five-year WHP area due to the proximity to the well/wellfield.

Kame—A small hill formed where sand and gravel accumulated by glacial meltwaters were deposited near or at the edge of the retreating ice.

Leakance (Streambed)—The rate of flow from a stream into an aquifer through the streambed.

Leakance (Till)—The rate of vertical groundwater flow through a till layer.

Maximum Contaminant Level—The highest concentration of a solute permissible in a public water supply as specified in the National Primary Drinking Water Standards.

Method Detection Limit—The lowest limit at which an analytical laboratory can accurately discern the presence and concentration of the constituent of concern in a soil or water sample.

MODFLOW—A numerical computer code developed by the U.S. Geological Survey used to develop three-dimensional groundwater flow models.

MODPATH/MODPATH-PLOT—Computer codes developed by the U.S. Geological Survey to simulate and plot particle movement in aquifers using output from the MODFLOW computer code.

National Geodetic Vertical Datum of 1929 (NGVD)—A datum maintained by the U.S. Coast and Geodetic Survey. Replaces Mean Sea Level.

Numerical Model—A mathematical model (typically solved with a computer) that represents an approximation of a field situation. Numerical models used discrete hydrogeologic variables over the modeled area, allowing for the simulation of heterogeneous conditions.

Outer Management Zone (OMZ)—WHP area defined by a ten-year capture zone. This zone is often used for long-term management planning.

Outwash—Generally refers to sediments, in this case sand and gravel with lenses of fine-grained material, deposited by glacial meltwaters.

Porosity—A measure of the amount of void space in a volume of geologic materials. The void portion of an aquifer is the space in which water is stored and through which groundwater flows.

Potentiometric Surface—In confined or semiconfined aquifers, the imaginary surface representing the confined pressure (hydrostatic head) throughout all or part of the aquifer.

Recharge—The addition of water to the aquifer system.

Remedial Investigation—A field investigation whose purpose is to attempt to define the nature and extent of contamination so that feasible alternatives for contaminant containment/cleanup can be evaluated.

Retardation Factor—A factor that describes how quickly a dissolved contaminant in the saturated zone moves relative to the groundwater velocity; for most contaminants, the retardation factor is greater than one, indicating that the dissolved contaminant has a lower velocity than the groundwater.

Saturated Zone—The zone below the water table where most of the pore spaces are occupied by water.

Sensitivity Analysis—A qualitative analysis of the impact of changing the value of a hydraulic parameter used in a groundwater flow model.

Solid Waste—Such unwanted residual solid or semisolid material as results from industrial, commercial, agricultural, or community operations, excluding earth or material from construction, mining, or demolition operations, other waste materials that would normally be included in demolition debris, nontoxic fly ash, spent nontoxic foundry sand, and other substances that are not harmful or inimical to public health. Solid waste includes, but is not limited to, garbage, tires, combustible and noncombustible material, street dirt, and debris. It does not include any material that is an infectious waste or hazardous waste.

Till—Generally, a glacial deposit that consists of a mixture of clay, silt, sand, and gravel and that has a relatively low hydraulic conductivity.

Transmissivity—The product of hydraulic conductivity multiplied by aquifer saturated thickness; a measure of the ability of an aquifer to produce water.

Unsaturated Zone—The zone between the land surface and the water table, where the majority of the pore spaces are occupied by air.

Volatile Organic Compound—An organic compound that is characterized by being relatively mobile in groundwater and that readily evaporates in its pure state.

Water Table—The groundwater surface in an unconfined aquifer; the point at which groundwater occurs at atmospheric pressure.

Wellhead Protection Area (WHP Area)—The area delineated around a wellhead to be protected from possible sources/causes of groundwater contamination; a zone around drinking water supply wells for the prevention, detection, and remediation of groundwater contamination (Ohio EPA 1992).

Acronyms and Abbreviations

BUSTR	Bureau of Underground Storage Tank Regulations
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Inventory System
DERR	Division of Emergency and Remedial Response
EROPIK	Emergency Response Online Pollution Incidents Listing
EROS	Emergency Response Online System
ERT	Emergency Response Team
ft	Feet
ft/day	Feet per Day
ft/ft	Feet per Foot
GMBVAS	Great Miami Buried Valley Aquifer System
gpd	Gallons per Day
gpd/ft	Gallons per Day Per Foot
fpd/ft^3	Gallons per Day per Cubic Foot
gpm	Gallons per Minute
IMZ	Inner Management Zone
in/yr	Inches per Year
MCD	Miami Conservancy District
MCL	Maximum Contaminant Level
mgd	Million gallons per day
mg/L	Milligrams per liter (parts per million)
MW	Monitoring Well

MODFLOW	Modular Finite Difference Groundwater Flow Model
NGVD	National Geodetic Vertical Datum
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
PAL	Preventative Action Limit
PCB	Polychlorinated biphenyls
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act of 1976
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
TH	Test Hole
TRI	Toxic Release Inventory
μg/L	Micrograms per liter (parts per billion)
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WHP	Wellhead Protection

Section 1
Introduction

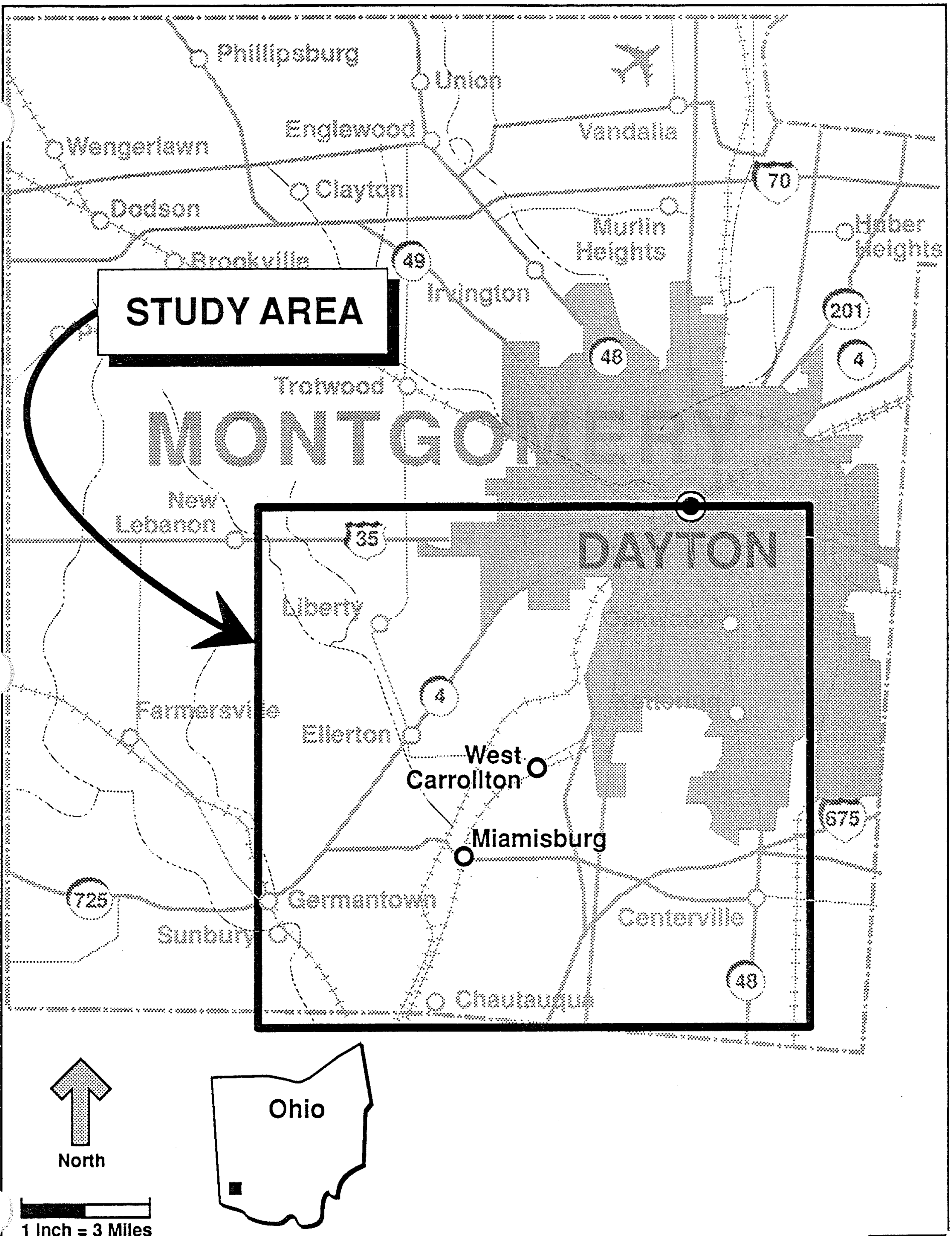
The Cities of Miamisburg and West Carrollton in Ohio (Figure 1-1) rely on groundwater derived from the Great Miami Buried Valley Aquifer System (GMBVAS) to supply water for domestic, municipal, commercial, and industrial needs within the cities. The GMBVAS has been designated by the U.S. EPA as a sole source aquifer under the Safe Drinking Water Act. An aquifer must supply 50 percent or more of the drinking water for a given aquifer service area to be considered for designation as a sole source aquifer. Both Miamisburg and West Carrollton rely entirely on the GMBVAS for their potable water supply. Because the GMBVAS is an unconfined or semi-confined aquifer, both cities' supplies are potentially vulnerable to contamination threats. The cities' wellfields are surrounded by a variety of land uses ranging from residential and light commercial to heavy industrial. Many local industrial operations have been in operation for several decades, long before it was understood how releases of solid waste or hazardous substances could adversely affect groundwater quality. Because of known groundwater contamination incidents, the existence of numerous potential contaminant sources, and recent Ohio regulatory requirements, Miamisburg and West Carrollton have begun to develop protection plans for their groundwater resources.

Miamisburg and West Carrollton have a history of collaboration (based on their proximity to each other) that has proved to be beneficial to both cities. In the spirit of mutual cooperation and benefit, the two cities entered into a joint agreement with a consultant (CH2M HILL) to develop the initial components of individual groundwater protection programs. Several components of the work described in this document were facilitated and accomplished at lower overall cost to each city because of cost-sharing under this joint agreement.

Although much of the work was performed concurrently, separate deliverables (based on each city's unique circumstances) have been produced. This document describes the activities conducted to date by the City of West Carrollton and CH2M HILL to develop the initial components of West Carrollton's wellhead protection plan. It is expected that it will be updated in the future as new information is obtained during further development and implementation of the program.

Regulatory Framework

The Safe Drinking Water Act (SDWA) Amendments of 1986 established a new wellhead protection (WHP) program to protect groundwater that contributes drinking water to public water supply systems. Under SDWA Section 1428, each state must prepare a WHP program for submittal to the U.S. Environmental Protection Agency (U.S. EPA). The Ohio Environmental Protection Agency (Ohio EPA), the agency responsible for



Base Map is USGS 1:5,000,000
State of Ohio Map, 1971.

Figure 1-1
Location of Study Area
Miamisburg/West Carrollton Wellhead Protection

administering WHP within the state of Ohio, issued its U.S. EPA-approved WHP program in May 1992. A statutory mechanism for enforcement of the state's WHP program requirements has not been established. Instead, the Ohio EPA encourages compliance with WHP program elements through voluntary actions.

Cities that rely solely on groundwater as a source of water supply, such as Miamisburg and West Carrollton, are especially sensitive to groundwater contamination. Many cities are implementing WHP plans to protect their water sources in advance of statutory requirements. Although the Ohio EPA does not presently have the statutory framework to approve or disapprove local WHP plans, the agency will accept submitted plans that meet all of the requirements in the state WHP program.

This report for the City of West Carrollton has been prepared to generally correspond with the WHP components described in the final version of the Ohio WHP Program. However, some of the components are presented herein as typical of a WHP plan but are not intended to represent a complete or final description of the City of West Carrollton's intentions with regard to the component. For example, this document presents only a general description of what the City's comprehensive management strategy (Section 6) for controlling potential contamination sources will likely be. That management strategy will develop, in part, based on the actions and recommendations of an advisory committee that will be established and active in the future.

Additionally, the Contingency Plan elements described in this document (Section 5) are intended only as an outline of the detailed steps and protection measures that would be taken in the event of an imminent or actual threat to groundwater quality. As required by the Ohio Administrative Code (Chapter 3745-85), the City of West Carrollton maintains a detailed contingency plan (relevant portions of which are attached to this document) for dealing with emergencies threatening its ability to provide safe drinking water to its citizens.

WHP Plan Components

The elements of a WHP plan required by SDWA Section 1428 can be divided into five major components:

- WHP Area Delineation
- Contaminant Source Inventory
- Groundwater Monitoring Plan
- Contingency Plan
- Management Strategy

The protection plan identifies potential sources of contamination within the protection area of the wellfield, prescribes appropriate actions to be taken if early detection methods indicate the potential for contamination of production wells, and reduces the potential for future contamination incidents by regulating land uses and chemical handling within the WHP area. The major components of a WHP plan are briefly described below.

WHP Area Delineation

As water is pumped from a production well, groundwater in the aquifer is drawn toward the well. The rate and direction of groundwater flow is a function of the hydraulic properties of the aquifer, such as hydraulic conductivity, porosity, hydraulic gradient, and aquifer recharge/discharge relationships. Considering these properties, it is possible to estimate the capture zone of a well or a wellfield over time using a variety of methods, ranging from simple arithmetic calculations to numerical computer simulations. The estimated capture zone of a wellfield over a given time period provides the basis for delineating WHP areas.

The method used to delineate WHP areas is selected on the basis of aquifer complexity. In simple, uniform aquifers, the protection area delineation is straightforward. In more complex settings such as the GMBVAS, protection area delineations may require more rigorous analysis. Additional information regarding the delineation of West Carrollton's WHP areas can be found in Section 2 and Appendix A.

The Ohio WHP Program prefers WHP plans to include protection area delineations for 1- and 5-year travel times. Stricter controls on permitted land use or chemical storage and use are placed on the smaller (1-year) protection area, and more lenient controls are placed on the larger (5-year) protection area. This concept of focused control is being implemented in several cities nationwide including Dayton and Columbus, Ohio.

Contaminant Source Inventory

Potential sources of groundwater contamination and known groundwater contamination incidents within the WHP area are inventoried as part of the WHP plan. Potential contaminant sources include underground storage tanks, industrial and commercial processes such as manufacturing or dry cleaning, accidental leaks or spills, landfills, and dispersed sources of contamination such as road salt used for ice control. Potential sources and known occurrences of contamination are plotted on a map and ranked to evaluate their relative threat to the drinking water supply. Section 3 and Appendix B contain additional information regarding the contaminant source survey.

Groundwater Monitoring Plan

After the locations of known occurrences and potential sources of contamination are noted, a groundwater monitoring plan is developed to monitor the quality of groundwater entering the wellfield along selected flow paths. The groundwater monitoring plan includes locations of monitoring wells, a description of sampling and analysis methods, a sampling schedule, and data management procedures. Additional information on the proposed groundwater monitoring plan for the City of West Carrollton can be found in Section 4 and Appendix C.

Contingency Plan

The contingency plan describes appropriate responses to detected contamination near the wellfield. In cases where groundwater contamination is already known to exist in the wellfield area, it also describes actions that should be taken to monitor and, if appropriate, remediate the contamination. The contingency plan also describes actions that should be taken in case of emergencies, such as fires at industrial or chemical storage sites and large quantity spills, such as from truck or rail accidents. The plan identifies individuals who are responsible for decision-making in emergency situations and describes the roles of parties such as the police and fire departments, city officials, and environmental regulators who may make up an emergency response team. Contingency plans for WHP plans are intended to supplement and expand on the city's existing water supply contingency plans. Section 5 and Appendix D contain additional information describing the contingency plans.

Management Strategy

This WHP plan component involves the development of an overall management strategy to fully implement the entire WHP plan. Once the risk of contamination to the wellfield is understood, the city has several options for reducing the potential for future contaminant releases. For example, alternative groundwater protection measures and regulatory mechanisms may preclude the development of activities that carry the greatest risk to groundwater resources. Activities posing less, but still significant, risks may require active groundwater protection measures to assure adequate protection of the groundwater resources. Possible contaminant sources with little potential for adverse effects may require still less restrictive protection measures.

The potential measures for implementing a WHP plan should be developed using a public participation process that includes formation of a committee made up of city staff, representatives of affected jurisdictions, local business and industry representatives, and local citizens. Technical assistance can be provided where necessary by environmental engineering and hydrogeological consultants, or by technical staff from regulatory agencies.

The committee's activities are to be undertaken with the active participation of the affected public to ensure that decisionmakers understand their constituent's concerns. At the same time, public education activities will take place to enhance the public's understanding of its responsibilities and obligations to help protect the community's water resources.

The overall management strategy will also examine the long-term water supply needs of the city with respect to the need for new wells to supplement or replace the city's existing wells.

Contents of This Report

The report describes the physical setting of the City of West Carrollton's wellfield, including the wellfield layout and local hydrogeology. Available data on the general groundwater quality of the wellfield and on the occurrence of groundwater contamination in and near the wellfield are summarized. The methods used to delineate the WHP areas are described, and maps showing the 1-, 5-, and 10-year capture zones are provided. Potential contaminant sources are listed and mapped, and the methods used to identify them are described. A groundwater monitoring plan and a contingency plan for dealing with detected contaminants or emergencies are outlined. Additionally, the report presents a general discussion of the management strategy to be developed in the future that will prescribe the specific actions and measures the City of West Carrollton will take to fully implement its WHP plan.

Section 2
WHP Area Delineation

As described in Section 1, delineating WHP areas in complex hydrogeologic environments like the GMBVAS requires the use of sophisticated methods such as mathematical computer modeling. For the Miamisburg and West Carrollton WHP area delineations, a numerical modeling effort provided the most accurate results. A numerical model is manifested as a grid over the conceptual model of the area being modeled. A conceptual model is a theoretical formulation developed prior to the modeling effort that describes the assumed hydrogeologic conditions of the area (for example, stratigraphic units, boundary conditions). Numerical models allow the assignment of discrete parameters to separate blocks of the grid to represent the hydrogeologic environment and heterogeneity in the aquifer system.

This section summarizes the conceptual model developed for this project and presents a brief discussion of the numerical model that was constructed (in a mathematical sense). Detailed descriptions of the modeling effort are presented in Appendix A.

Conceptual Model

Table 2-1 summarizes the sources of information used to develop the conceptual model for the study area. The information was obtained primarily from the City of Miamisburg, Ohio Department of Natural Resources (ODNR), Miami Conservancy District (MCD), selected reports from the United States Geological Survey (USGS) and others on the Dayton area geology/hydrology, and CH2M HILL files.

Conceptual Model of Area Geology

The following conceptual model of the project area geology was developed to summarize key geologic characteristics relevant to the project:

- **The bedrock valley** that contains the buried valley aquifer from which Miamisburg and West Carrollton draw water has a wide, relatively flat floor and steeply sloping walls, giving it a U-shaped appearance when viewed in cross section. The limestone to shale valley narrows considerably near the southern boundary of the study area. A tributary valley, similar to the main valley, enters the study area in its western part. The aquifer (GMBVAS) consists of unconsolidated sand and gravel.

- **The buried valley deposits** consist predominantly of permeable sand and gravel with discontinuous lenses of lower permeability material. The outwash deposits are separated into upper and lower layers by a slightly dipping low-permeability layer (till). The total thicknesses of valley fill deposits range from less than 20 feet to greater than 200 feet.

Table 2-1
Sources of Data For Model Development
Miamisburg/West Carrollton

Title	Author of Source
Groundwater Level Data and River Profile Information for the Great Miami River, Holes Creek, and Bear Creek. April 1993.	Miami Conservancy District
Well Logs from Montgomery County. 1992.	Ohio Department of Natural Resources
Mound Plant, RI/FS O.U. 9, Site Scoping Report: Volume 2 - Geologic Log and Well Information Report. May 1992.	U.S. Department of Energy, Albuquerque Field Office
Application of a Three-Dimensional Ground Water Flow Model and Particle Tracking for Well Field Management. Unpublished master's thesis. Wright State University, 1991.	Adrian Field
Mound Plant, ER Program Rev. 2, RI/FS O.U. 9, Site-Wide Work Plan, Installation Background Sec. 4. June 1991	U.S. Department of Energy, Albuquerque Field Office
Final Remedial Investigation Report; Cardington Road Landfill Site. Moraine, Ohio. November 1991.	McLaren/Hart Environmental Engineering Corp.
Description of Current Conditions. Task 1 of the RCRA Facility Investigation for Harrison Radiator Div.—GMC. Moraine, Ohio. January 1991.	Geraghty & Miller, Inc.
Sand and Gravel Resources of Montgomery County, Ohio. 1987	Ohio Department of Natural Resources
Ground Water Development, Production Well 11, Miamisburg, Ohio. February 1976.	Moody & Associates
Seismic Refraction Survey of Pleistocene Drainage Channels in the Lower Great Miami River Valley, Ohio. U.S. Geological Survey Professional Paper 605-B. 1971	Joel S. Watkins and Andrew M. Spieker
Ground-Water Hydrology and Geology of the Lower Great Miami River Valley, Ohio. U.S. Geological Survey Professional Paper 605-A. 1968	Andrew M. Spieker
Ground-Water Resources of the Dayton Area, Ohio. U.S. Geological Survey Water-Supply Paper 1808. 1966	Stanley E. Norris and Andrew M. Spieker
The Water Resources of Montgomery County, Ohio. Bulletin 12, Ohio Water Resources Board. Columbus, Ohio. June 1948.	Stanley E. Norris
Record of Wells in Montgomery County. Bulletin No. 1, Ohio Water Resources Board. Columbus, Ohio. November 1945.	Ralph J. Bernhagen

- **The surficial deposits** in the central part of the valley are thin layers (typically only a few feet thick) of clay or soil. These layers are considerably thicker (up to 150 feet or more) in the bedrock uplands and in the western part of the area above the tributary valley. Thick sand and gravel deposits (100 to 200 feet thick) in the form of kames and eskers occur in the eastern part of the study area.

Conceptual Model of Area Hydrology

- **Surface water** is a major source of recharge to the buried valley aquifer. The Great Miami River, in addition to smaller tributary creeks and streams, recharges the aquifer along its length throughout the study area. Streambed permeability is assumed to be relatively consistent throughout the area.

- **Groundwater** in the study area occurs principally in the buried valley aquifer system. Under natural conditions groundwater flows to the south-southwest through the coarse, permeable glacial outwash deposits. A low permeability confining till locally divides the system into upper and lower aquifers. Pumping from production wells causes groundwater flow lines to converge near areas of intense pumping.

  The low permeability till is leaky, allowing groundwater to flow between the upper and lower aquifers. The rate of flow across the till depends on its thickness, its hydraulic conductivity, and the magnitude of the vertical gradient across the till. The till layer is regionally discontinuous, which creates regionally semi-confined conditions. For this study, the hydraulic conductivity of the semi-confining layer is assumed to be constant.

- **Recharge** to the aquifer is mainly from infiltration of precipitation and from river (surface water) leakance. Recharge by precipitation is assumed to be greatest in areas with permeable surficial material. In areas where the surface is composed of relatively low permeability material (either naturally-occurring or manmade), recharge is expected to be less.

Numerical Model

Code Description

MODFLOW is a numerical code developed by the USGS as a tool for use in specialized groundwater investigations. This project used the 1987 revision of the code (McDonald and Harbaugh 1987). MODPATH (Version 1.2) and MODPATH-PLOT (Version 1.1; both Pollack 1989) were used in conjunction with MODFLOW to compute and display pathlines used to estimate the selected time-of-travel areas.

MODFLOW was created to satisfy the need for a groundwater flow model that was:

- In the public domain (and therefore available at low cost)
- Easily modified
- Simple to use
- Easily maintained
- Compatible with a variety of computer types with few modifications

MODFLOW was selected in part because it can easily handle the hydrogeologic complexities of the aquifer as defined in the conceptual model developed for the project. The MODFLOW computer code uses data sets (created to represent the conceptualized conditions) to arrive at numerical solutions that simulate (or estimate) what is occurring (or what will occur) in the hydrogeologic system being modeled.

Model Calibration

Model calibration is an iterative process that occurs after model set-up, by which the model is run; its results are compared to measured data, overall model performance is checked (for numerical stability, logical water balance, etc.), small adjustments are made to certain model input parameters to improve its accuracy, and the model is rerun to observe the changes in output caused by the parameter adjustment. The degree to which parameter values can be changed during calibration are as follows:

- Parameter values should vary within ranges of known values measured in the area or in other areas with similar physical conditions.

- Parameter values for a particular physical property should be constant throughout the model area unless conditions are known to vary.

Prior to model development, the goal of matching model simulations to actual measured data was established. Therefore, calibration was considered complete when general criteria were met (such as an acceptable match of simulated and actual data). The groundwater level data used for calibration were acquired from a variety of sources from March 1990. The calibration procedure and results are presented in Appendix A.

Model Verification

After model calibration was completed, the model was run using a different set of data to see how the model output changed under different hydraulic conditions. This process is referred to as model verification. The data set selected for verification was from November 1990, which represents seasonal and pumping conditions different from the March 1990 calibration data set. The verification procedure and results are presented in Appendix A.

Capture Zone Analysis

Introduction

Groundwater capture zone analysis is the process of delineating the area of an aquifer contributing groundwater to a well (or wells) within a specified time interval based on groundwater travel time. Capture zone analysis is used in the testing of model sensitivity to changes in specific model parameters and in the delineation of the WHP area. The WHP area corresponds to the 5-year capture zone as defined by the Ohio EPA, which also recommends delineating a 1-year protection area to be used as an inner management zone (IMZ). A 10-year capture zone (referred to by Ohio EPA as the optional outer management zone) was also delineated as part of this project to provide additional long-term planning information.

The capture zone delineations were completed by coupling future groundwater predictions made using MODFLOW with the USGS's post-processing programs MODPATH and MODPATH-PLOT. MODPATH was used to compute groundwater flow pathlines based on the output from the MODFLOW steady-state simulations. MODPATH-PLOT was used to plot the pathlines for 1-, 5-, and 10-year times-of-travel. The resulting pathline plots defined the area contributing groundwater to the well(s) within the specified time interval. Figure 2-1 schematically represents the pathlines calculated by MODPATH and MODPATH-PLOT for groundwater flow over 1 year to the Miamisburg wellfield.

The area encompassed by a capture zone is delineated based on groundwater movement. When considering the movement of contaminants within a capture zone, it should be kept in mind that reactions such as adsorption, precipitation, biotransformation, hydrolysis, and volatilization can cause concentrations of dissolved contaminants to decrease with increased distance from the source area, and thus can slow the rate of contaminant movement relative to the ambient groundwater flow rate. Therefore, contaminants typically do not move as fast as groundwater does, providing additional response time for the city to implement corrective actions.

Sensitivity Analysis

Groundwater flow models are sensitive to varying degrees to the changes in the modeled hydraulic parameters. For some of these parameters a range of field-measured values may be available (such as for the lower aquifer hydraulic conductivity). For other parameters (such as river leakance), few or no known field-measured values are available. A qualitative measure of the model's sensitivity to these parameters was obtained by varying each parameter individually and comparing the resulting 1-year capture zone for the wellfield to the baseline 1-year capture zone produced for the wellfield using calibrated parameter values. Because model conditions are similar at both Miamisburg's and West Carrollton's wellfields, only one was selected for sensitivity analysis. It is expected that both cities' wellfields would respond similarly. Additional details on the sensitivity analysis can be found in Appendix A.

GL035147.WP.RP Examp Part Tracks C... 12/7/93 kmw

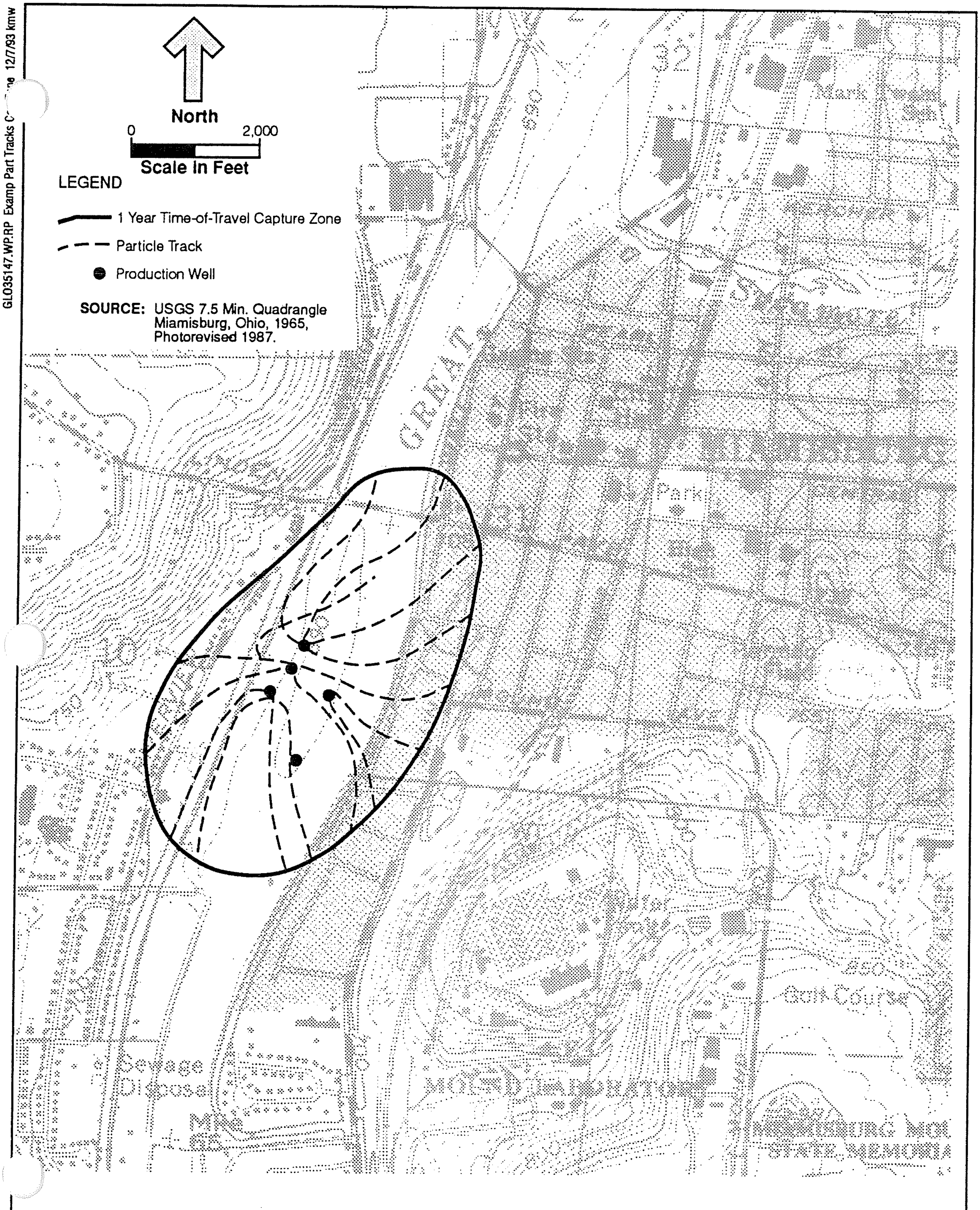


Figure 2-1
Example Particle Tracks and Capture Zone
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

WHP Delineation

The MODPATH and MODPATH-PLOT codes were used to delineate 1-, 5- and 10-year capture zones for each of the wellfields by:

- Running the MODFLOW calibrated model using 1998 pumping conditions as estimated by each city (Ohio EPA recommends that public water systems use maximum pumping rates when delineating WHP areas)
- Using the MODFLOW output and selected MODFLOW input files from the 1998 simulation in the MODPATH program
- Creating individual wellfield plots of groundwater pathlines originating from each production well within the wellfield and moving backwards (hydraulically upgradient) for periods of 1, 5, and 10 years
- Drawing capture zones around the pathline ends in the modeled area of the aquifer
- Including a portion of the bedrock upland if the capture area edge intersected the model edge (simulated aquifer valley edge) to account for potential impacts from surface water runoff from the upland into the aquifer

The resulting capture zones are presented in Figures 2-2 and 2-3. The procedures for the capture zone delineations are presented in Appendix A.

LEGEND

- Wellhead Protection Area
- Inner Management Zone
- Outer Management Zone
- Aquifer Boundary

SOURCE: USGS 7.5 Min. Quadrangle Dayton South, Ohio, 1966, Photorevised 1981.

North

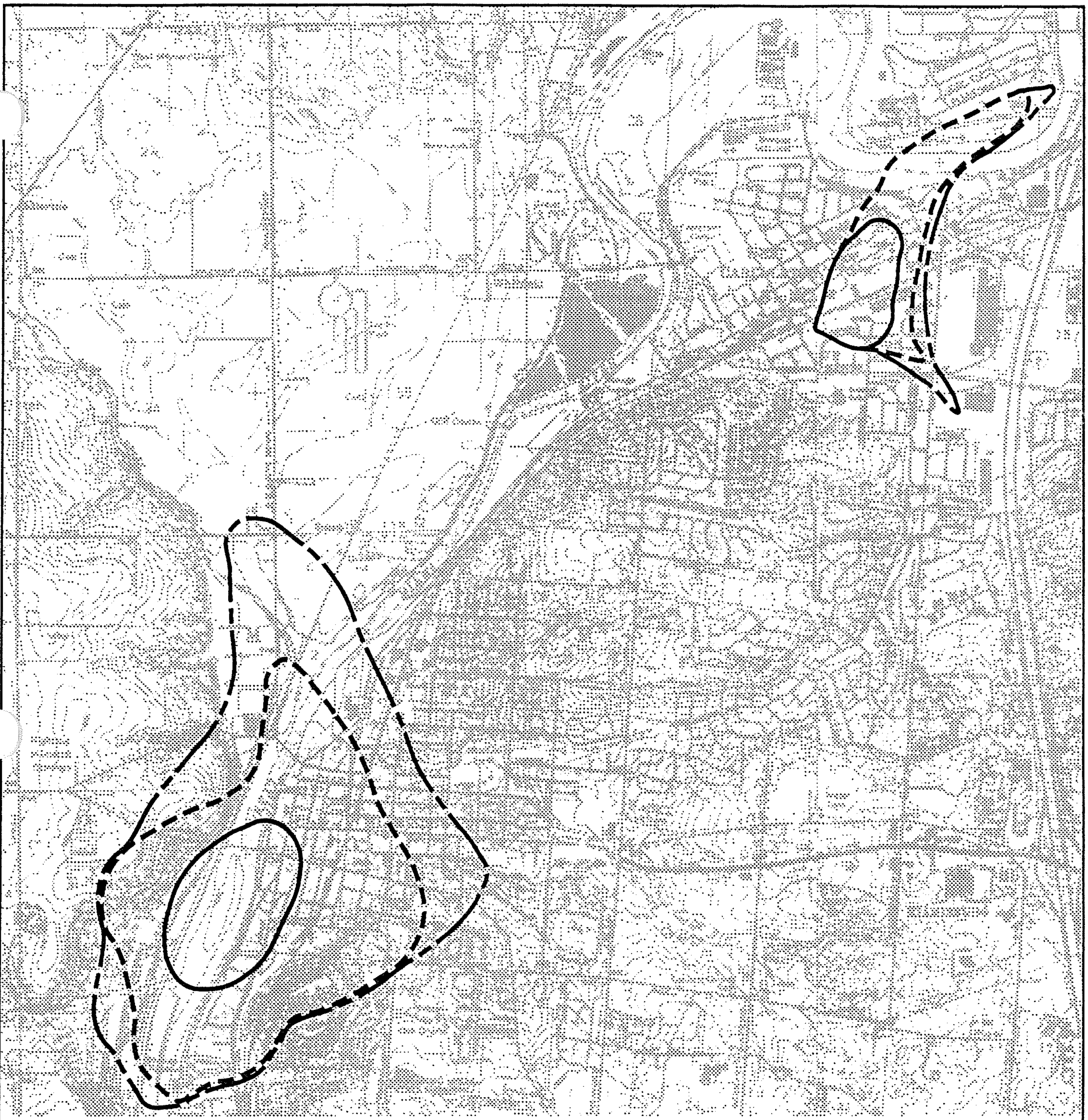
0 2,000

Scale in Feet

Figure 2-2
Inner Management Zone, Wellhead Protection Area, and Outer Management Zone for West Carrollton Area
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

GL035147.WP.RP ' In Mgmt Zon 12/13/93kmw



LEGEND

- - - - Wellhead Protection Area

——— Inner Management Zone

— — Outer Management Zone

North

0 3,000

Scale in Feet

SOURCE: USGS 7.5 Min. Quadrangle Dayton South, Ohio, 1966, Photorevised 1981.

Figure 2-3
Miamisburg and West Carrollton Inner Management Zone, Wellhead Protection Areas, and Outer Management Zones
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

Section 3
Known Contamination Incidents and Potential Contaminant Source Survey

The potential source survey is intended to identify potential groundwater contamination sources and, subsequently assist in the development of the groundwater monitoring and contingency plans.

City staff and CH2M HILL completed a potential contaminant source inventory for the West Carrollton Wellfield during the summer of 1993. The goal of the survey was to identify known groundwater contamination incidents and potential contaminant sources located within the estimated 5-year capture zone of the wellfield.

Aquifer Susceptibility

The aquifer system in the West Carollton area is susceptible to contamination because the aquifer is composed of permeable sand and gravel with a relatively thin (up to 30 feet thick) unsaturated zone of similar materials above the water table. Contaminants released at or near the ground surface would be expected to move vertically downward through the unsaturated zone to the water table, where lateral movement to discharge points such as pumping wells or streams may predominate. The presence or absence of a low permeability till layer within the aquifer system can significantly affect the movement of contaminants in the subsurface. Where the till layer is thick and pumping occurs primarily from the shallow aquifer, contaminants will more likely remain within the shallow aquifer. If the confining layer is absent or pumping from the deep aquifer creates a strong downward hydraulic gradient, contaminants could migrate vertically through the shallow aquifer into the deep aquifer.

Groundwater contamination occurs from a variety of sources, including infiltration of surface spills, surface spreading of chemicals, underground storage tank leakage, leakage from chemical storage lagoons, landfill leakage, septic system effluent, and river pollution. If a contaminant release occurs within or near the potential capture area of the wellfield, these contaminants could eventually enter the City of West Carrollton's raw water supply.

Certain liquid organic contaminants behave in a different manner in the subsurface. Petroleum fuels, for example, will tend to float on the groundwater as a separate, distinct layer when released in sufficient quantities. Other liquids, such as some industrial or dry cleaning solvents, creosote oil, or polychlorinated biphenyls (PCBs), are denser than water and, when released in sufficient quantities, will tend to sink through the aquifer until encountering a relatively low permeability layer. The movement of these kinds of contaminants can occur independent of groundwater flow and may require special consideration if they are suspected to be present.

General Description of Protection Areas

The IMZ and WHP areas encompass a variety of land uses in West Carrollton including industrial, commercial, and residential. The primary industrial activity occurs at a number of pulp and paper mills. Commercial activities include service stations, auto repair facilities, machine shops, and an airport. Transportation routes that lie within the IMZ and WHP areas are Central Avenue and South Alex Road, which carry a substantial amount of traffic, and a Conrail railroad line. A portion of Miami Shores Wellfield, one of four inactive Montgomery County wellfields, is located in the northern part of the WHP area.

The Great Miami River crosses the WHP area in the north and Holes Creek runs near the southern edge of the WHP area. The Great Miami River enters the West Carrollton WHP area at River Mile 72.1. Upgradient of West Carrollton, the river has a drainage area of over 2,500 square miles (USGS 1992). This drainage area also represents a variety of land uses, including heavily industrialized areas. Any major spill incident located within the drainage area could be a potential source of contamination to West Carrollton's Wellfield.

Known Contamination Incidents

Only one location in the vicinity of West Carrollton's wellfield has documented groundwater contamination. Miami Shores Wellfield is one of four wellfields in Moraine operated by Montgomery County. Production from these wellfields ceased in 1987 as a result of the detection of high levels of various metals and VOCs. Currently, Montgomery County is operating a pump-to-waste program (Pumping Dryden North Well No. 13 at approximately 2.6 mgd) in an effort to prevent further migration of contaminants into the Miami Shores Wellfield.

Potential Contaminant Sources

Table 3-1 lists resources that were reviewed to compile the initial potential source inventory (and to identify known contamination cases). After compiling the initial inventory the list was reviewed and revised by the City of West Carrollton (Hill, 1993).

Potential sources identified using these resources were plotted on a map of the wellhead protection area (Figure 3-1), and known and estimated information about the sources is tabulated in Table B-1 (Appendix B). Initial information on potential contaminant sources was supplemented by a windshield survey of major nonresidential streets within the WHP area. Table B-1 also includes a list of the types of contaminants that may be present at each source area, based upon knowledge of site activities and upon general information about hazardous materials commonly associated with similar industrial and commercial activities (Noake 1989). This information is provided as a guideline because little information is available about actual site activities in most cases.

Table 3-1 **Resources Reviewed For Potential Contaminant Sources**
• The Ohio EPA's Site Status Report summarizing Ohio EPA's progress in correcting problems at abandoned and unregulated hazardous waste sites (Ohio EPA 1991) (used to identify known contamination cases)
• The Ohio EPA's master list of unregulated sites ''discovered'' under the federal Superfund program (Ohio EPA 1993a)
• The Ohio EPA's list of hazardous waste generators and treatment, storage, and disposal facilities (Ohio EPA 1993e)
• The Ohio EPA's emergency response listing for reported pollution incidents (EROPIK) for January 1978 through June 1993 (Ohio EPA 1993c)
• The Ohio EPA's Generator Annual Report summarizing hazardous wastes and the major generators that sent them offsite (Ohio EPA 1993b)
• The Ohio EPA's list of permit holders in the National Pollutant Discharge Elimination System (Ohio EPA 1993d)
• The U.S. EPA's list of Montgomery County PCB Waste Handlers (U.S. EPA 1993a)
• The ODNR Report on Ohio Mineral Industries (ODNR 1992b)
• The U.S. EPA's Toxic Release Inventory Database (U.S. EPA 1991)
• Files of the Ohio EPA's Southwest District Division of Hazardous Waste Management (Ohio EPA 1993f)
• Files of the Ohio EPA's Southwest District Division of Solid and Infectious Waste Management (Ohio EPA 1993g)
• Files of the Ohio EPA's Southwest District Division of Drinking and Ground Waters (Ohio EPA 1993h)
• U.S. Army Corps of Engineers, Dredge and Fill Permitting Section (Correspondence). 1993.
• The Ohio Department of Commerce, Division of State Fire Marshal Underground Storage Tank Registration System Summary Listing. 1993.
• The U.S. EPA's list of CERCLIS sites in Montgomery County (U.S. EPA 1993b)
• 1975 and 1987 aerial photographs of the City of West Carrollton
• Business directory for West Carrollton (1993)

The Great Miami River may be a potential source of contamination, although it is not shown as such in Figure 3-1. Upstream releases could be carried in the river to West Carrollton and affect groundwater quality in the vicinity of the wellfield. Such a release could include a chemical spill near the river or a release from an industrial facility or wastewater treatment plant.

Future Considerations

The listings for the potential source survey pertain to the WHP area and IMZ and reflect estimated 1998 pumping rates at the West Carrollton Wellfield and estimated current pumping rates for other groundwater users. Should future pumping rates at the wellfield or the rates of other groundwater users be significantly different from those used in the capture zone delineations, the capture zones will change and the list of potential sources will therefore change.

As part of the City's long-term management strategy (see Section 6), the City may consider conducting personal site inspections and interviews at potential pollution sources (prioritized by the relative risks posed by each facility). Such inspections and interviews are generally used to obtain more detailed information about potential pollution-causing activities at high-risk facilities than can be obtained by conducting literature searches and windshield surveys. After conducting inspections and interviews, the City might need to re-examine its existing groundwater monitoring program and revise it accordingly (perhaps by installing additional monitoring wells or conducting more frequent sampling events).

Updating the Source Survey

Ohio EPA's WHP Program indicates that each purveyor will conduct and submit to the Ohio EPA a comprehensive update and verification of the pollution source inventory every 10 years. To make the process of meeting this requirement easier, the City may consider implementing a program in which copies of new building permits issued within the WHP area are automatically sent to the Department of Public Works so that the source survey list can be more easily updated. A similar reporting system could be used for chemical inventory information files by the Fire Department.

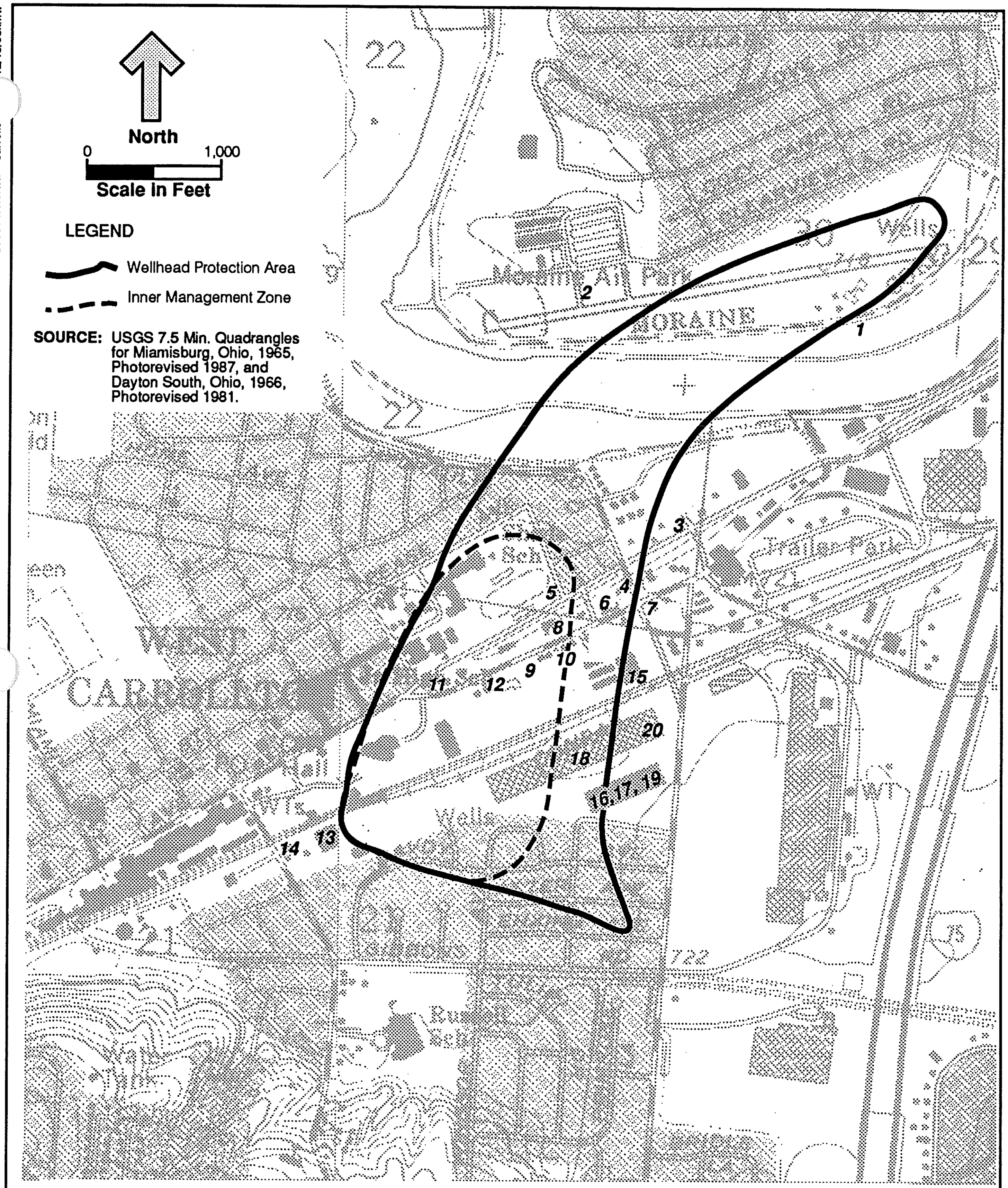


Figure 3-1
Locations of Known Groundwater Contamination and Potential Contamination Sources Within the West Carrollton Wellhead Protection Area
Miamisburg/West Carrollton Wellhead Protection

GLO35147.WP.RP Carrollt 12/13/93kmw

Section 4
Groundwater Monitoring Plan

The proposed groundwater monitoring plan describes the means by which the City of West Carrollton can monitor the quality of the groundwater entering the wellfield from areas downgradient of selected potential sources. The groundwater monitoring plan proposes monitoring well locations, describes a groundwater sampling and analysis plan, proposes data management methods, and discusses the need for periodic evaluation of the groundwater monitoring program.

Contaminant Movement

Contaminants in groundwater generally fall into two major groups: miscible and immiscible contaminants. Miscible, or soluble, contaminants include inorganic contaminants such as heavy metals, chloride, or nitrate, as well as highly soluble organic compounds such as acetone and benzene. Immiscible, or hydrophobic, contaminants include a variety of organic contaminants such as chlorinated solvents, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons. Despite their classification as immiscible contaminants, some of these compounds actually have solubilities in the range of more than 1,000 parts per million, which for a compound such as trichloroethene (a chlorinated solvent) exceeds the U.S. EPA's drinking water maximum contaminant level (MCL) by a factor of several orders of magnitude. In other words, a contaminant classified as immiscible might still dissolve in water to some degree.

Immiscible contaminants also can be divided into two major groups: those with a density less than water (approximately 1,000 grams per liter) and those with a density greater than water. When released in sufficient quantities, light immiscible contaminants such as petroleum fuels tend to ''float'' on the water table, where they spread on the water table surface and migrate laterally with the hydraulic gradient or along high permeability pathways such as gravel-filled utility trenches. Dense contaminants such as some solvents and PCBs, on the other hand, tend to sink through the aquifer where they may pond on the low permeability aquifer bottom. When they occur as pools at the bottom of the aquifer, dense contaminants can move in response to the slope of the aquifer bottom or in response to gradients within the dense contaminant pool caused by pumping from the pool. Groundwater movement over a dense contaminant pool has little effect on the movement of the pool. A major threat posed by immiscible contaminants in the subsurface is that they can occur as relatively immobile sources of dissolved contaminants that may contaminate large quantities of groundwater unless physically or hydraulically contained.

Dissolved contaminants (both miscible and immiscible) generally migrate in the direction of groundwater flow. Depending on aquifer heterogeneities and temporal or spatial variability in groundwater flow directions, dissolved contaminant plumes spread laterally to varying degrees along the predominant flow path. Reactions such as adsorption, precipitation, biotransformation, hydrolysis, and volatilization can cause concentrations of dissolved contaminants to decrease with increased distance from the source area, and can slow the rate of contaminant movement relative to the ambient groundwater flow rate. Retardation factors for dissolved contaminant migration (the rate of groundwater movement divided by the rate of contaminant movement) are less than 5 for mobile organic contaminants such as benzene, and can exceed 1,000 for relatively immobile contaminants such as PCBs or lead. Conservative (nonreactive) ions such as chloride and nitrate, by comparison, are generally considered to migrate at about the same rate as groundwater.

Proposed Monitoring Well Locations

Groundwater samples collected from monitoring wells are more representative of groundwater conditions in the aquifer at a particular location than those collected from production wells. Production wells generally have long well screens that can dilute a sample by mixing contaminated groundwater from one depth in the aquifer with non-contaminated groundwater from other depths. In addition, the high flow rate and extended pumping times that are typical for production well operation create a large cone of depression that can mix contaminated groundwater from a narrow plume with non-contaminated groundwater from outside the plume. Monitoring wells, which are generally pumped for a brief time prior to sampling, create a small cone of depression and obtain groundwater from the immediate vicinity around the well screen. Because of the small volume of groundwater sampled by a monitoring well and the potentially narrow width of some contaminant plumes (due to proximity of the plume to its source, unexpected subsurface conditions, etc.), a given monitoring well may fail to detect contamination that exists in the area. Because of this fact, frequent and detailed analyses of production well water quality is imperative.

The City of West Carrollton currently does not have a network of monitoring wells. Due to this lack of existing monitoring wells and the presence of many potential sources of contamination in the area, the installation of six monitoring wells at five locations is proposed in this plan. For planning purposes these locations are designated A, B, C, D, and E (Figure 4-1). All locations are recommended to have shallow monitoring wells except location D, which proposes both a shallow and a deep well. Proposed locations A, B, and C are considered to have equally high priorities; the remaining locations are presented in order of decreasing priority.

Based on data from known groundwater contamination sites around the country, several types of activities or industrial facilities present more of a risk of causing groundwater contamination than do others. Examples of generally high risk potential sources of contamination include:

- Leaking underground storage tanks
- Hazardous waste generators and treatment, storage, and disposal facilities
- Federal military-related facilities
- Landfills

GLO35147.WP.RP Ca 4-1 12/13/93kmw

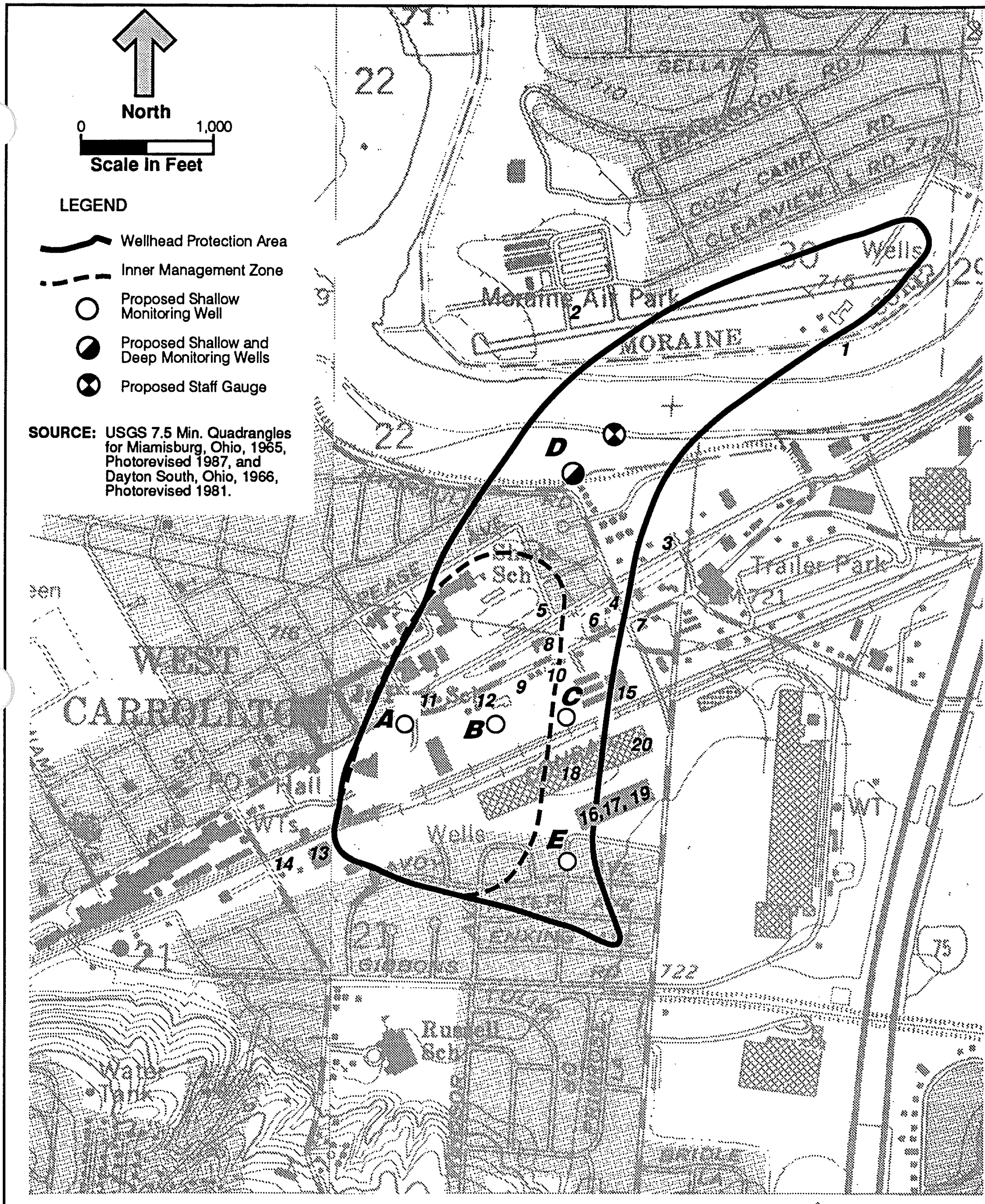


Figure 4-1
Proposed Monitoring Well Locations
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

That is not to imply that relatively small commercial enterprises do not pose a threat to groundwater quality. To the extent that they are unregulated with respect to groundwater quality issues, small enterprises can also pose significant problems.

To the degree possible, the proposed locations for new monitoring wells (described below) are intended to allow monitoring of those activities that present the highest probability of causing contamination. Additionally, the proposed locations and the recommended prioritization were determined after considering how far the sources to be monitored are from the City's production wells. In other words, some relatively high-risk activities may have a lower priority for monitoring because of their relatively great distance from the City's wellfield.

Location A

Location A is immediately downgradient of a gasoline vendor (a high priority potential source). Because this potential source is very close to the wellfield, the proposed shallow well would help to provide warning should a spill occur in the area.

Location B

This location is downgradient of two machine shops, a former warehouse (a high priority potential source), a car wash, and a lawn and garden center. A shallow well at location B would help monitor these sources for contamination.

Location C

Location C is downgradient of a furniture stripper, a machine shop, and a gasoline vendor (a high priority potential source). Again, the installation of a shallow well near these sources is recommended for monitoring groundwater quality in the area.

Locations D

These wells are designed to monitor water quality from the Moraine Air Park (a high priority potential source) as well as the Miami Shores Wellfield, a known location of groundwater contamination that warrants monitoring. Nested wells are proposed in this location to monitor both the upper and lower aquifers for contamination, particularly because the Great Miami River may affect the pathways of contaminants (due to strong vertical gradients). Early warning of possible contamination migrating toward West Carrollton's Wellfield should be provided by monitoring at this location.

Location E

Location E is immediately downgradient of an industrial park that includes a delivery service, and several small industrial facilities. Three of these sources are hazardous waste generators and therefore high priority potential sources. This location is also valuable in the event that Appleton Papers, Inc. ceases pumping, because these monitoring wells could be used to help monitor any contamination that has historically been captured by Appleton's production wells.

Monitoring Well Network Evaluation

Installation of the proposed monitoring wells will provide additional groundwater level data that can be used to evaluate groundwater flow directions. A good understanding of groundwater hydraulics is essential when it comes to trying to assess or predict where a detected contaminant may be coming from. The additional data provided by the proposed monitoring wells will greatly facilitate this effort should it become necessary. The adequacy of the monitoring well network should be re-evaluated in regard to its effectiveness at monitoring high priority potential sources after additional groundwater level data are obtained.

Monitoring Well Drilling and Construction

New Monitoring Wells

Monitoring wells should be installed by a qualified drilling contractor under the supervision of an experienced hydrogeologist. Based on the type of subsurface materials present in the area, appropriate monitoring well drilling methods include cable tool, hollow stem auger, and air rotary casing hammer. Well construction specifications that are appropriate for the selected drilling method should be prepared prior to well installation. The specifications should include detailed plans for equipment decontamination.

In general, shallow monitoring wells should be drilled to a total depth of about 50 feet or less, depending on the presence of a till layer. If an underlying till layer is encountered during drilling above 50 feet, the well should be completed above the till layer. The well screen in shallow monitoring wells should be positioned to straddle the water table, so floating contaminants such as oil or gasoline can be detected. An understanding of historical water table functuations may be necessary to position the screen correctly. Also, positioning the well screen with respect to the water table may mean that the bottom of the well will have to be positioned somewhat above the top of the till layer. Still, drilling to at least the maximum depth at which a till layer would be expected (if it exists at a location) will provide the City with valuable additional information on the exact depth to the till, the possible presence of contaminants on top of the till, and other factors.

Deep monitoring wells are expected to be about 90 feet deep, depending on the presence of a shallow till layer. If contamination is apparent in the shallow aquifer during drilling at locations A, B, C, and E, installing deep aquifer monitoring wells may be considered. In this case, special precautions (for example, double casing, grouting into a till layer) will be necessary to reduce the potential for carrying contamination from the shallow aquifer to the deep aquifer.

The City should survey the elevation of the top of the actual well materials, the top of the protective casing, and the ground level outside the concrete apron at each new well. The surveyed elevations should be relative to the National Geodetic Vertical Datum (NGVD) and be tied into the existing monitoring well network. These data are needed to construct accurate potentiometric surface maps that will be used to determine groundwater flow directions.

Groundwater Monitoring Plan Evaluation

Appendix C presents the recommended sampling and analysis plan for the City to follow when sampling its monitoring wells. After installing the proposed monitoring wells described by this monitoring plan, collecting initial water quality data, and evaluating groundwater hydraulic conditions near the wellfield, the groundwater monitoring plan should be re-evaluated. The proposed monitoring wells are located within both the IMZ and within the WHP area. For wells near the edge of the 5-year WHP area, a less frequent sampling interval may be considered such as sampling every other year (because of the longer travel time of groundwater to the wellfield). Additional monitoring wells may be considered at other high priority source areas identified during implementation of the WHP plan. Every three years, or more often if needed, the monitoring plan should undergo a comprehensive re-evaluation to determine whether the program should be maintained, changed, expanded, or reduced.

Section 5
Contingency Plans

Contingency plans consist of multiple actions that may be implemented if:

- Substantial changes in groundwater quality occur during the routine groundwater monitoring of monitoring wells or production wells (Groundwater Quality Contingency Plan)

- An emergency occurs that could adversely affect groundwater quality in the wellfield protection area (Emergency Response Contingency Plan)

Different actions will be taken depending on whether potential contaminants are detected in a monitoring well or a production well. The detection of potential contaminants in a monitoring well but not in a production well means that the City probably has time to respond in a non-crisis mode. If potential contaminants are detected in production wells without first being detected in monitoring wells, the City may need to respond in a more timely manner depending on the concentration of the contaminant and its MCL.

The City has prepared a detailed contingency plan for emergency operations (OCS, Inc. 1989) as required by the Ohio Administrative Code (Chapter 3745-85). This plan describes the necessary steps to be taken in the event of a number of emergency situations:

- Short-term or extended power failures
- Civil disorder
- Major water main breaks
- Major fire in a service area
- Contamination of the water supply
- Flood
- Tornadoes, high winds, and lightening
- Earthquakes
- Nuclear accidents
- Drought

Portions of the City emergency plan relevant to potential groundwater contamination occurrences are included in Appendix D of this document. The City plan deals with emergencies ranging from relatively minor occurrences to occurrences that may lead to notification of the Office of the President of the United States for seeking national disaster relief.

While the City's existing emergency plan identifies and prioritizes alternative water sources that could be used in an emergency (see Appendix D), Ohio's WHP Program requires that cities amend their contingency plans to specifically identify both temporary (emergency) and long-term alternatives for providing drinking water as well as the funding mechanisms for financing those alternatives. As part of its overall WHP management strategy development and implementation, the City of Miamisburg will need to address the requirements of the State's program.

The Ohio WHP Program also specifies that, in addition to ensuring compliance with state emergency planning requirements, cities coordinate their overall water system contingency plan with the emergency planning requirements of the federal Superfund Amendments and Reauthorization Act (SARA) of 1986, Title III. These requirements deal with the development of emergency response and preparedness plans for chemical releases that could pose environmental risks. As part of its WHP management strategy, the City also needs to ensure compliance with these requirements.

The remainder of this section describes appropriate actions that may need to be taken under certain circumstances.

Groundwater Quality Contingency Plans

The City may need to implement a groundwater quality contingency plan if analytical results from either a monitoring well or production well reports concentrations greater than or equal to a trigger concentration, referred to as a preventive action limit (PAL). The PAL for each constituent to be monitored will be defined as:

- Volatile Organic Compounds (VOCs) above 10 percent of the MCL or above the method detection limit, whichever is greater (Table 5-1)

- Inorganic constituents above 50 percent of the MCL (Table 5-2)

PALs for VOCs and inorganic constituents were established using different criteria primarily because VOCs are generally not naturally occurring and their presence typically indicates manmade contamination. Conversely, inorganic constituents occur naturally at levels that may fluctuate. However, based on available historical wellfield data, insufficient data (fewer than 8 to 10 data points) were available to determine appropriate inorganic PALs using statistical methods. Table 5-2 lists temporary PALs that may be revised after more inorganic data are available from new monitoring wells.

Possible Contamination of Monitoring Wells

Figure 5-1 is a flow chart showing the actions that may be taken if potential contamination is detected in a monitoring well. A description of these steps follows.

Reported Value Verification

The well with a reported value above a PAL should be resampled as soon as possible after receipt of the laboratory report. A duplicate sample should be collected during

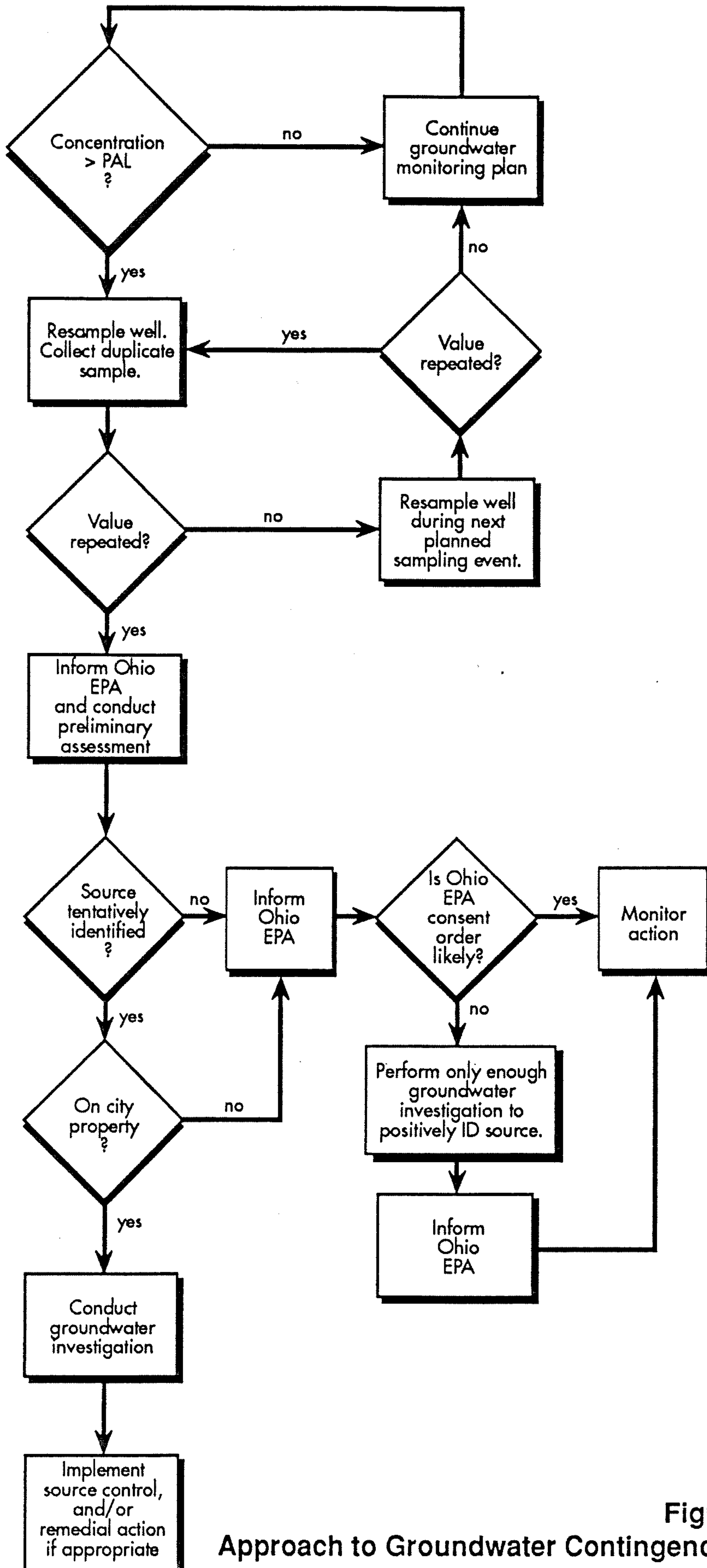


Figure 5-1
Approach to Groundwater Contingency Plan
Monitoring Well Showing Contamination
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

GLO35147.WP.RP Appro to GW Conting Plan 12/7/93 kmw

Table 5-1
Volatile Organic Constituents
Preventive Action Limits
Miamisburg/West Carrollton Wellhead Protection

Constituent	MCL	PAL
Benzene	5	0.5
Bromobenzene	none	detection
Bromochloromethane	none	detection
Bromodichloromethane	100	10
Bromoform	100	10
Bromomethane	none	detection
n-Butylbenzene	none	detection
tert-Butylbenzene	none	detection
sec-Butylbenzene	none	detection
Carbon tetrachloride	5	0.5
Monochlorobenzene	100	10
Chloroethane	none	detection
Chloroform	100	10
Chloromethane	none	detection
o-Chlorotoluene	none	detection
p-Chlorotoluene	none	detection
Dibromochloromethane	100	10
Dibromomethane	none	detection
Dichloromethane	5	0.5
Dichlorodifluoromethane	none	detection
o-Dichlorobenzene	600	60
m-Dichlorobenzene	600	60
p-Dichlorobenzene	75	7.5
1,1-Dichloroethane	none	detection
1,2-Dichloroethane	5	0.5
1,1-Dichloroethene	7	0.7
1,1-Dichloropropane	none	detection
cis-1,2-Dichloroethene	70	7
cis-1,3-Dichloropropene	none	detection
1,2-Dichloropropane	5	0.5
2,2-Dichloropropane	70	7
Ethyl benzene	700	70
Fluorotrichloromethane	none	detection
Hexachlorobutadiene	none	detection
Isopropylbenzene	none	detection
p-Isopropyltoluene	none	detection
n-Propylbenzene	none	detection
Styrene	100	10
1,1,1,2-Tetrachloroethane	none	detection

Table 5-1
Volatile Organic Constituents
Preventive Action Limits
Miamisburg/West Carrollton Wellhead Protection

Constituent	MCL	PAL
1,1,2,2-Tetrachloroethane	none	detection
1,2,3-Trichloropropane	none	detection
1,2,4-Trichlorobenzene	70	7
1,2,3-Trichlorobenzene	none	detection
1,2,4-Trimethylbenzene	none	detection
1,3,5-Trimethylbenzene	none	detection
Tetrachloroethene	5	0.5
Toluene	1,000	100
1,1,1-Trichloroethane	200	20
1,1,2-Trichloroethane	5	0.5
Trichloroethene	5	0.5
Vinyl chloride	2	detection
Total Xylenes	10,000	1,000

NOTES:
1. All concentrations are in μg/L.
2. PALs for VOCs are set at one-tenth the MCL or at the method detection limit, whichever is higher. For VOCs that have no MCLs, PALs are set at the detection limit, generally 0.5 μg/L.
3. Analytical Method: EPA 524.2
4. MCLs listed are either primary (health based) or proposed primary MCLs.
5. "None" indicates that no MCL has been set for that constituent.

Table 5-2
Inorganic Constituents Preventive Action Limits
Miamisburg/West Carrollton Wellhead Protection

Constituent	MCL	PAL
Arsenic	0.050	0.025
Barium	1	0.5
Cadmium	0.0055	0.0025
Chloride	250 S	125
Chromium	0.100	0.05
Copper	1 S	1
Iron	0.30 S	0.15
Lead	0.005	0.0025
Manganese	0.050 S	0.025
Mercury	0.002	0.001
Nickel	0.10	.05
Nitrate	10	5
Silver	0.050	0.025
Total Dissolved Solids	500 S	225
Zinc	5 S	2.5

NOTES:
1. All concentrations are in mg/L.
2. Table includes selected general chemistry constituents and metals.
3. The PAL was set at one-half the MCL.
4. "S" indicates that the MCL is secondary (aesthetic). All other MCLs shown are primary (health based).

If the value is not repeated for either sample, the contingency plan need not be implemented. The well should be sampled again during the next planned sampling event.

Preliminary Assessment

If reported water quality values above the PALs are confirmed, the Ohio EPA should be notified and the need for additional investigation of the situation will be determined by assessing:

- Potential impacts on the City's water treatment operations.
- Existence of potential upgradient sources (Figure 3-1) and location of the monitoring site relative to the source area. A reported concentration may not represent the peak concentration in a contaminant plume. The location of the monitoring point may be on the fringe of a plume, therefore higher concentrations could migrate into the wellfield at another location nearby.
- Distance from the nearest production well.

Based on the preliminary assessment, the need for additional investigation will be evaluated. Each situation should be evaluated separately, as the factors involved with each will vary widely. If the City determines that the groundwater situation is a potential threat to its water supply, additional investigation and possible remedial action is warranted.

Potential Source Area Review and Discussion of Possible Actions by the City

During the preliminary assessment, an initial evaluation of potential sources will be made. Subsequent actions will depend on whether potential sources can be identified and on the locations of the identified potential sources.

Source Not on City Property——Tentatively Identified. The City may choose to install and sample a monitoring well immediately downgradient of a tentatively identified source, if access is possible. This will provide strong evidence to the Ohio EPA that a responsible party is identified so the agency can provide regulatory assistance during the responsible party's subsequent investigation and remediation. The City should consider requesting that it receive copies of communications between the Ohio EPA and the responsible party so that the City is informed of the progress of the investigation. The City may also consider retaining technical services to help monitor the City's interests during the investigation and remediation by the responsible party.

Source Not on City Property——Not Identified. The City should report unidentified offsite sources to the Ohio EPA's Southwest District Division of Drinking and Ground Waters in Dayton. Further actions by the City will depend on the Ohio EPA's response to the City's request for assistance in identifying the source. The response of the Ohio EPA's Division of Emergency and Remedial Response (DERR), from whom the Division of Drinking and Ground Waters will request assistance will depend upon the priority of the City's request relative to other requests and the DERR's available budget. If the DERR is unable to respond in a timely manner, the City may consider implementing an interim remedial measure to protect its production wells or it may consider conducting its own investigation. The Ohio EPA may be able to assist the City in obtaining offsite access agreements during such an investigation. If an investigation is undertaken, its goal would be only to identify the source to determine the responsible party. The Ohio EPA could then compel the responsible party to remediate the contamination. The City may be able to seek reimbursement from the responsible party for costs incurred.

If the DERR responds positively to the City's request for assistance, the City should maintain an active role in the progress of the investigation to monitor the timely and successful completion of the project.

Source on City Property. The City should report the onsite source to the Ohio EPA's Southwest District Division of Drinking and Ground Waters in Dayton. If the potential source is located on property within the City's ownership, the City may consider implementing groundwater or source control remedial measures. Additional investigation would likely be needed before implementation of these activities.

Possible Contamination of Production Wells

Figure 5-2 is a flow chart showing the actions that may be taken if potential contamination is detected in a production well. The initial actions are the same as would be taken if contamination is detected in a monitoring well (i.e., resampling to verify concentration). If the value is repeated, the City would follow a different course of action than they would if contamination is detected in a monitoring well. A description of steps follows.

Notify Ohio EPA and Discuss Problem

In the event that the resampling shows that contamination probably exists, the City should schedule a meeting with the Ohio EPA to notify the agency of the potential problem and come to an agreement on what followup actions the City needs to take. Potential followup actions may range from simply increasing the sampling frequency to track water quality changes to, in the worst case, abandoning the production well and replacing it (in conjunction with remedial measures to contain/cleanup the contamination).

The specific actions that may be necessary will depend on factors such as the type and concentration of the contaminant, whether or not an MCL exists for the particular contaminant, potential impacts on other production wells, and potential public health impacts. Because of the wide range of scenarios that are possible in the event of a contamination event, it is not possible to describe the exact actions the City would need to take should contamination be detected in one (or more) of its production wells. Therefore, Figure 5-2 (and the following general discussion of some of its elements) is intended to outline some of the responses that may be necessary.

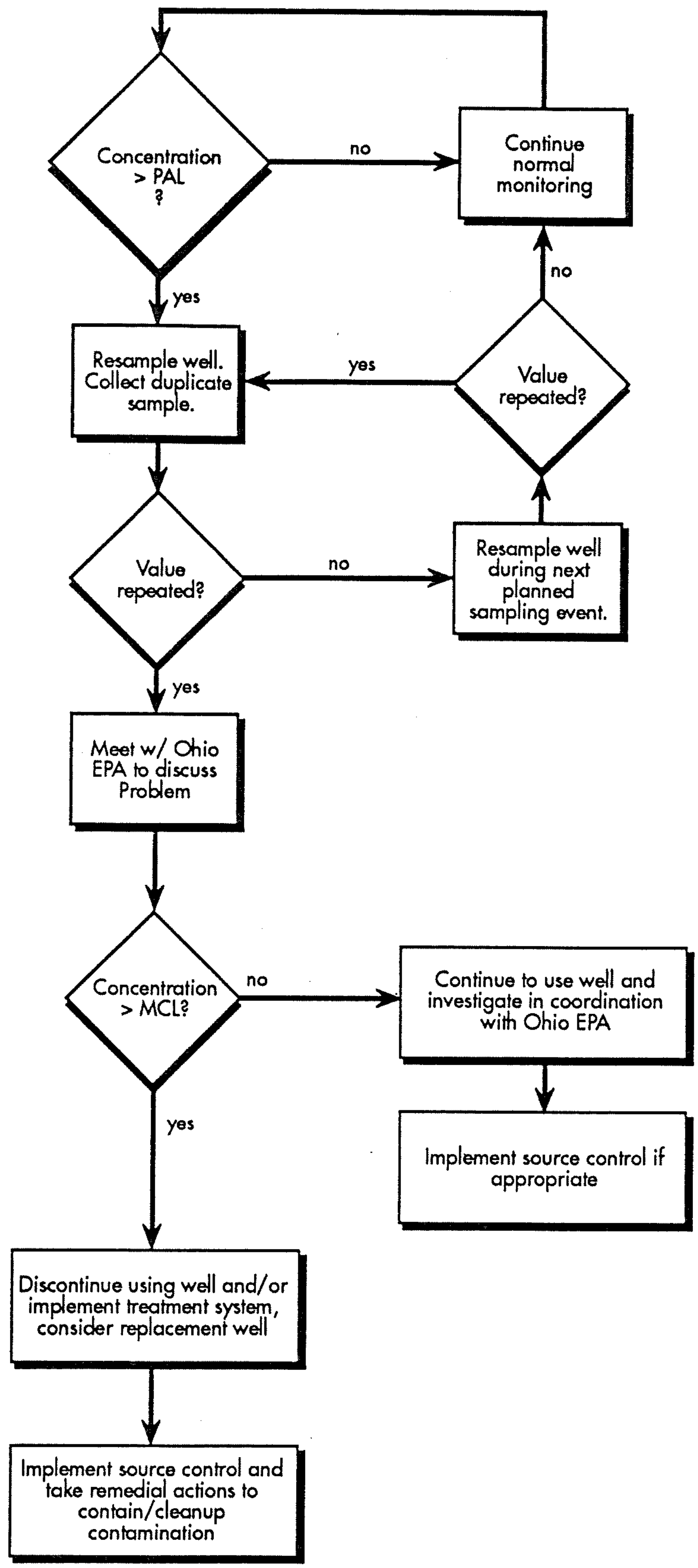


Figure 5-2
Approach to Groundwater Contingency Plan
Production Well Showing Contamination
Miamisburg/West Carrollton Wellhead Protection

GLO35147.WP.I ...pro to GW Show Contam 12/7/93 kmw

Continue to Use Well and Coordinate with Ohio EPA

If a source is not identified and the concentration of the contaminant is below the MCL the City may be able to continue using the well while coordinating a source investigation with the Ohio EPA. The investigation into possible sources would follow many of the same steps as described above for contamination in a monitoring well. Depending on the nature and level of contamination in such a situation, it may be desirable to begin implementing some type of treatment even though MCLs have not been reached.

Implement Source Control/Take Remedial Actions

If the source of the contamination has been identified, control and/or removal actions will be necessary. As with monitoring well contamination, specific actions will depend on whether or not the source of the contamination is located on City property. An example of a source control action would be excavating a leaking underground storage tank and removing or remediating associated contaminated soils that could act as a continuing source of groundwater contamination.

Wellfield operation may influence the migration of groundwater contaminants. If contaminants are migrating to specific wells, cessation of pumping at those wells may reduce the threat to the water supply. However, changing the pumping scheme at the wellfield may actually allow the contamination to move farther into the wellfield. Each case should be evaluated individually.

An alternative option would be to redirect discharge from affected wells to separate treatment facilities, such as an air stripping facility or a carbon unit, or to the City's wastewater treatment plant. This may prevent a reduction in wellfield capacity. Another option would be to install an interceptor well (with its pumped water discharged to a treatment facility) to control the migration of contamination within the aquifer and to protect other production wells. Still another option would be to pump to waste (into either the sanitary sewer or the storm sewer).

Emergency Response Contingency Plan

Emergencies that occur within the wellhead protection area that could affect groundwater quality include the following:

- A tanker truck or railroad accident that releases hazardous material to the ground or to the Great Miami River

- A fire at a facility with hazardous substances stored onsite

- An aboveground storage tank that ruptures and releases hazardous material to the ground or to the Great Miami River

- A leaking underground storage tank that releases hazardous substances or petroleum products

- A major break in a sanitary or storm sewer

Steps taken when such an emergency occurs should be consistent with the City's emergency plan described above (West Carrollton Service Department 1993). The following are specific steps the City may need to take (in addition to those outlined in their overall emergency plan) in the event that an emergency situation threatens the City's groundwater supply.

Emergency Response Team Formation

The following officials within the City administration have been identified as possible participants in an emergency response team (ERT):

- Public Works Director
- Superintendent of the Water Treatment Plant
- City Fire Chief
- City Police Chief
- City Manager

Procedures for the notification of ERT members in an emergency, leadership assignment, responsibilities of each individual, and decision-making roles should be prepared and accepted by each ERT member. The City Fire Department has a general emergency response plan that may serve as a basis for the wellfield emergency response contingency plan. The Fire Department's plan should be reviewed to determine its adaptability to the wellfield emergency response contingency plan. In an emergency such as those described above, the Fire Chief has overall responsibility for emergency action.

If an emergency occurs that could threaten groundwater quality, the following sequence of activities is proposed:

- **Notification of ERT members**——Notify each member of the ERT that an emergency is occurring and that the emergency response contingency plan is being implemented.

- **Respond to the Emergency**——Implement the emergency response contingency plan and handle the emergency considering public safety and the potential impact on the wellfield.

- **Evaluate Threat to Production Wells**——As soon as possible after the immediate threat of the emergency is over, evaluate whether the groundwater has been affected. Some analyses of soil and groundwater may be needed to make this determination.

- **Contaminant Cleanup**——Cleanup may be performed during the evaluation of potential threat to production wells. Materials that may continue to affect soil or groundwater should be removed as quickly as possible.

- **Modify Wellfield Operations**——If the current pumping regime enhances the potential migration of contaminants in the groundwater towards a production well, or if one or more production wells are immediately adjacent to the area in which the emergency occurred, the use of the affected production wells should be temporarily discontinued, unless doing so will have a worse impact than continuing to pump, or the well discharge should be redirected to the wastewater treatment plant.

- **Soil and Groundwater Remediation**——It may be necessary to determine whether the effect of the contaminants on groundwater will be lessened by removal of contaminated soils or extraction of contaminated groundwater.

If the wellfield is threatened, the Ohio EPA and the party responsible for the emergency will probably be heavily involved in post-emergency activities. It is in the City's interest to maintain an active role in these events to protect the water supply for its residents.

Section 6
Management Strategy

Overview

The City of West Carrollton should consider developing and implementing a comprehensive management strategy to control both existing and potential sources of groundwater contamination. In addition to the groundwater monitoring and contingency plans previously outlined, components of this strategy may include local management initiatives to prevent contamination, identification of financial resources to support the WHP plan, identification of the need for additional new wells, and public participation and educational activities. In addition to local authority, many activities fall under the regulatory authority of state or federal agencies, so coordinating contamination control activities with all three levels of government will ensure enforcement of regulations, help avoid duplication of effort, and prevent possible conflicts with existing regulations.

Planning Committee

Ohio's WHP Program promotes the establishment of a council or committee to assist in the development and implementation of the WHP plan. Suggested committee members may include:

- Water Plant Superintendent
- Director of Public Works
- Senior Planner
- Fire Chief
- City Manager
- City Environmental Consultant
- Local Industry Representatives
- Board of Health Representative
- Local Citizens

The purpose of the committee is to "foster effective and consistent management of potential pollution sources and land use activities throughout the entire WHP area" (Ohio EPA 1992). The committee may also assist with determining local priorities with respect to the WHP plan and how to implement and address their recommendations.

Potential Protection Measures

A number of options are available for management of WHP area activities. The following is a list of possible options that each city and/or committee may consider using in its management strategy (Ohio EPA 1992). Not every option, however, may be appropriate for each city's particular WHP needs.

- **Groundwater monitoring** can help assess historical groundwater quality as well as provide early warning of contamination.

- **Spill reporting and emergency response** provides notification to water plant officials and initiates emergency response procedures.

- **Source prohibitions** prohibit development or materials that may threaten groundwater.

- **Purchase of property/development rights** ensures control of land uses in wellhead protection areas consistent with Ohio EPA's approved plan.

- **Operating standards** regulate potentially hazardous practices by prescribing methods for safe operations.

- **Design standards and site plan review** consists of setting and reviewing building and site design and construction standards to help prevent groundwater contamination.

- **Zoning ordinances** direct land development and regulate land uses by specifying activities as allowed, restricted, or prohibited.

- **Household hazardous waste collection** reduces threats to groundwater from residential hazardous waste disposal and involves the public in wellhead protection.

- **Public education** instills pollution prevention ethics in residents and builds support for groundwater protection activities.

Other measures that may be considered include:

- **Underground storage tank reporting/upgrading requirements** to monitor UST activities and mandate stringent containment and spill prevention requirements (in a manner more stringent than existing UST regulations).

- **Surface water drainage** evaluation to review potential surface water impacts on groundwater in WHP areas.

- **Sanitary sewers and septic tanks** review and inspection to promote the safe siting, density, design, maintenance, and removal of sanitary systems.

As part of the WHP management activities, the City of West Carrollton should consider an annual evaluation of industrial groundwater pumping operations near and within the WHP area. Changes in pumping at nearby facilities can potentially alter the groundwater flow direction and subsequently the WHP area (see Table 6-1). As an example, the City's initial

WHP area was developed with the assumption that Appleton Papers Inc. is pumping 6.2 MGD of groundwater. If (for reasons unknown) Appleton Papers Inc. ceased pumping, the groundwater capture area for the City of West Carrollton's wellfield would change dramatically (Figure 6-1). A change such as this one in the capture area and the related WHP area would effect the groundwater monitoring activities, the potential source inventory, some activities related to regulatory authority, and the contingency plan. This issue should be addressed in further detail with the WHP planning committee.

Table 6-1
Pumping Rates for Water Users in the Immediate Vicinity of West Carrollton's Wellfield
Miamisburg/West Carrollton Wellhead Protection

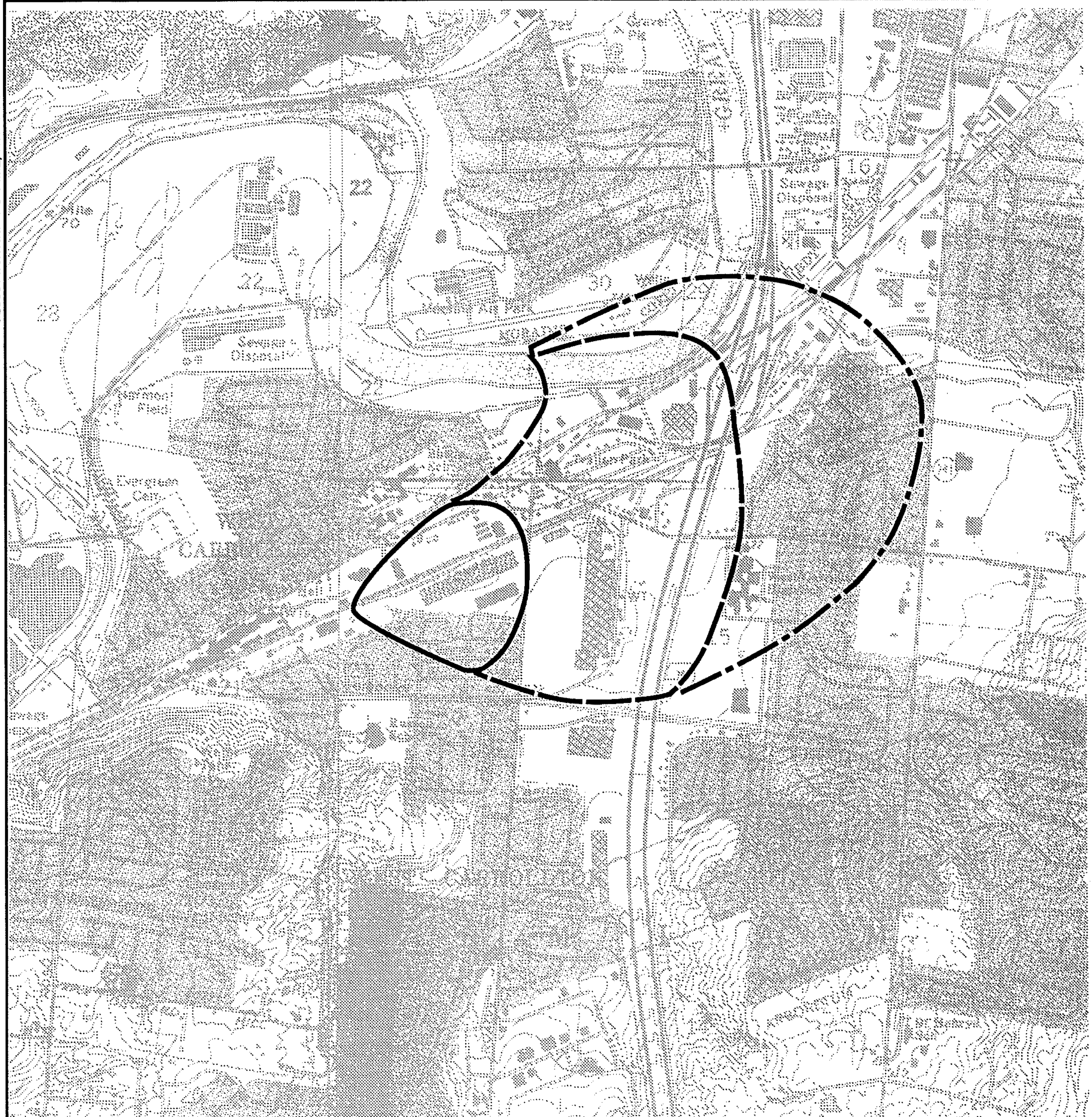
User	March 1990 Pumping Rate (in MGD)
Appleton Papers, Inc.	6.2
Miami Papers	3.8
West Carrollton Parchment	0.51

Implementation Mechanisms

The review and implementation of potential measures may be evaluated by the committee with regard to the following factors:

- Ease of implementation
- Limitations of the measure
- Potential social and economic impacts
- Compatibility and coordination with other regulatory programs
- Institutional issues
- An analysis of the economic and social benefits and the costs associated with implementing the measure

GL035147.WP.RP F 6-1 IMZ_WPA OMZ 12-29-93mms



LEGEND

Possible Inner Management Zone

Possible Wellhead Protection Area

Possible Outer Management Zone

North

0 2000

SCALE IN FEET

Figure 6-1
Possible Changes
In Inner Management Zone, Wellhead Protection Area,
and Outer Management Zone for West Carrollton
without Appleton Papers, Inc., Pumping
Miamisburg/West Carrollton Wellhead Protection

Need for New Production Wells

Working in conjunction with the WHP plan committee, and using its own projections of long-term water needs, the City should prepare a water supply plan that provides estimates of the need for future additional new wells to supplement or replace the City's existing production wells. The plan should describe actions the City will take to identify and evaluate potential locations for the new wells. These actions may include investigations of land ownership status as well as the performance of limited subsurface investigations to confirm site conditions and provide an initial check on groundwater quality and quantity. Should a good candidate site for new wells be located, the City may take steps to protect the site. These steps may include purchasing the surrounding land so that appropriate pollution prevention actions can be taken well in advance of the actual installation of the new wells.

Public Participation and Education

An informed public contributes to the solution of pollution problems. The City has a responsibility to alert the public to possible hazards and educate the public as to what they can do to help prevent pollution. Because plan implementation will be more successful if the affected public is fully informed and actively involved, the City should develop a program to ensure public participation in the regulatory process, educate the public, and provide the regulated community with technical assistance.

A comprehensive public involvement and education program was implemented by the City of Albuquerque and Bernalillo County, New Mexico, in 1992. It included:

- Holding public information meetings
- Establishing an outreach program for educating school children
- Preparing informational handouts
- Communicating through electronic and print media
- Disseminating material through libraries and public meetings
- Establishing a public participation program to obtain public comment on potential regulations to address pollution problems

Section 7
Summary of Recommendations

The preceding sections of this document presented the results of the work undertaken to date to develop and implement a comprehensive WHP plan for the City of West Carrollton. A number of recommendations have been presented herein that the City may consider in its continuing efforts to accomplish the goals of Ohio EPA's WHP Program. The major recommendations made in this report are summarized below:

1. Re-evaluate wellfield capture zones in the future if significant changes in production well pumping rates (or locations) occur or are proposed (see Section 3).

2. Consider conducting a limited number of personal site visits and interviews at sites posing the greatest threat to the City's groundwater quality (see Section 3).

3. Develop procedures to facilitate the required periodic updating of the potential source inventory (see Section 3).

4. Install the recommended new monitoring wells using industry-accepted practices. Following their installation, survey them and collect the recommended water quality samples and water level measurements (see Section 4 and Appendix C).

5. Perform a comprehensive re-evaluation of the overall groundwater monitoring program at least every 3 years and modify the program as necessary to meet the City's objectives (see Section 4).

6. Develop and implement a detailed data management system to store data obtained from the monitoring program and to facilitate data evaluation (see Appendix C).

7. Tie the outlined contingency plan elements described in this report into the City's overall contingency plan for emergency operations, and invoke the suggested plan as needed (see Section 5).

8. As required by Ohio EPA's WHP Program, amend the City's existing contingency plan for emergency operations to specifically identify and prioritize both temporary and long-term alternatives for providing drinking water and the funding mechanisms to finance them (see Section 5).

9. As required by Ohio EPA's WHP Program, ensure that the City's contingency plan for emergency operations is coordinated with the federal SARA Title III emergency response requirements (see Section 5).

10. Form an emergency response team to deal specifically with emergencies that may threaten the City's groundwater supply (see Section 5).

11. Form a WHP planning committee to develop and implement an overall management strategy for conducting needed WHP work elements (see Section 6).

12. Develop and implement a public involvement/public education program to fully involve the affected public in all future WHP work elements (see Section 6).

13. In conjunction with the WHP planning committee, identify and evaluate potential groundwater protection measures and implementation mechanisms (see Section 6).

14. Evaluate the long-term water supply needs of the City and take feasible steps to identify and protect geographic areas in which possible new water supplies would be developed (see Section 6).

As discussed in the report and emphasized above, the capture zones delineated to date are based on the current best estimates of the pumping configurations (locations and amounts) of major groundwater users in the vicinity of the City's wellfield and estimates of future (1998) pumping rates from City wells. In addition to the re-evaluation of data described above, the City may at some time want to know what effect a different set of assumed conditions would have on the delineations. For example, the City may want to know what would happen to the capture zone configurations if an existing well (or wells) stopped pumping, or what would happen if a new well (or wells) began to pump.

References

Bernhagen, Ralph J. *Record of Wells in Montgomery County.* Bulletin 1, Ohio Water Resources Board. Columbus, Ohio. June 1948.

CH2M HILL, Inc. Well Field Protection Program, Volatile Organic Compound Investigation. 1991a.

CH2M HILL, Inc. *CONTOUR2, A Contouring Graphics Package,* Version 7.0. 1991b.

Chow, V.T. *Handbook of Applied Hydrology.* New York: McGraw-Hill Book Company. 1964.

City of Albuquerque and Bernalillo County. *Draft Final Ground-Water Protection Policy and Action Plan.* Albuquerque, New Mexico. October 1992.

City of Miamisburg. *Business Directory.* 1993.

City of West Carrollton. *Business Directory.* 1993.

Field, Adrian. *Application of a Three-Dimensional Ground Water Flow Model and Particle Tracking for Well Field Management.* Unpublished masters thesis. Wright State University. 1991.

Geraghty & Miller, Inc. *Mad River Wellfield Assessment.* June 1987.

Geraghty & Miller, Inc. *Description of Current Conditions: Task 1 of the RCRA Facility Investigation for Harrison Radiator Div.—GMC, Moraine, Ohio.* January 1991.

Hill, Donald. Personal Communication. 1993.

McDonald, M.G., and A.W. Harbaugh. *A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model.* U.S. Geological Survey Open File Report 83-875. 1984.

McLaren/Hart Environmental Engineering Corp. *Final Remedial Investigation Report. Cardington Road Landfill Site, Moraine, Ohio.* November 1991.

Miami Conservancy District. Daily Precipitation Data for Dayton, Centerville, West Carrollton, Miamisburg, and Franklin Stations. 1990.

Miami Conservancy District. Groundwater Level Data and River Profile Information for the Great Miami River, Holes Creek, and Bear Creek. April 1993.

Miami Valley Regional Planning Commission. Aerial photographs for the Cities of Miamisburg and West Carrollton. 1993.

Moody & Associates, Inc. *Ground Water Development, Production Well 11, Miamisburg, Ohio.* Moody & Associates, Inc. Columbus, Ohio. February 1976.

Noake, K.D. *Guide to Contamination Sources for Wellhead Protection.* Massachusetts Department of Environmental Engineering, Division of Water Supply. 1989.

Norris, Stanley E. *The Water Resources of Montgomery County, Ohio.* Bulletin 12, Ohio Water Resources Board. Columbus, Ohio. June 1948.

Norris, Stanley E., and Andrew M. Spieker. *Ground-Water Resources of the Dayton Area, Ohio.* Geological Survey Water-Supply Paper 1808. 1966.

Ohio Department of Commerce, Division of State Fire Marshal. *Underground Storage Tank Registration System Summary Listing.* 1993.

Ohio Department of Natural Resources. Well Logs from Montgomery County. 1992a.

Ohio Department of Natural Resources. *Report on Ohio Mineral Industries.* 1992b.

Ohio Department of Natural Resources. *Monthly Water Inventory Report for Ohio.* 1992c.

Ohio Department of Natural Resources. *Sand and Gravel Resources of Montgomery County, Ohio.* Division of Geological Survey. 1987.

Ohio Environmental Protection Agency, Division of Drinking and Ground Waters. *Site Status Report.* 1991.

Ohio Environmental Protection Agency, Division of Drinking and Ground Waters. *Ohio Wellhead Protection Program.* 1992.

Ohio Environmental Protection Agency, Division of Emergency and Remedial Response. Master Site List. 1993a.

Ohio Environmental Protection Agency, Division of Hazardous Waste Management. *Generator Annual Report.* 1993b.

Ohio Environmental Protection Agency, Division of Emergency and Remedial Response. EROPIK printout. 1993c.

Ohio Environmental Protection Agency, Division of Water Pollution Control. List of NPDES Permit Holders. 1993d.

Ohio Environmental Protection Agency, Division of Hazardous Waste Management. RCRA One-Liners. 1993e.

Ohio Environmental Protection Agency, Division of Hazardous Waste Management. Various files. 1993f.

Ohio Environmental Protection Agency, Division of Solid and Infectious Waste Management. Various files. 1993g.

Ohio Environmental Protection Agency, Division of Drinking and Ground Waters. Various files. 1993h.

OCS, Inc. *Contingency Plan for Emergency Operations for the City of Miamisburg, Ohio, Water System*. June 1989.

Pollack, D.W. *Documentation of Computer Programs to Compute and Display Pathlines Using Results from the U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground-Water Flow Model*. U.S. Geological Survey. 1989.

Rozelle, J.L. Personal Communication with J.L. Rozelle, General Manager and Chief Engineer of the Miami Conservancy District. 1992.

Spieker, Andrew M. *Ground-Water Hydrology and Geology of the Lower Great Miami River Valley, Ohio*. Geological Survey Professional Paper 605-A. 1968.

U.S. Army Corps of Engineers, Dredge and Fill Permitting Section. Personal correspondence with Doug Shelton. 1993.

U.S. Department of Energy, Albuquerque Field Office. *Mound Plant, ER Program Rev. 2, RI/FS O.U. 9, Site-Wide Work Plan: Installation Background Sec. 4*. June 1991.

U.S. Department of Energy, Albuquerque Field Office. *Mound Plant, RI/FS O.U. 9, Site Scoping Report: Volume 2 — Geologic Log and Well Information Report*. May 1992.

U.S. Environmental Protection Agency, Office of Toxic Substances. Toxic Release Inventory Database. 1991.

U.S. Environmental Protection Agency, Pesticides and Toxic Substances Branch. PCB Waste Handlers Listing. 1993a.

U.S. Environmental Protection Agency, Freedom of Information Office. CERCLIS file listing. 1993b.

U.S. Geological Survey. Dayton South—7½ minute quadrangle; Montgomery County, Ohio. 1966 (Photo-revised 1981).

U.S. Geological Survey. Franklin—7½ minute quadrangle; Montgomery, Butler, and Warren Counties, Ohio. 1965 (Photo-revised 1981).

U.S. Geological Survey. Miamisburg—7½ minute quadrangle; Montgomery County, Ohio. 1965 (Photo-revised 1987).

U.S. Geological Survey. Springboro—7½ minute quadrangle; Montgomery and Warren Counties, Ohio. 1965 (Photo-revised 1981).

U.S. Geological Survey. *Water Resources Data, Vol. 1.* 1992.

Watkins, Joel S., and Andrew M. Spieker. *Seismic Refraction Survey of Pleistocene Drainage Channels in the Lower Great Miami River Valley, Ohio.* Geological Survey Professional Paper 605-B. 1971.

West Carrollton (Ohio) Service Department. *Contingency Plan for Emergency Operations for the City of West Carrollton, Ohio Water System.* August 1993.

APPENDIX A
GROUNDWATER MODELING

Appendix A

Groundwater Modeling

Conceptual Model

Depositional Environment

The project area is underlain by a major buried valley that follows the trend of the Great Miami River. The ancient stream valleys that cut into the bedrock of the area were eroded and enlarged by several periods of glaciation. As the glaciers retreated, meltwater deposited in the valleys permeable sand and gravel interbedded with less permeable silt and clay. After the valleys were filled with glacial deposits, surface drainage features formed and the valleys were covered with alluvium.

Bedrock Geology

The near-surface bedrock in the study area consists of flat-lying shale interbedded with thin limestone beds. There are two buried bedrock valleys within the project area, with the main buried valley trending northeast-southwest and a tributary valley trending northwest-southeast.

Well logs and seismic data indicate that the main valley floor is at an elevation of between 500 and 550 feet (NGVD 1929). Seismic data from Watkins and Spieker (1971) show the northwest-southeast trending tributary valley in the western portion of the study area; its floor may be even deeper (between 400 and 450 feet NGVD 1929) than that of the main valley. Driller's logs from the northern part of the tributary valley show the floor to be at least as deep as 550 feet, but logs from the southern part of the valley disagree with the seismic data by about 300 feet, placing the floor at closer to 650—700 feet (see Figures A-1 through A-4).

The main buried valley ranges in width from about 10,000 to 12,000 feet in the northern part of the area (near the West Carrollton Wellfield) to about 3,000 to 4,000 feet near the Miamisburg Wellfield. The tributary valley may be as wide as 15,000 feet. Both valleys are characterized by relatively flat floors bounded by steep valley walls, which are typical of glacial U-shaped valleys.

Buried Valley Geology

In the deepest part of the main valley, 200 feet or more of coarse-grained glacial sand and gravel (outwash) occur. These outwash deposits thin to less than 20 feet near the valley walls. Most of these deposits can be described as well-sorted, coarse-grained sediments with lenses of fine-grained materials occurring within the coarser deposits.

A fairly continuous layer of fine-grained, clay-rich sediments (till) divides the outwash into two layers referred to as the upper and lower aquifers. The thickness of this till

GLO35147.WP.RP Gen Cros...ocs 12/13/93 kmw

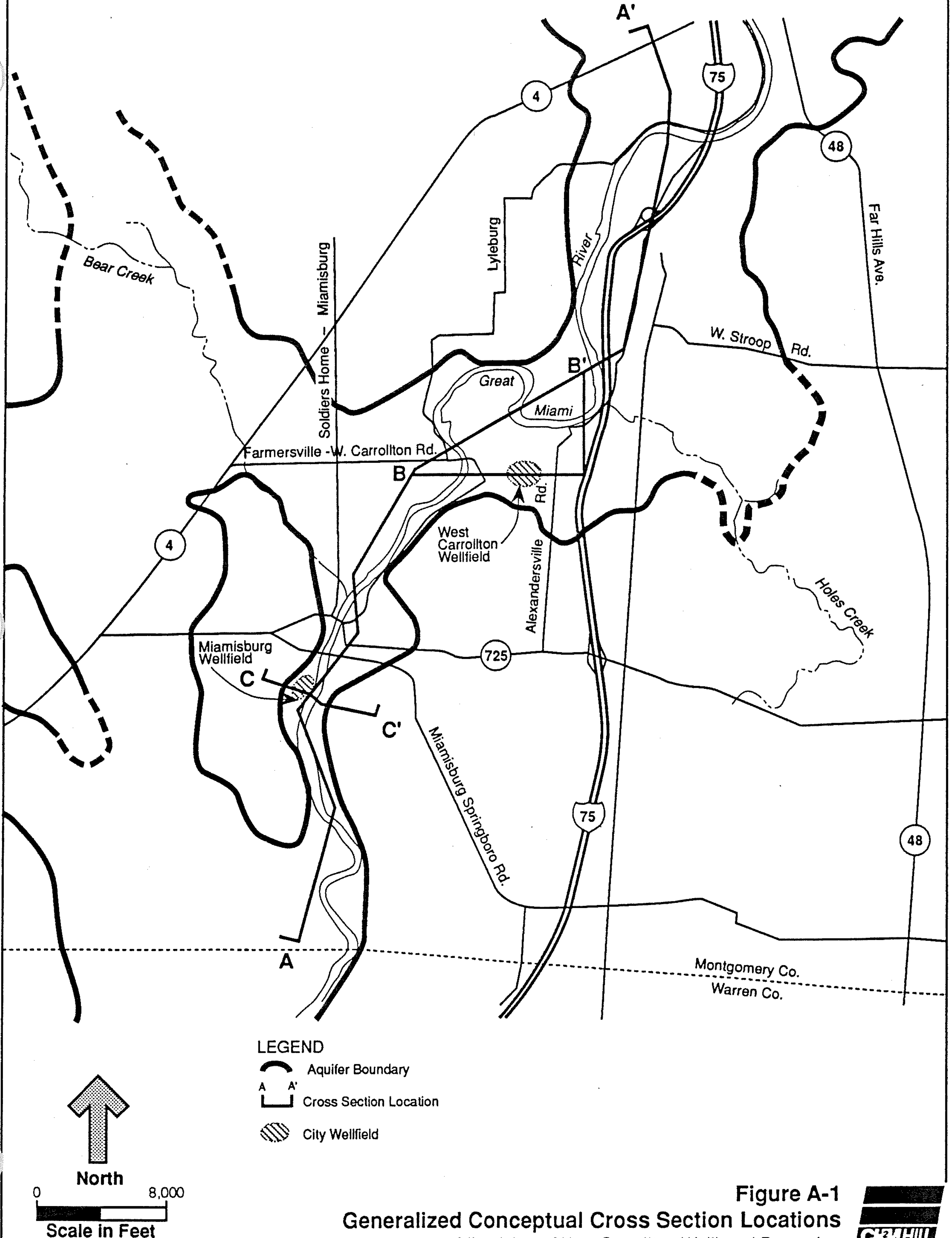
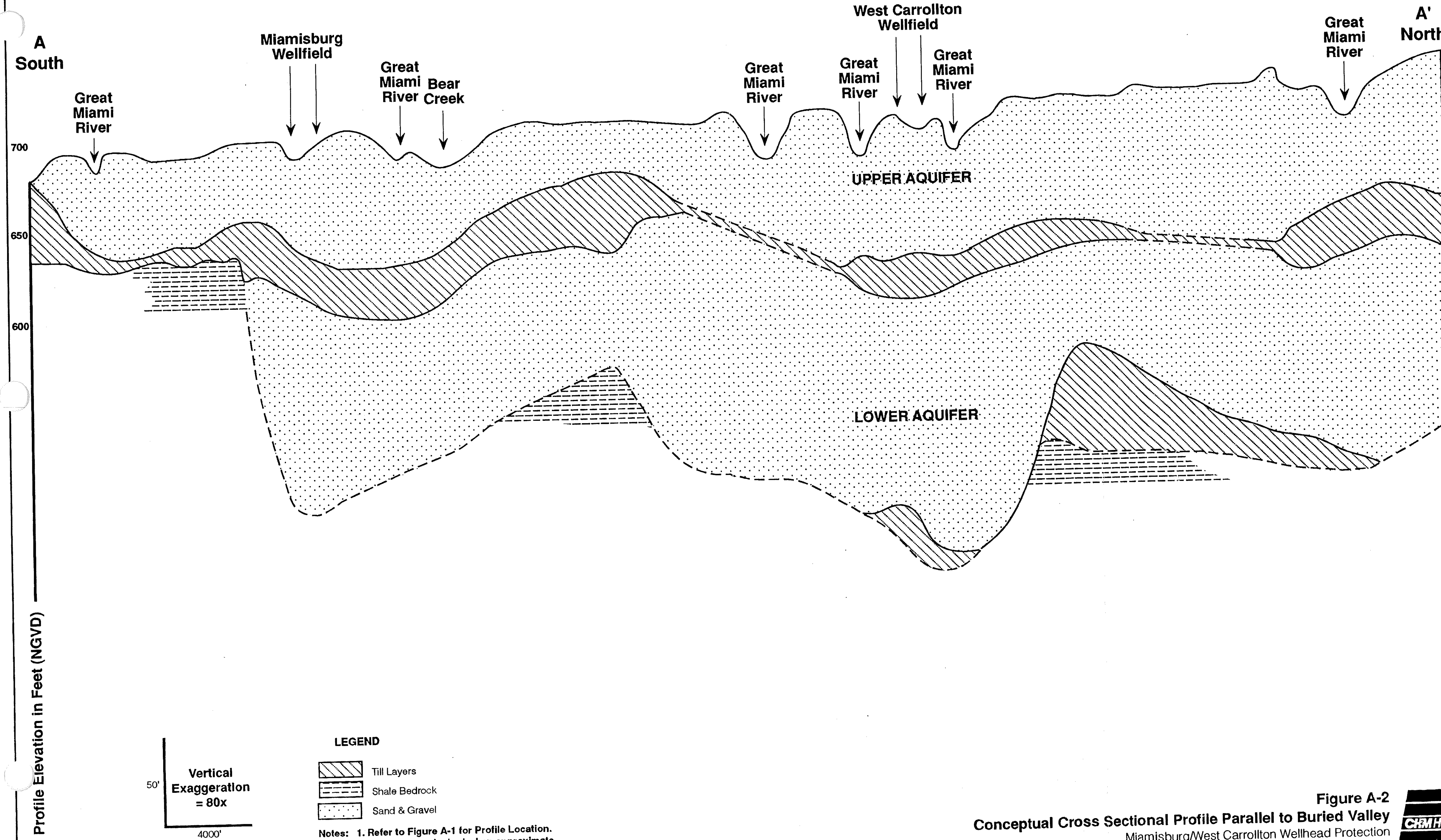


Figure A-1
Generalized Conceptual Cross Section Locations
Miamisburg/West Carrollton Wellhead Protection

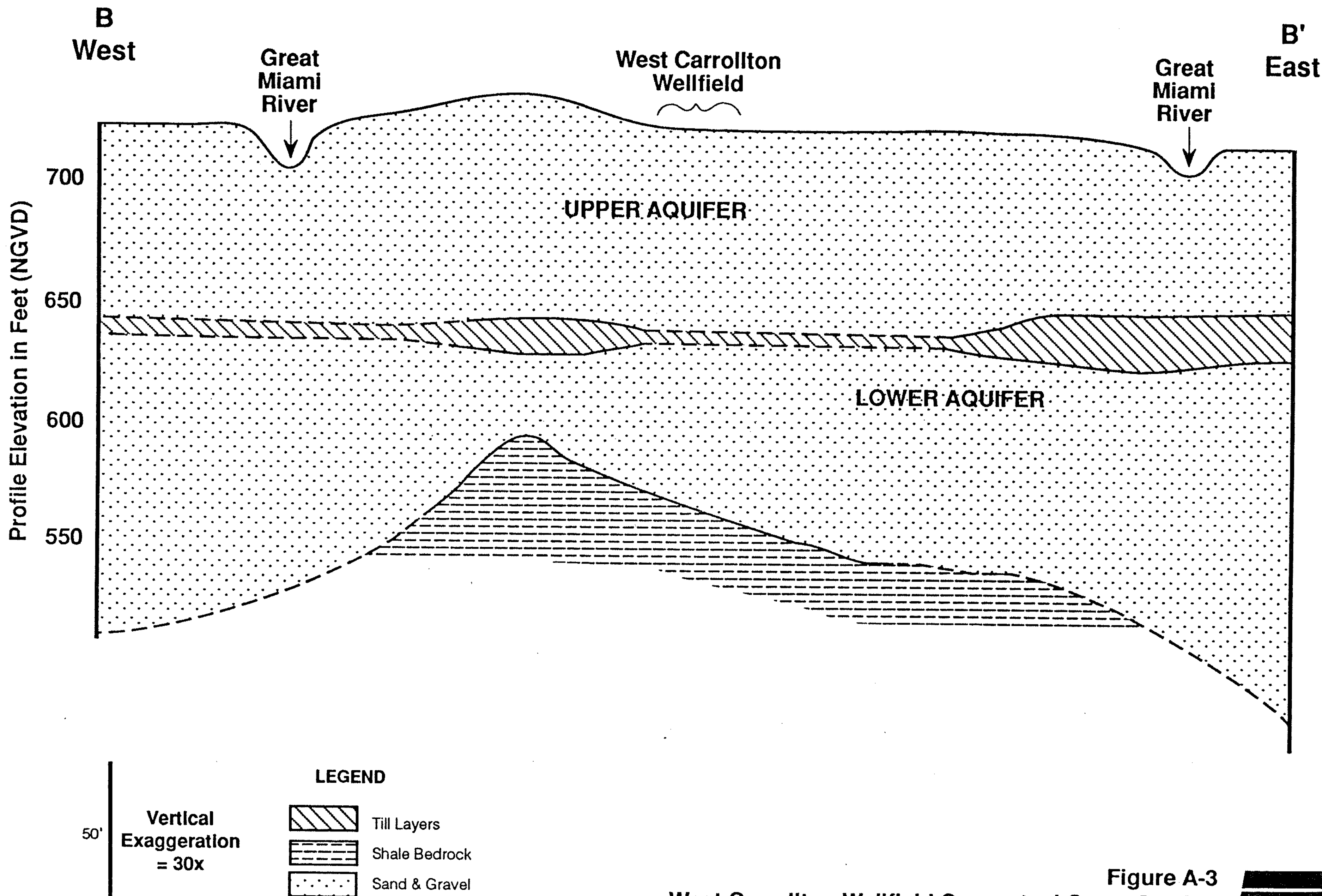
CH2M HILL



Notes: 1. Refer to Figure A-1 for Profile Location.
2. Contacts are dashed when approximate.

Figure A-2
Conceptual Cross Sectional Profile Parallel to Buried Valley
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL



Notes: 1. Refer to Figure A-1 for Profile Location.
2. Contacts are dashed when approximate.

Figure A-3
West Carrollton Wellfield Conceptual Cross Section
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

GLO35147.WP. A-4 X-Section 12/29/93 kmw/mms

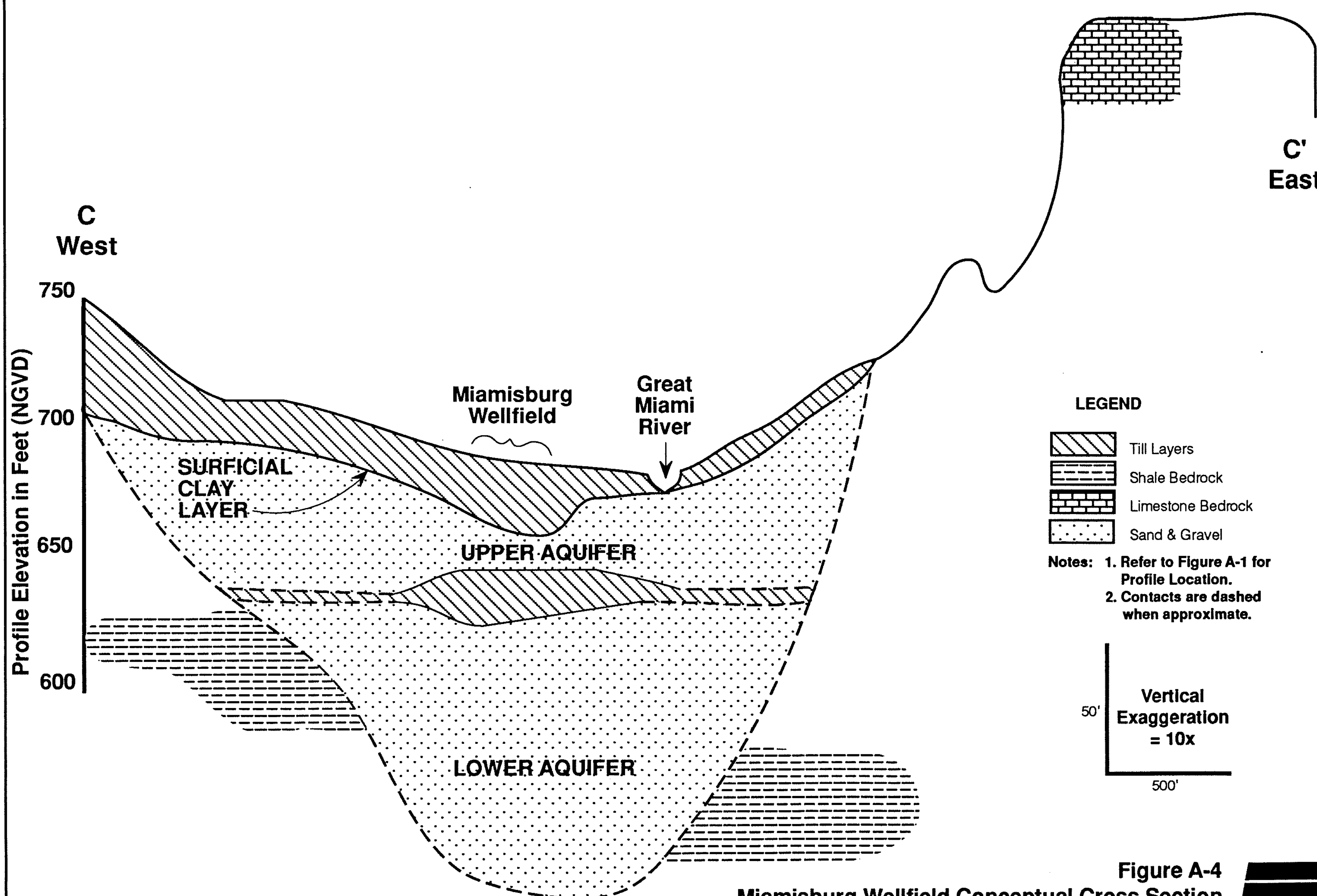


Figure A-4
Miamisburg Wellfield Conceptual Cross Section
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

ranges from nonexistent in the central portion of the study area near Whitfield to almost 60 feet in the tributary buried valley. The till is gently sloping to the south with a gradient between 0.001 and 0.002. Near the northern section of the area, the surface elevation of the till averages 700 feet; in the southern section the elevation is about 650 feet (Figure A-2).

Deeper logs from the Miami Shores Wellfield indicate basal till may be present immediately above the valley floor. Because most of the logs from the deepest part of the valley do not reach bedrock, it is difficult to determine how extensive this till might be. In Moraine, near the Harrison Radiator plant, McLaren/Hart (1991) notes the basal till to be 2 to 20 feet thick.

A small boulder zone is present in the Miamisburg Wellfield and is approximately 20 feet thick, 500 to 1,000 feet wide, and less than 500 feet long. Scattered small boulder zones are also seen in other parts of the study area, including in the Miami Shores Wellfield.

Surficial Deposits

Surficial outwash deposits in the form of kames and eskers occur in the study area. These deposits occur in the eastern part of the study area (near the Kettering/Oakwood area) and, according to driller's logs, may be 100 to 200 feet thick.

Surficial deposits in the central part of the valley are usually thin, with only a few feet of soil or clay present above the upper outwash sand and gravel. In the western part of the study area (near the tributary valley), the till cover can be up to 150 feet thick. In the bedrock uplands, overburden can vary from a few feet to more than 50 feet of clay.

Surface Water Hydrology

The Great Miami River flows southwest throughout the study area and is the major stream providing recharge to the area. Surface water either enters the groundwater flow system as recharge or flows out of the study area in the Great Miami River. Holes Creek and Bear Creek are the two principal tributaries to the Great Miami River in the study area. Smaller streams in the area include Opossum Creek, Sycamore Creek, and Crains Run, and numerous intermittent creeks.

On the average, the area receives about 40 inches of precipitation per year. The precipitation in 1990 averaged 46.5 inches for five nearby precipitation stations (MCD 1990). The modeling assumed that about one-third of normal annual precipitation is available to the aquifer as recharge (Norris and Spieker 1966; Rozelle 1992).

Groundwater Hydrology

Groundwater Occurrence

Groundwater within the project area occurs primarily in the sand and gravel deposits of the buried valley aquifer. Yields from wells producing from the outwash deposits may be between 500 and 1,500 gpm (Spieker 1968; Norris 1948). The fine-grained till deposits also contain groundwater, but these deposits contribute relatively little water to wells because of their low hydraulic conductivity (Spieker 1968).

The till locally divides the aquifer into upper and lower layers. Within the study area the similarity in the elevations of water levels at the water table and the piezometric surface suggests that these two layers are hydraulically connected (Spieker 1968; Geraghty & Miller 1991). The lower aquifer is considered to be semi-confined.

Groundwater Recharge

The upper aquifer receives recharge from the infiltration of precipitation and stream recharge. Recharge occurs over much of the project area where surficial sediments are permeable. Where the kame and esker deposits are present in the eastern portion of the study area, groundwater inflow from precipitation is estimated at more than 1 mgd per mile of valley wall (Norris and Spieker 1966). In areas where the surficial sediments are less permeable (such as areas covered with manmade materials such as asphalt), recharge by precipitation is assumed to be less than in the main valley.

Where distinct upper and lower aquifers exist, the lower aquifer is primarily recharged by groundwater from the upper aquifer flowing vertically downward through the semi-confining till layer.

Minor amounts of recharge to the aquifers are supplied by discharge from the bedrock walls. Norris and Spieker (1966) estimated boundary recharge through the eastern bedrock valley wall near West Carrollton to be between 0.1 and 0.2 mgd per mile of valley wall.

Groundwater Flow

Regionally, the hydraulic gradient of the aquifer system is from the northeast to the southwest along the general trend of the buried valley. Groundwater flow near pumping centers tends to converge toward production wells. Generally, the hydraulic gradient in the lower aquifer is toward the southwest and ranges between 0.001 and 0.002 ft/ft. For the Cardington Landfill area (located about 3 miles north-northeast of West Carrollton's wellfield), the hydraulic gradient in the upper aquifer ranges from 0.0002 to 0.0005 ft/ft and in the lower aquifer ranges from 0.0004 to 0.0005 ft/ft (McLaren/Hart 1991). Near the Mound site area, the regional hydraulic gradient has been estimated to be as high as 0.02 ft/ft (U.S. DOE 1991).

Hydrogeologic Properties

Table A-1 summarizes the hydrogeologic properties of the study area that were identified during data review. *Hydraulic conductivity* is the measure of the ease with which groundwater will move through a saturated medium. *Transmissivity*, the water-yielding capacity of a confined aquifer, is calculated by multiplying the hydraulic conductivity by the aquifer's saturated thickness. For the study area, Spieker (1968) suggests transmissivities of 100,000 gpd/ft for the upper aquifer and 200,000 to 250,000 gpd/ft for the lower aquifer, with induced infiltration by streams in the upper aquifer.

Water Users

The ODNR requires water users to register if they have a capacity to produce a surface or groundwater withdrawal of at least 100,000 gpd. There are a number of registered water users in the study area. Public water suppliers include the Cities of Miamisburg, West Carrollton, and Oakwood; Jefferson Regional Water Authority; Montgomery County Sanitary Department; and the Village of Germantown. Major industrial users include DP&L, several General Motors facilities, Appleton Papers, Inc., Standard Register, and the U.S. DOE at the Mound site. St. Elizabeth Hospital, Miami Valley Hospital, and the University of Dayton Arena, all north of the project area, are also substantial local water users.

Seasonal water users include two golf courses and a small orchard. At least two sand and gravel operations (Hilltop Basic Resources and Carter & Carter) are currently operating in the study area.

Numerical Model

As stated in Section 2, MODFLOW was selected because it best met the objectives of this modeling effort (e.g., it is easy to use, fully documented, widely used)

As with all groundwater flow modeling codes, general assumptions are made about the way aquifer conditions and stresses on the aquifer system (i.e., pumping wells) will be represented in the model. The following major assumptions are inherent to the MODFLOW code:

- Pumping wells fully penetrate their assigned layers.
- Pumping wells are located in the center of their respective cells.
- Pumping wells are assumed to draw water from the entire cell volume with 100 percent efficiency.
- Vertical flow between surface water and groundwater obeys saturated groundwater flow theory.

Table A-1
Hydrogeologic Properties
Miamisburg/West Carrollton

Layer	Property (source)	Units	Reported Value	Modeled Value
Upper	Thickness (Norris & Spieker 1966, Well logs from ODNR, McLaren/Hart 1991)	ft	20-100	5-80
	Hydraulic conductivity (U.S. DOE 1991)	ft/day	50-300	200
	Transmissivity (Spieker 1968, U.S. DOE 1991)	gpd/ft	100,000-200,000	—
Lower	Thickness (Norris & Spieker 1966, Well logs from ODNR, McLaren/Hart 1991)	ft	30-200	5-150
	Hydraulic conductivity (Spieker 1968, Norris & Spieker 1966, Geraghty & Miller 1991)	ft/day	135-460	450
	Transmissivity (Norris & Spieker 1966, Spieker 1968, Moody & Assoc. 1976, U.S. DOE 1991)	gpd/ft	100,000-450,000	—
	Horizontal Gradient (McLaren/Hart 1991, Geraghty & Miller 1991)	ft/ft	0.002-0.005	—
Semi-confining Unit (Till)	Thickness (Norris & Spieker 1966, Well logs from ODNR)	ft	0-70	0-80
	Hydraulic conductivity (Norris & Spieker 1966, Field 1991, Geraghty & Miller 1987, 1991)	ft/day	0.004-0.37	0.2
	Leakance (Norris & Spieker 1966, Field 1991)	gpd/ft^3	0.001-0.019	—
Great Miami River	Streambed vertical hydraulic conductivity (Field 1991)	ft/day	0.0987-2.63	0.5
	Riverbed thickness (Norris & Spieker 1966, Field 1991)	ft	1	—
	Infiltration rate (Field 1991)	ft/day	0.033-0.113	—
Holes Creek	Streambed vertical hydraulic conductivity (Field 1991)	ft/day	0.56	0.1
	Infiltration rate (Field 1991)	ft/day	0.074	—
Model Area	Recharge[1] (Norris and Spieker 1966, Chow 1964)	in/yr	15.5-agricultural areas 5.2-industrial areas	15-agricultural areas 5-industrial areas

Notes:

Norris and Spieker (1966) Estimate groundwater recharge is about one-third of precipitation in agricultural areas. Chow (1964) used to estimate recharge in industrial areas.

- Water levels in individual cells are averaged over the entire cell area.

These assumptions should have little discernable effect on the development of WHP areas and time-of-travel groundwater capture areas. The assumption of full penetration may lead to inaccurate simulation of vertical groundwater gradients within the cells that contain pumping wells. WHP area and time-of-travel capture area delineation considers flows at extended distances from wells; thus inaccuracies have little, if any, effect on resulting WHP area and time-of-travel capture zone boundaries.

Model Area

The model area encompasses portions of Miami, Jefferson, Germantown, Van Buren, Moraine, and Dayton Townships in Montgomery County (Figure A-5). The area measures 38,200 feet along the northern and southern boundaries and 49,000 feet along the western and eastern boundaries and has been rotated N33.2°E relative to northings (State Plane Coordinates). The size of the model was chosen by estimating the area in which 10 years of groundwater flow travel could be calculated around each wellfield. A model grid was developed with 79 rows and 57 columns and two layers. Locations of the active cells in each layer are shown in Figures A-6 and A-7. The row and column cell dimensions range from 200 feet by 200 feet at the Miamisburg and West Carrollton Wellfields (for greater accuracy in the subject areas) to 1,000 feet by 1,000 feet near the model boundaries.

The Great Miami Buried Valley Aquifer enters the model area near Moraine, Ohio and exits the model area near Chautauqua, Ohio. The Buried Valley Aquifer is defined in the model as areas where Spieker (1968) and Watkins and Spieker (1971) defined major buried valley aquifer material as shown in Figure A-1. Where the model cells along the model boundary intersect the buried valley aquifer, the cell is defined as having a constant head. In a cell with a constant head, the groundwater level remains the same throughout model execution. In areas outside the buried valley aquifer where the model boundary intersects simulated bedrock areas, the cell is defined as inactive (no-flow). No water is contributed to the aquifer by an inactive cell during model simulation.

Model Layers

Representation of the till unit in MODFLOW is accomplished by adding a leakance term (to account for the transmission of water between the two aquifers) between the two layers representing the upper and lower aquifers. In other words, when using MODFLOW, we do not typically model the till unit as a specific model layer.

The model is divided into two layers to simulate the two aquifer systems present in the project area. Within each layer, groundwater flow is assumed to move horizontally.

The upper aquifer is bounded on the top by the water table and on the bottom by the top surface of the till; it was modeled as an unconfined layer. The hydraulic conductivity in the upper aquifer is assumed to be constant throughout the study area.

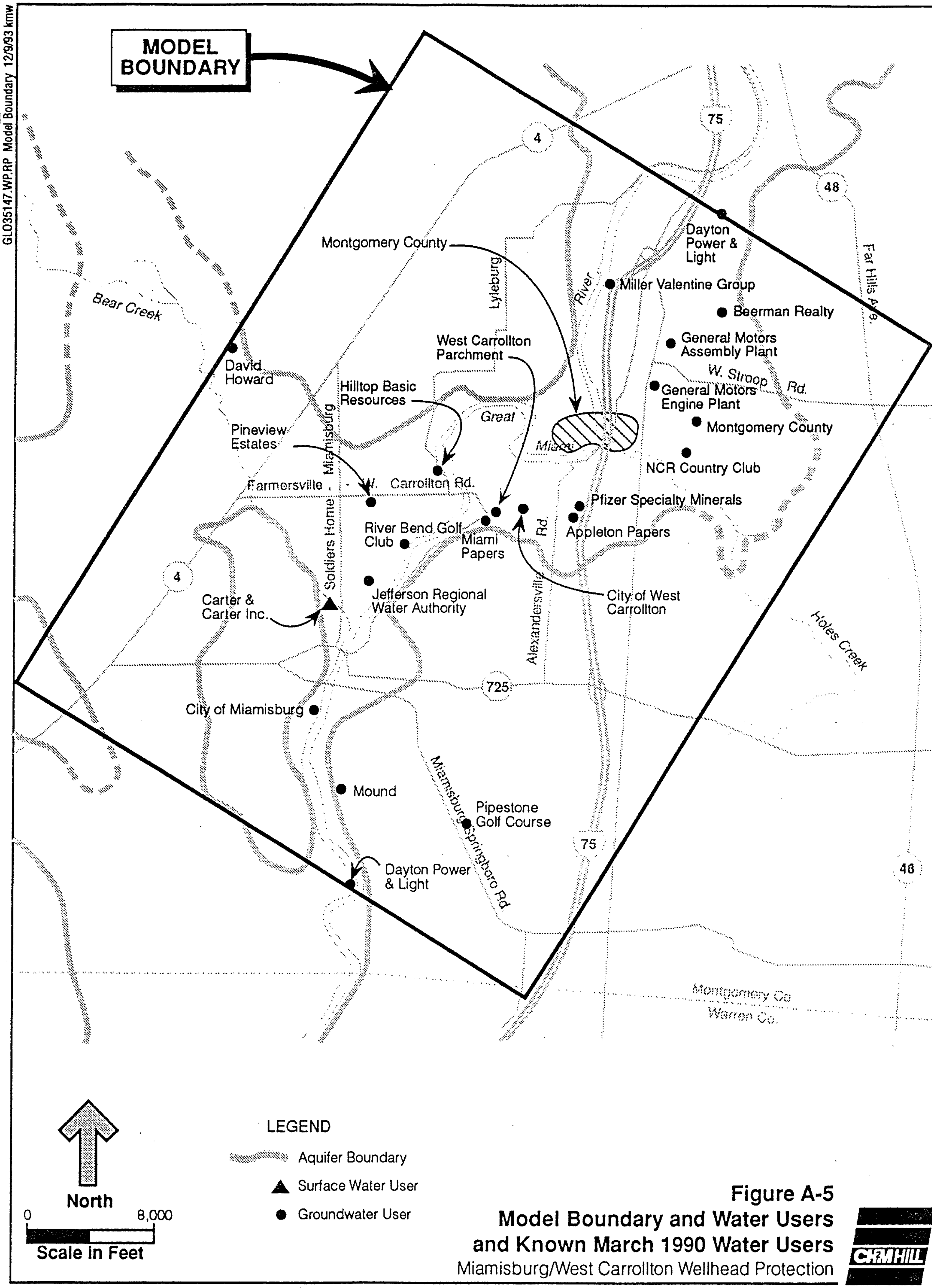
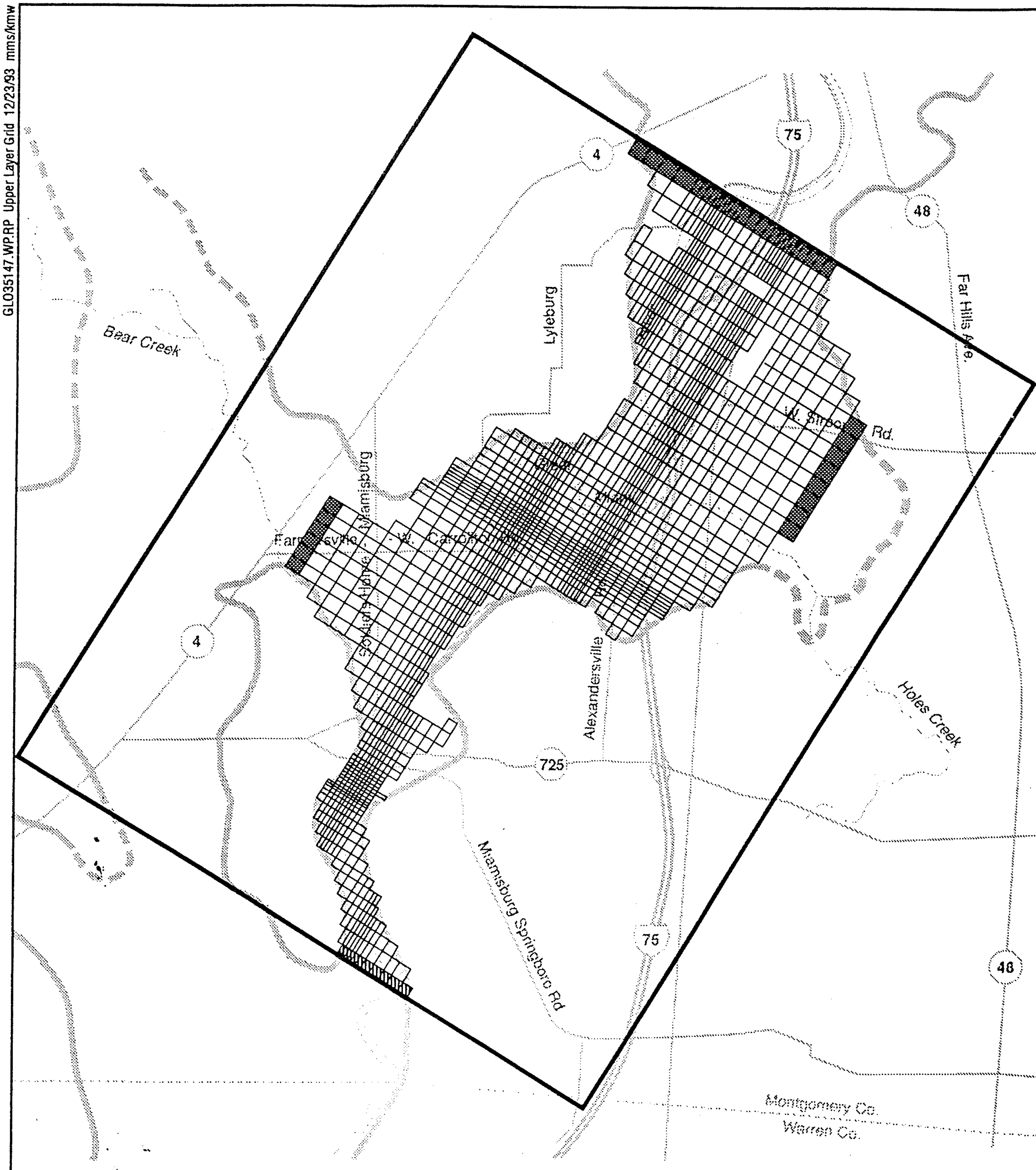


Figure A-5
Model Boundary and Water Users and Known March 1990 Water Users
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

GL035147.WP.RP Upper Layer Grid 12/23/93 mms/kmw



North

0 8,000

Scale in Feet

LEGEND

Aquifer Boundary

Constant Head Boundary

General Head Boundary

Figure A-6
Upper Layer Grid
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

GL035147.WP.RP Lower Layer Grid 12/23/93 mms/kmw

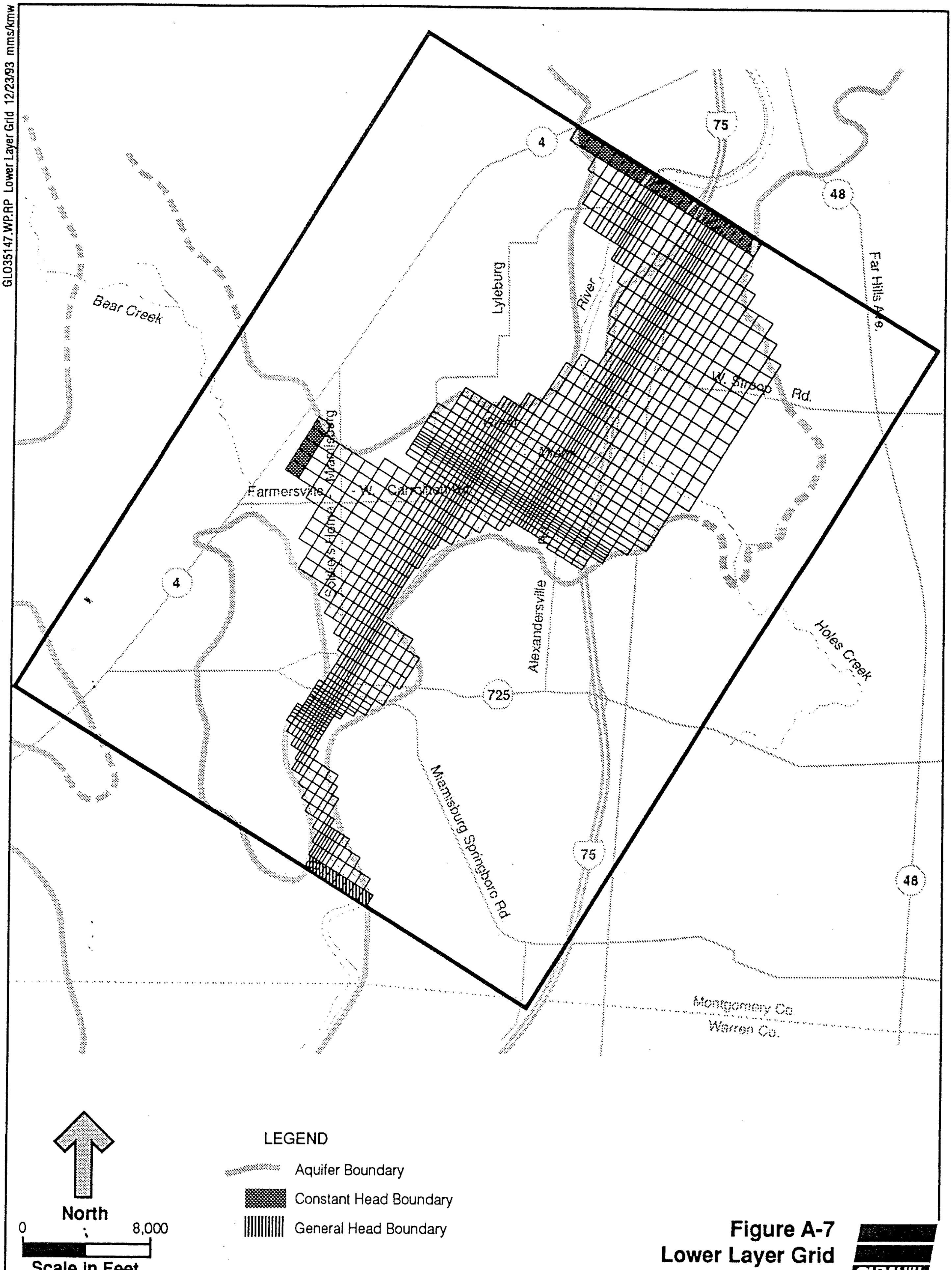


Figure A-7
Lower Layer Grid
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

The lower aquifer was modeled as a semi-confined aquifer. The base of the separating till layer was modeled as the top of layer 2 and the bottom of the layer was modeled as the bedrock surface/lower aquifer base interface. The bedrock surface was modeled using well log data and bedrock maps from Norris and Spieker (1966) and Watkins and Spieker (1971).

Modeled surfaces (top of bedrock, water table, etc.) were developed by contouring the data using the contouring program CONTOUR2 (CH2M HILL 1991b). CONTOUR2 develops a matrix that was transferred to the MODFLOW model.

The till unit was modeled as a leaky, semi-confining layer separating the upper and lower aquifers; it was defined as an area of vertical leakance. Flow through the till was modeled as vertical only, and leakance was calculated by dividing the estimated vertical hydraulic conductivity of the till by its estimated thickness. Modeled surfaces were checked for accuracy by both visual inspection and comparison to conceptual cross-sections.

Simulated Water Surfaces

For this model, available March 1990 water table and potentiometric surface groundwater levels (MCD 1993; various reports) were used to create upper and lower aquifer groundwater surfaces (Figure A-8). Thirty-five points were used for the water table surface (shallow aquifer), and 55 points were used for the potentiometric surface (deep aquifer). During contouring, the water surfaces were supplemented by inferred data in areas where actual data were not available.

Simulated Rivers

The Great Miami River, Holes Creek, and Bear Creek were modeled as sources of surface water in the model. Smaller, seasonal tributaries were not included in the model because they were assumed to contribute a relatively insignificant amount of water to the aquifer system on an annual basis. The Great Miami River and its tributaries were input into the model by overlaying a model grid map over the topographic quadrangles. MCD water level measurements from the March 15, 1990, profile were input into the model as part of the river stage data. River measurements in the extreme southern part of the model were not available and therefore were extrapolated from available data. Riverbed elevations were included as an estimate in the model after studying a number of MCD-developed cross sections throughout the model area. The river and its tributaries were assumed to be located only in the upper model layer.

Simulated Wells

Based on a comparison of current water use and near-term population projections, the City estimated its 1998 water pumping needs for input into the model. Non-City water users in the model area (Figure A-5) were simulated as extraction wells based on ODNR pumping data for March 1990. Data for available users indicate that pumping is done only from the lower aquifer (Layer 2). Residential wells were not included in the well

GL035147.WP.RP Measured Water Table2 12/9/93 kmw

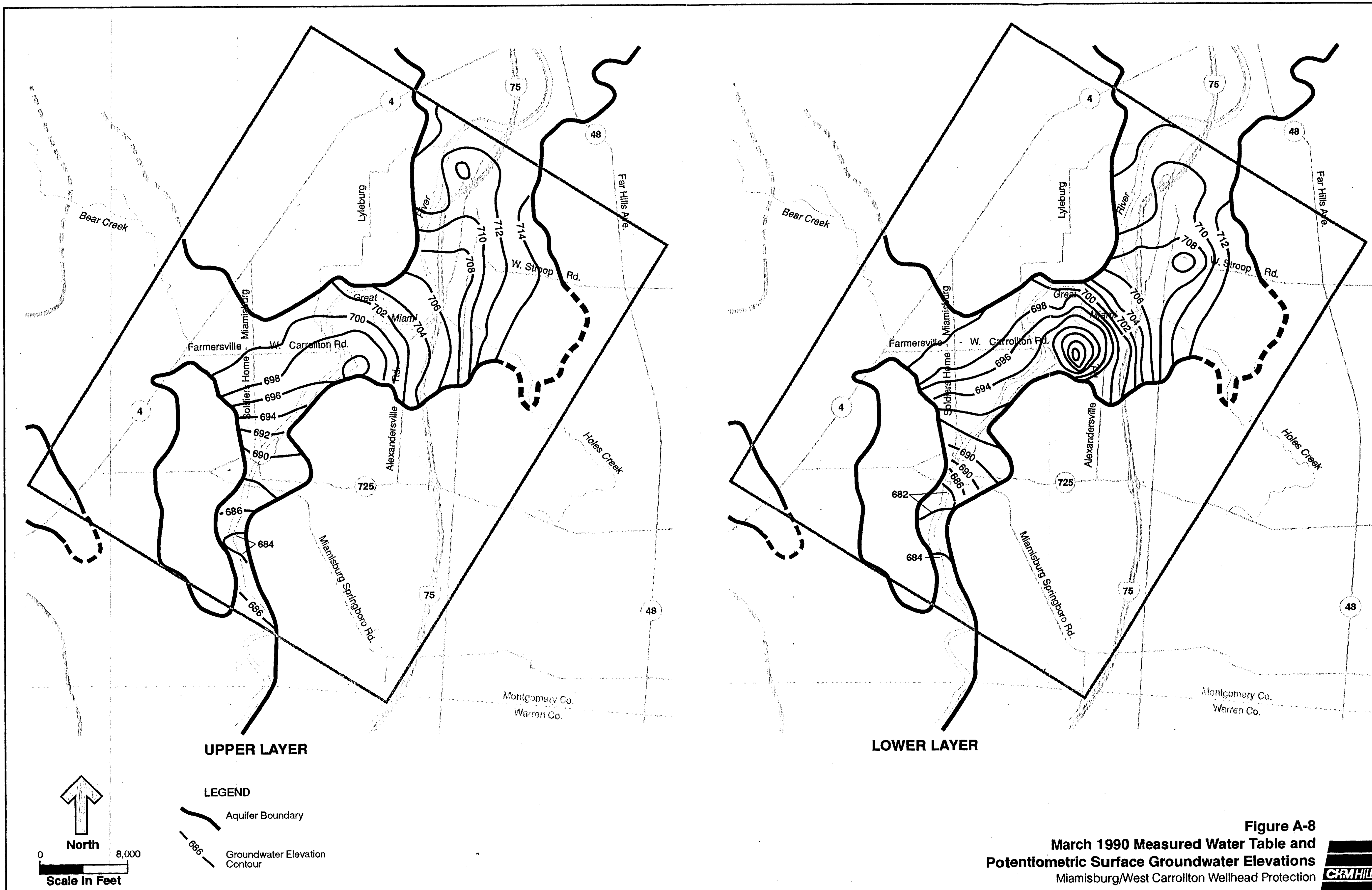


Figure A-8
March 1990 Measured Water Table and Potentiometric Surface Groundwater Elevations
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

data because their overall effect on groundwater flow was considered to be negligible compared to the effects of municipal, commercial, and industrial wells.

Simulated Areal Recharge

Aquifer recharge from precipitation was initially estimated by assuming that one-third of the annual precipitation infiltrated into the aquifer system in agricultural portions of the valley. However, an average precipitation for the month of March was finally used because March 1990 water levels were used in model calibration. The average rainfall totals for five precipitation stations near the model area were calculated using data from March 1990. Rainfall for March was about 4 inches, or about 0.01 ft/day. One-third of this total, or 0.004 ft/day, was used in model calibrations in agricultural areas.

Parts of the valley have heavy industrial or highly populated areas that receive less recharge. The empirical runoff equation (Chow 1964) was used to estimate the relative amount of precipitation recharge in these areas. From this equation, it was assumed that industrial areas would receive only 30 percent of the recharge received in agricultural areas (0.0012 ft/day).

Model Calibration

Procedure

Model calibration is achieved through an interactive process of adjusting model parameters, running the model, and then comparing the model output against field-measured data. The parameters adjusted during the calibration process were:

- Upper layer hydraulic conductivity
- Lower layer hydraulic conductivity
- Till vertical hydraulic conductivity
- Streambed vertical hydraulic conductivity

The model output was compared to field-measured groundwater elevation data from March 1990. The model output was evaluated by three methods:

- Target groundwater elevation data comparison
- General groundwater surface comparisons
- Volumetric water budget error

Model calibration was considered complete when pre-selected criteria for each method were satisfied.

Target Groundwater Elevation Data Comparison. After each simulation, the field-measured March 1990 groundwater elevation data (for 31 observation wells within the model area) were compared to the model output. Thirteen of these wells provided data from the upper aquifer while eighteen wells provided data from the lower aquifer (Figure A-9).

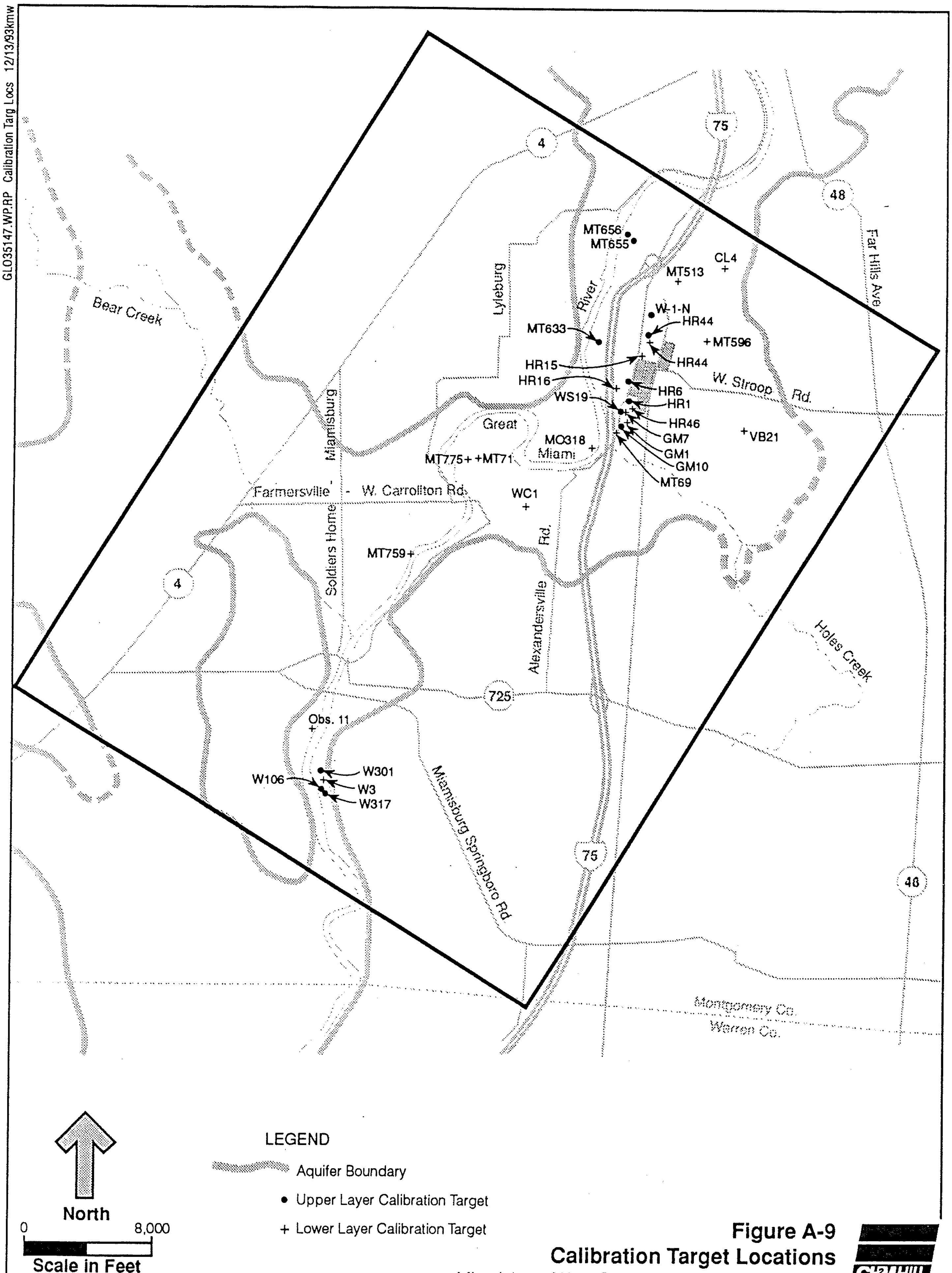


Figure A-9
Calibration Target Locations
Miamisburg/West Carrollton Wellhead Protection

The comparison consisted of subtracting the field-measured groundwater elevation from the model predicted groundwater elevation at the target locations and calculating the:

- Average of the differences
- Average of the absolute differences
- Standard deviation of the differences

This procedure was repeated for each layer. The criteria chosen for average, absolute, and standard deviation of the differences were ±1 foot, 2 foot and 2 foot. For example, if the average difference between field-measured elevations and model-predicted elevations was more than ±1 foot, the model was adjusted and rerun.

General Groundwater Surface Comparison. A groundwater surface plot was prepared for each aquifer based on the groundwater elevations measured in March 1990 and the conceptual understanding groundwater flow within the study area. Following each calibration run the model output were contoured, plotted and compared with the conceptual groundwater surface plot for each aquifer.

The criterion for this comparison was to achieve simulated surfaces that reflected the general hydraulic gradients throughout the model area. If the simulated hydraulic gradients did not adequately reflect the conceptual hydraulic gradients, the model was adjusted and rerun.

Volumetric Water Budget Error. MODFLOW calculates a volumetric water budget for each flow model run. The volumetric budget summarizes all model inflows and outflows for each run and serves as a general check on the acceptability of the model solution. For steady-state runs such as these, this error should generally be less than 1 percent.

Results

Target Groundwater Elevation Data Comparison. The final calibration run average, absolute average, and standard deviation of differences met the stated criteria for the upper layer; they were 0.21, 1.54, and 1.66 feet (Table A-2). The differences were generally positive in the northern portion of the model area and negative in the southern portion (refer to Figure A-10).

Eighteen groundwater elevations locations from the lower aquifer (March 1990) were available for comparison to the model output. The final calibration run statistics satisfied the stated criteria for this layer also. The average, absolute average, and standard deviation were 0.13, 1.03, and 1.28 feet (Table A-3). The differences generally fluctuated positively or negatively with no apparent trend to the fluctuation. The greatest difference was 2.67 feet at well MT513 while differences near the wellfield were as low as 0.53 feet (well WC1 at West Carrollton) and 0.23 feet (well Obs.11 at Miamisburg).

General Groundwater Surface Comparisons. The model-predicted groundwater elevations for the final calibration simulation were plotted for each layer (Figure A-11). Comparisons of the conceptual versus modeled surfaces indicate that modeled hydraulic

GLO35147.WP.RP Sample Border HORIZ 9-13-93mms

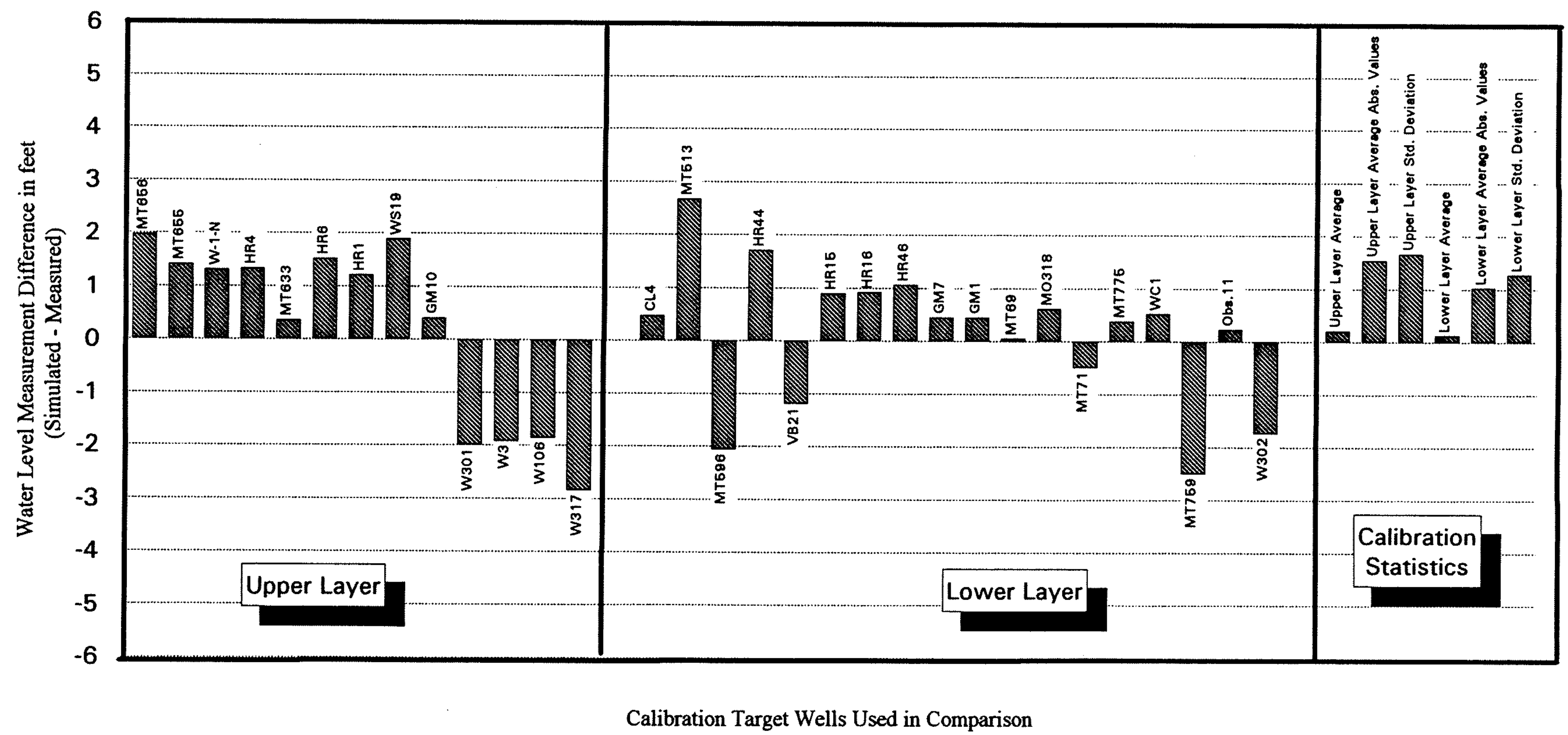


Figure A-10
Calibration Target Well Comparison
Miamisburg/West Carrollton Wellhead Protection

GL035147.WP.RP Groundwater Elevations2 12/9/93 kmw

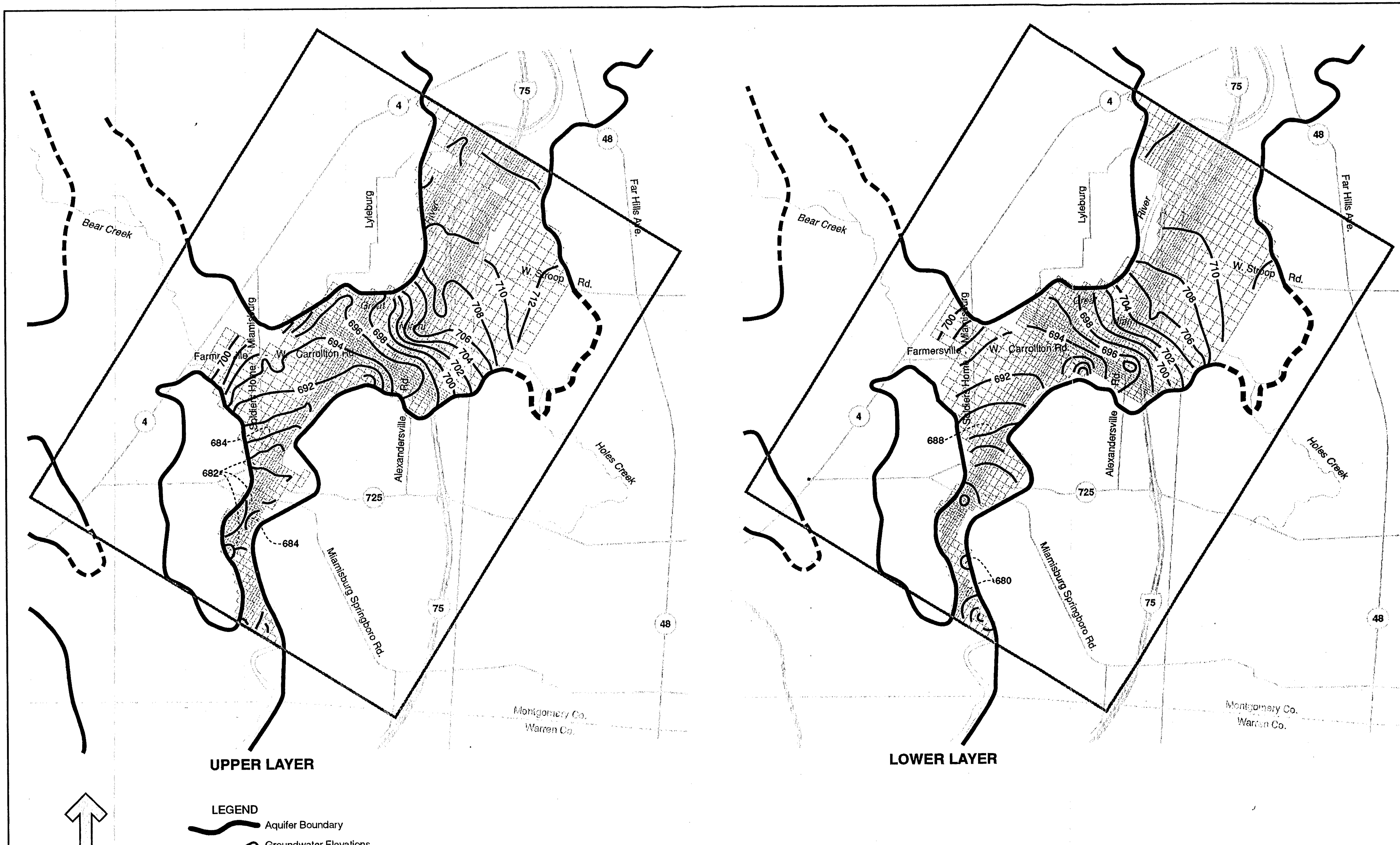


Figure A-11
Upper and Lower Layer Calibrated Groundwater Elevations
Miamisburg/West Carrollton Wellhead Protection

Table A-2
Upper Aquifer Target Water Level Location Data and Calibration Statistics
Miamisburg/West Carrollton Wellhead Protection

Location ID	Aquifer	Modeled Layer	Simulated Water Level (ft)	Measured Water Level (ft)	Difference (ft)
MT656	Upper	1	711.80	709.83	1.97
MT655	Upper	1	711.40	709.99	1.41
W-1-N	Upper	1	710.20	708.89	1.31
HR4	Upper	1	710.20	708.86	1.34
MT633	Upper	1	709.60	709.24	0.36
HR6	Upper	1	709.10	707.58	1.52
HR1	Upper	1	708.50	707.28	1.22
WS19	Upper	1	707.30	705.41	1.89
GM10	Upper	1	706.80	706.40	0.40
W301	Upper	1	682.10	684.10	-2.00
W3	Upper	1	682.00	683.94	-1.94
W106	Upper	1	681.70	683.57	-1.87
W317	Upper	1	680.40	683.24	-2.84
Upper Aquifer Statistics				**Average**	**0.21**
				Absolute Average	**1.54**
				Standard Deviation	**1.66**

Table A-3
Lower Aquifer Target Water Level Location Data
and Calibration Statistics
Miamisburg/West Carrollton Wellhead Protection

Location ID	Aquifer	Modeled Layer	Simulated Water Level (ft)	Measured Water Level (ft)	Difference (ft)
CL-4	Lower	2	711.10	710.63	0.47
MT513	Lower	2	711.20	708.53	2.67
MT596	Lower	2	711.20	713.27	-2.07
HR44	Lower	2	709.90	708.19	1.71
VB21	Lower	2	711.60	712.80	-1.20
HR15	Lower	2	709.00	708.10	0.90
HR16	Lower	2	708.00	707.08	0.92
HR46	Lower	2	707.90	706.84	1.06
GM7	Lower	2	707.00	706.55	0.45
GM1	Lower	2	707.20	706.75	0.45
MT69	Lower	2	706.40	706.34	0.06
MO318	Lower	2	705.30	704.69	0.61
MT71	Lower	2	697.50	698.00	-0.50
MT775	Lower	2	696.00	695.62	0.38
WC1	Lower	2	693.20	692.67	0.53
MT759	Lower	2	691.50	694.00	-2.50
Obs.11	Lower	2	680.40	680.17	0.23
W302	Lower	2	681.00	682.75	-1.75
Lower Aquifer Statistics				**Average**	**0.13**
				Absolute Average	**1.03**
				Standard Deviation	**1.28**

gradients generally agree with conceptual hydraulic gradients deveoped from field measurements. Groundwater flow, in both the conceptual and the modeled surfaces, is generally from north to south through the modeled area except where pumping causes the flow to converge. Easterly and westerly hydraulic gradient components are noted near the vicinity of the mouth of Holes Creek and of Bear Creek.

A quantitative method of comparing groundwater surface maps is to prepare a contour map of the differences between the conceptual and modeled surfaces. The differences are calculated for each active model cell within each layer and are then contoured. The resulting contour plot is commonly called a residual map. A residual map (Figure A-12) was prepared for each layer as described above.

Two areas in each model layer have the greatest difference between conceptual and modeled groundwater elevations. These areas are:

- An area of positive residual located generally between West Carrollton's Wellfield and the General Motors truck plant

- An area of negative residual located generally between West Carrollton's and Miamisburg's Wellfields.

These residuals are most likely related to lack of data in the areas, or the inclusion of erroneous water level data during conceptualization.

Overall, the availabe data tended to be clustered near pumping centers and were lacking in undeveloped areas (Figure A-9). However, data in the vicinity of West Carrollton's wellfield were limited to the wellfield and so the impacts of pumping in this area were over estimated. (This results in the positive residual noted above).

The area of negative residual noted was most likely caused by the use of erroneous water level data during groundwater surface conceptualization. During model calibration the residual in this area fluctuated between -4 and -6 feet. Conversations with Paul Plummer at the Miami Conservancy District indicated that the observation well data used to conceptualize the groundwater surfaces in this area were accurate to ± 5 feet at best because the measuring point elevations for these wells had been estimated from a topographic map.

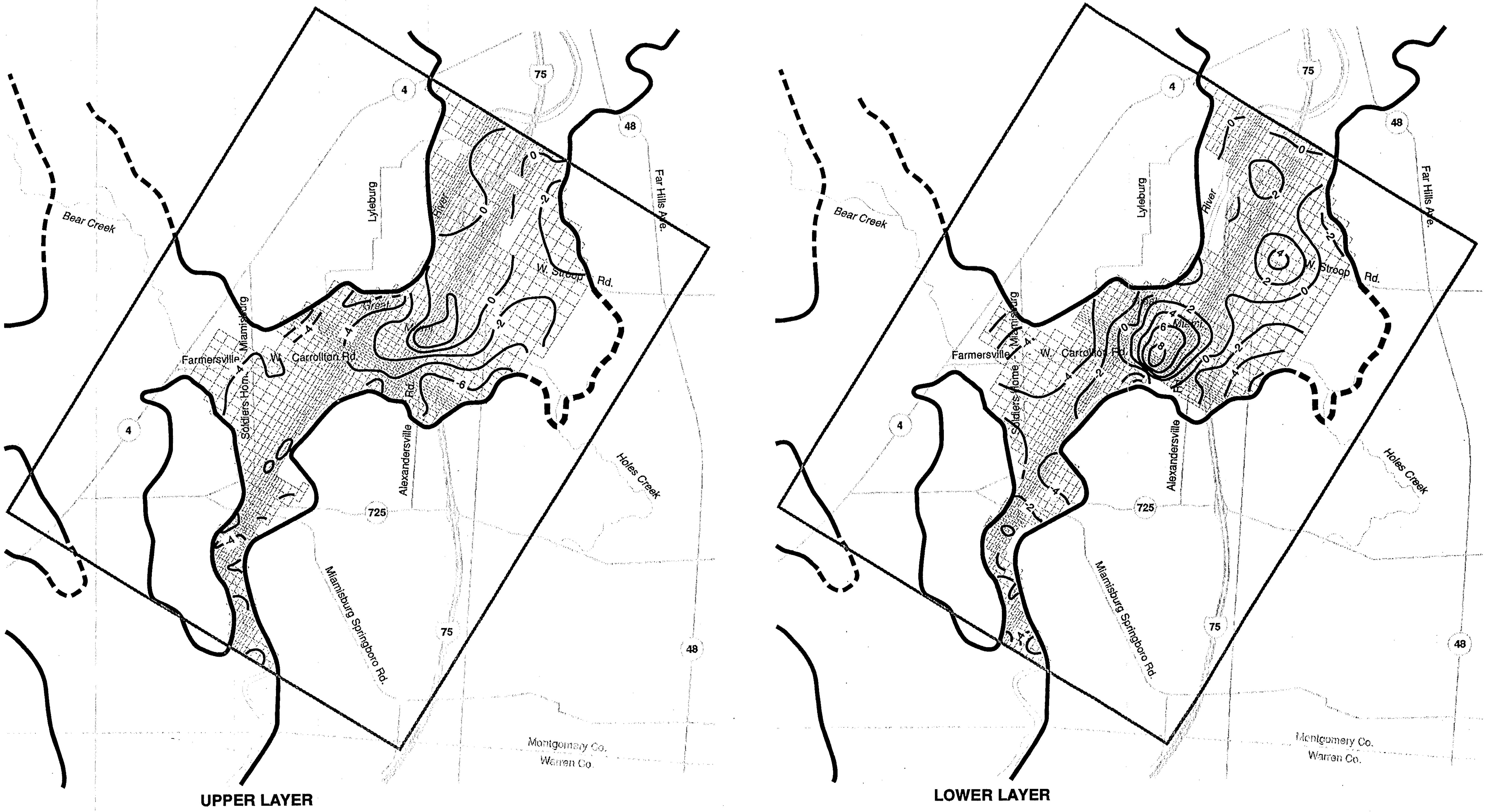
Volumetric Water Budget Error. The volumetric water budget error for the final calibration run was 0.03 percent. This error is well below the generally accepted steady-state flow model error criterion of 1 percent.

Model Verifications

Procedure

After the model was calibrated it was run using stress (i.e., pumping, precipitation, river, and groundwater) data from November 1990. The aquifer hydraulic properties

GL035147.WP.RP Upper and Lower Layers2 12/9/93 kmw



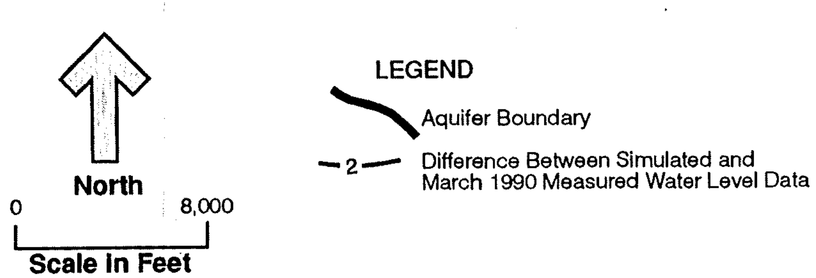


Figure A-12
Residual Plots for Upper and Lower Layers Comparing Simulated and Measured Water Levels
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

established through the calibration process—upper and lower layer hydraulic conductivity and streambed and till vertical hydraulic conductivity—however, remained unchanged during the verification run.

The pumping rates used for the verification run were based upon water use records for 1990 collected from the Ohio Department of Natural Resources (ODNR). These records provided the total pumpage per month from each water user and these data were input for the verification run.

Precipitation data for November 1990 was available from MCD (MCD 1992). Based on data collected at these stations between October 20, 1990 and November 20, 1990, the total precipitation was 1.62 inches. This would amount to about 19 inches per year. Because an estimated one-third of the yearly precipitation in agricultural areas recharges the groundwater system, the rate of areal recharge was set at 0.0014 feet/day. The rate of areal recharge to heavily industrial/residential areas was set at 0.0005 feet/day for the verification run.

Differences in groundwater elevations between March and November 1990 were incorporated by first determining the difference in the elevation data at locations where March and November data existed. The November data were subtracted from the March data for each layer and the average of these differences was calculated. The average of both layers was about 1 foot (March groundwater elevations averaged about 1 foot higher than November elevations for both layers). These differences were incorporated in the verification run by subtracting 1 foot from each layer's starting head array.

Profile data for the Great Miami River were available for November 1990 from MCD. Again, these data were compared to the March 1990 data used for calibration. The average of differences between the March and November 1990 elevation data at seven measuring stations was about 1 foot (March elevations were higher than November elevations). These differences were incorporated in the verification run by subtracting 1 foot from each river cell is stage value.

The model output was compared to November 1990 field-measured data at target groundwater elevation data locations. The overall model performance was again reevaluated relative to the volumetric water budget error.

Results

Nine groundwater elevation measurements (November 1990) from the upper aquifer were available for comparison to the model output for the upper layer (Figure A-13). The elevation differences at these locations were calculated as during calibration and the same statistics were determined (Table A-4). The differences were all positive and ranged from 0.05 to 1.83 feet. The average, absolute average, and standard deviation were 0.68, 0.68 and 0.57 feet.

Fifteen groundwater elevation measurements (November 1990) from the lower aquifer were available for comparison to the lower layer model output. The elevation differences

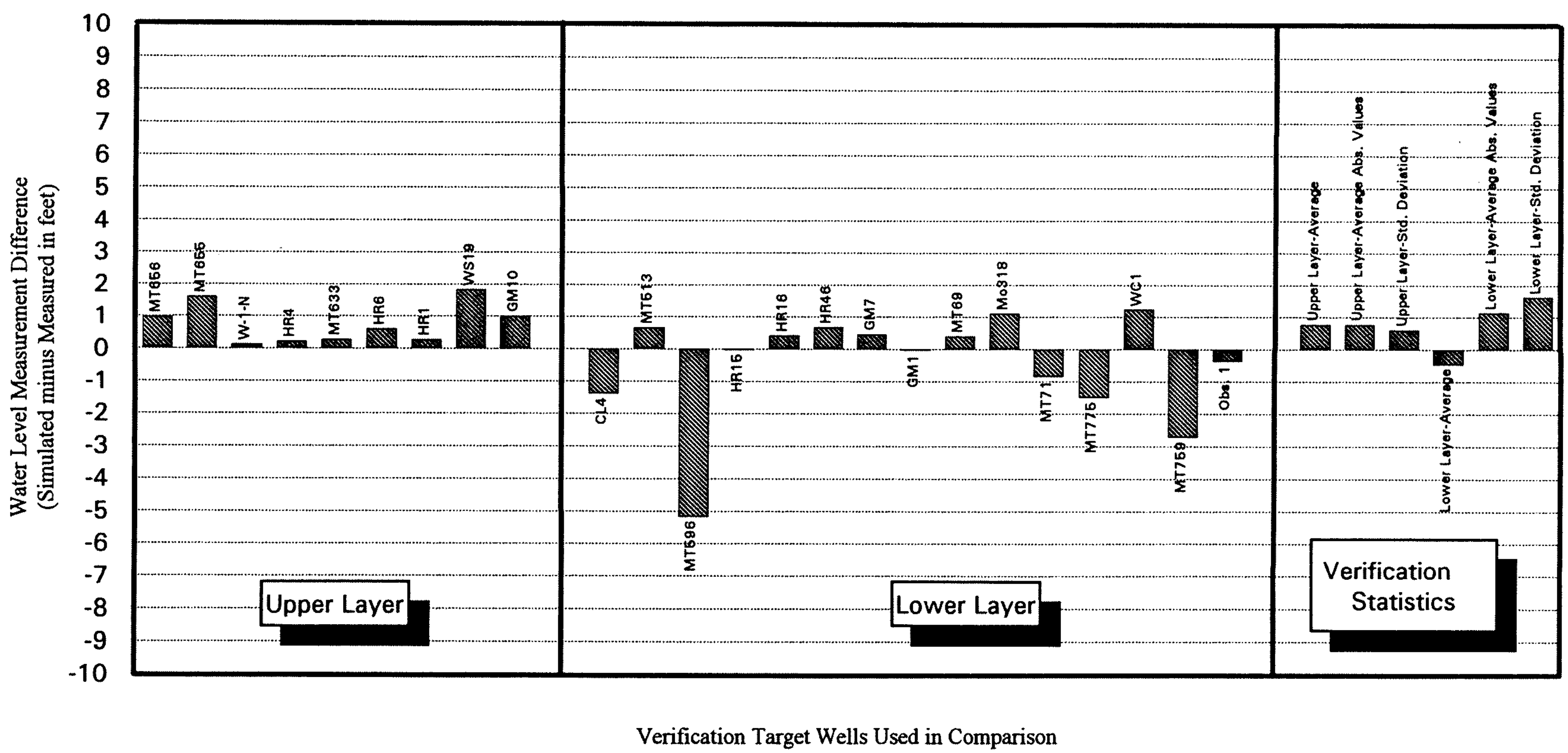


Figure A-13
Verification Target Well Comparison
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

Table A-4
Upper Aquifer Target Water Level Location Data
and Verification Statistics
Miamisburg/West Carrollton Wellhead Protection

Location ID	Aquifer	Modeled Layer	Simulated Water Level (ft)	Measured Water Level (ft)	Difference (ft)
MT656	Upper	1	710.50	709.53	0.97
MT655	Upper	1	710.10	708.49	1.61
W-1-N	Upper	1	708.60	708.48	0.12
HR4	Upper	1	708.60	708.38	0.22
MT633	Upper	1	708.40	708.13	0.27
HR6	Upper	1	707.50	706.90	0.60
HR1	Upper	1	706.80	706.53	0.27
WS19	Upper	1	705.60	703.77	1.83
GM10	Upper	1	705.00	704.95	0.05
Upper Aquifer Statistics				**Average**	**0.68**
				Absolute Average	**0.68**
				Standard Deviation	**0.57**

generally fluctuated from positive to negative and ranged from -5.19 to 1.25 feet. The average, absolute average, and standard deviation determined were -0.48, 1.14, and 1.64 feet (Table A-5).

The volumetric water budget error for the verification run was 0.03 percent. This value is, again, well below the 1 percent error generally accepted in the case of steady-state flow simulations.

Capture Zone Analyses

MODPATH and MODPATH-PLOT Code Description

A particle-tracking postprocessing package consisting of two programs, called MODPATH and MODPATH-PLOT (Pollack 1989), was developed by the USGS to compute three-dimensional groundwater flow pathlines based on the output from MODFLOW steady-state simulations. MODPATH calculates pathlines and MODPATH-PLOT plots the pathlines.

MODPATH input files consist of data from both MODFLOW input and output. These data are necessary to compute the velocity of particle movement in the simulated aquifer system. MODPATH-PLOT graphically represents the particle locations or pathlines simulated by MODPATH for a given length of time at a given map scale. Either planar or cross-sectional views can be plotted. The input files required by MODPATH-PLOT are the same as for MODPATH, with the addition of the plotting output directions.

The capture zone of a given well (or wellfield) is the area surrounding the well through which groundwater is expected to travel to the well within a specified time interval. Capture zones are determined by:

- Calculating reverse pathlines for particles (i.e., from the production well toward areas of recharge) with MODPATH
- Plotting the reverse pathlines for all layers with appropriate time limits (1, 5, or 10 years) with MODPATH-PLOT
- Drawing a line around the ends of the pathlines

For this project, 1-year capture zones were used to qualitatively evaluate model sensitivity to parameter changes and 1-, 5-, and 10-year capture zones were delineated to address Ohio EPA's WHP program.

Limitations. The program MODPATH has the following limitations:

- Flow can only be simulated for simple linear velocity in the seven directions recognized in three-dimensional finite-difference problems

Table A-5
Lower Aquifer Target Water Level Location Data and Verification Statistics
Miamisburg/West Carrollton Wellhead Protection

Location ID	Aquifer	Modeled Layer	Simulated Water Level (ft)	Measured Water Level (ft)	Difference (ft)
CL-4	Lower	2	709.90	711.29	-1.39
MT513	Lower	2	709.70	709.05	0.65
MT596	Lower	2	709.20	714.39	-5.19
HR15	Lower	2	707.40	707.43	-0.03
HR16	Lower	2	706.40	705.97	0.43
HR46	Lower	2	706.10	705.42	0.68
GM7	Lower	2	705.30	704.84	0.46
GM1	Lower	2	705.40	705.44	-0.04
MT69	Lower	2	704.80	704.40	0.40
MO318	Lower	2	704.00	702.89	1.11
MT71	Lower	2	695.70	696.56	-0.86
MT775	Lower	2	694.50	696.01	-1.51
WC1	Lower	2	691.90	690.67	1.23
MT759	Lower	2	689.90	692.63	-2.73
Obs.11	Lower	2	679.20	679.58	-0.38
Lower Aquifer Statistics				**Average**	**-0.48**
				Absolute Average	**1.14**
				Standard Deviation	**1.64**

- The accuracy of particle pathlines is limited by the level of detail (for example, cell size) available from the MODFLOW simulation of the hydrogeologic setting

- The level of uncertainty in hydrogeologic parameters being simulated will affect the uncertainty of predicted pathlines

Sensitivity Analysis

Groundwater flow models are sensitive to the various hydraulic parameters used in calibration. For some of those parameters (such as lower aquifer hydraulic conductivity), a range of field-measured values may be available. For other parameters (such as streambed vertical hydraulic conductivity), few or no known field-measured values may exist. In this study, a qualitative measure of the model's sensitivity to these parameters was obtained by varying each parameter individually and comparing the resulting 1-year capture zone to the baseline 1-year capture zone produced using the calibrated model parameter values.

Procedure. The calibration production scenario for the model area was selected as a basis for the sensitivity analysis. Selected files from the MODFLOW simulation of this scenario were used in the MODPATH program. Using MODPATH, groundwater particles originating at each of the City of West Carrollton's production wells were tracked backwards (i.e., in the upgradient direction) from the production wells for a period of 1 year. A line drawn around the ends of the particle pathlines indicates the 1-year capture zone for the wellfield. Since the results indicate overall model sensitivity, a similar excerise was not necessary for the City of Miamisburg's production wells.

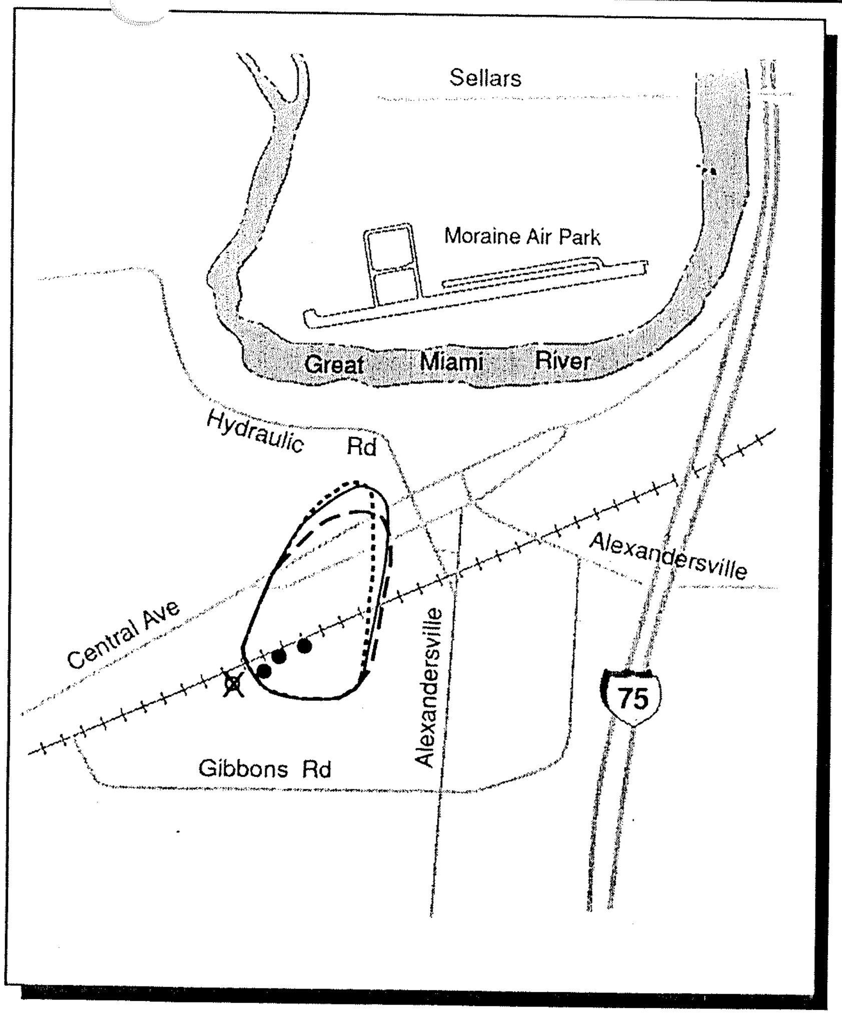
For this project, the model's sensitivity to five parameters was analyzed:

- Horizontal hydraulic conductivity of the upper layer
- Horizontal hydraulic conductivity of the lower layer
- Vertical hydraulic conductivity of the till
- Vertical hydraulic conductivity through the streambeds
- Rate of areal recharge from precipitation

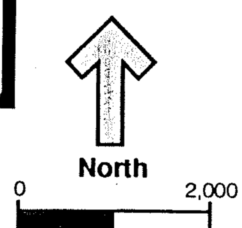
Generally, each parameter was individually varied by 50 and 150 percent of its calibrated value. The ten resulting 1-year capture zones were compared against the 1-year capture zone developed brom the calibrated model parameters (Figures 14a and 14b).

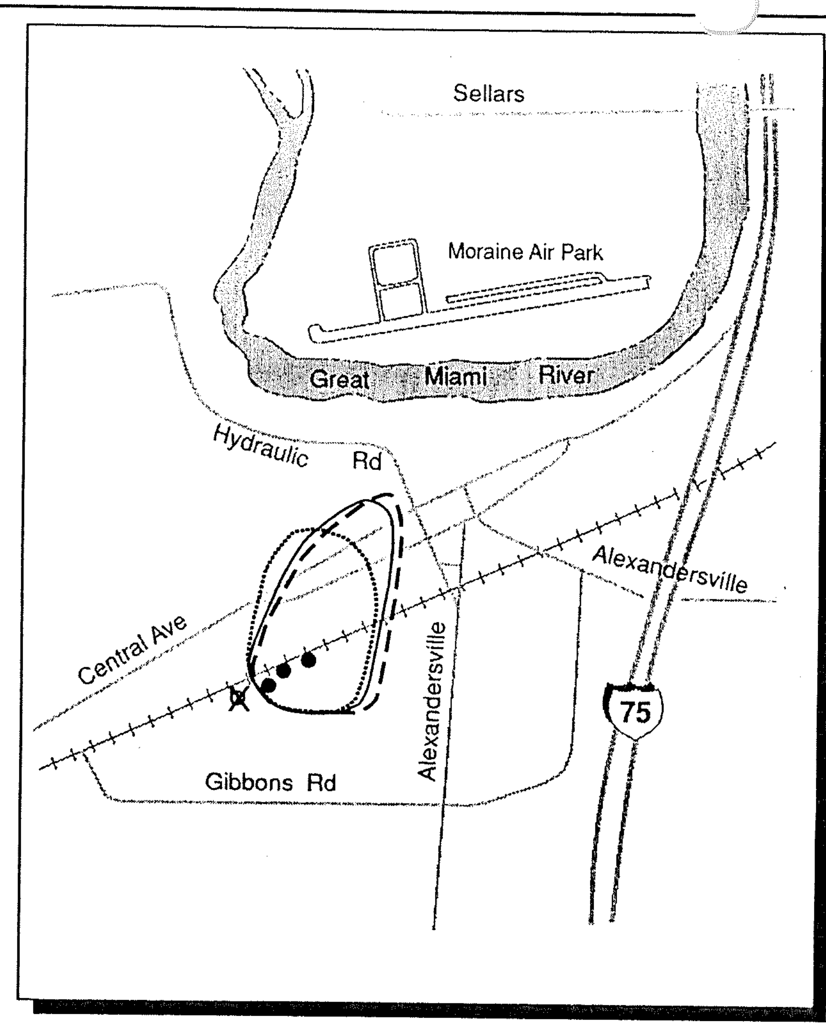
Results. Overall, the most notable changes in the 1-year capture zone resulted from increasing the upper layer hydraulic conductivity and decreasing the lower layer hydraulic conductivity (Figure 14a). The model appeared to be relatively insensitive to changes in the till and streambed vertical hydraulic conductivity, areal recharge, decrease in the upper layer hydraulic conductivity, and increases in the lower layer hydraulic conductivity.

GL03514? West Carrollton 12/16/93 kmw



Upper Layer Hydraulic Conductivity





Lower Layer Hydraulic Conductivity

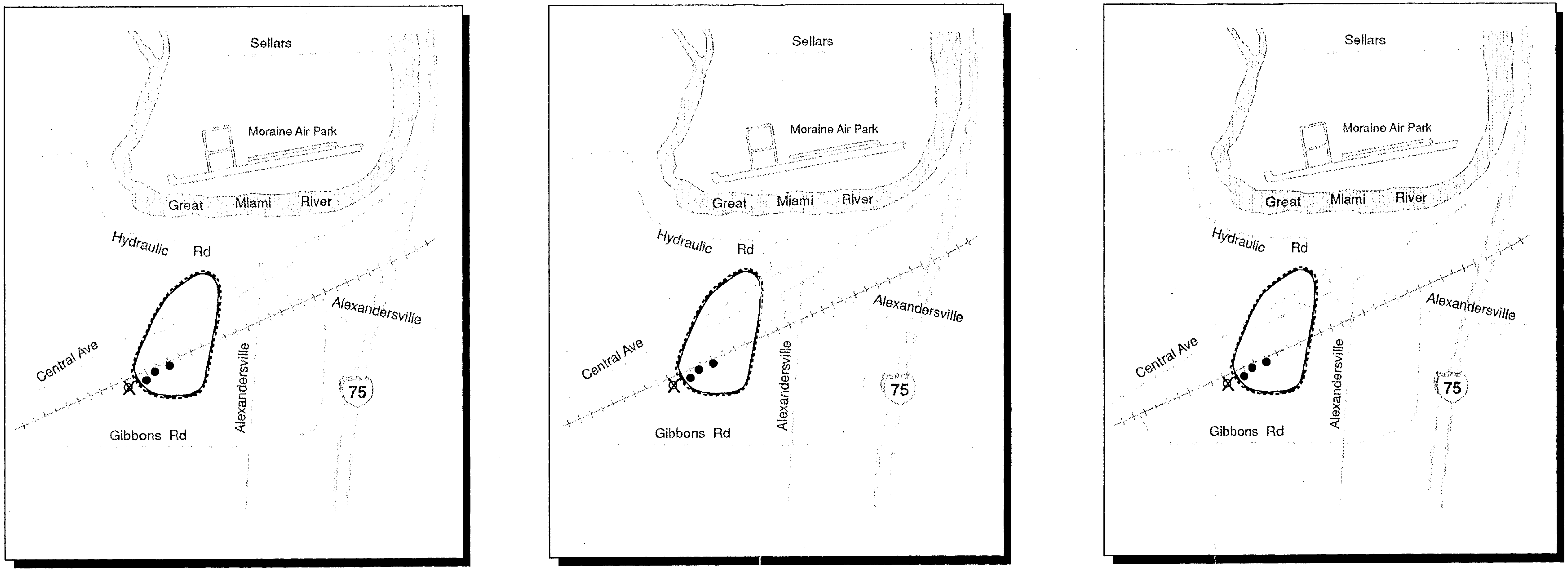
LEGEND

- ● Pumping Wells
- ⊗ Non-Pumping Wells
- ——— Calibrated Parameters
- ········ 50% Calibrated Parameter*
- — — — 150% Calibrated Parameter

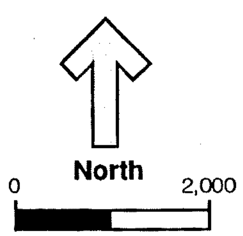
*Upper Layer Value was 63% of the Calibrated Parameter

Figure A-14a
Capture Zone Sensitivity to Adjusted Model Parameters
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL



Till Vertical Hydraulic Conductivity | **Areal Recharge** | **Streambed Vertical Hydraulic Conductivity**



LEGEND

- ● Pumping Wells
- ⊠ Non-Pumping Wells
- ——— Calibrated Parameters
- .... 50% Calibrated Parameter
- — — — 150% Calibrated Parameter

Figure A-14b
Capture Zone Sensitivity to Adjusted Model Parameters
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

3LO35147.WP.RP Cap Zon2 Sens Adj Mod Par 12/9/93 kmw

Wellhead Protection Delineations

In its WHP Program, Ohio EPA recommends delineating an Inner Management Zone (the 1-year capture zone) and a Wellhead Protection area (the 5-year capture zone). They also indicate that a water supply system may choose to delineate a 10-year capture zone that may be used as an Outer Management Zone (OMZ). The IMZ, WHP area, and OMZ were delineated following model calibration and verification.

Procedure. Based upon client meetings, average stress conditions (i.e., precipitation, surface water elevations, and groundwater elevations) were simulated in the delineation run. Average conditions were determined by evaluating surface water and groundwater elevation data available from the USGS from water years 1985 and 1991, and by referencing ODNR data (1992c). Water production rates for the two cities were taken as their maximum monthly demand (averaged daily) plus additional demand anticipated through 1998.

Another consideration during delineation was how to handle areas where the capture zones intersected the simulated aquifer edge. Two principal approaches have been used in the past:

- Extending the WHP area an arbitrary distance (such as 1,000 feet) away from the simulated aquifer edge

- Extending the WHP area to the surface water drainage divide

During discussions with the clients, it was decided that a logical, not arbitrary, approach would be used. It was also recognized, however, that extending to drainage divides could lead to unreasonably large WHP areas. Therefore, the decision was made to extend the WHP area to upland topographic breaks; where the ground slope changes from steeply ascending out of the valley to a more gentle upland slope.

The pumping rates for the two Cities were simulated in the delineation run by determining the maximum monthly production (for the period of 1988 to present) and adding the additional demand anticipated through 1998. The maximum month for Miamisburg was March 1992 when the daily average was 3.22 mgd. The maximum month for West Carrollton was July 1991 when the daily average was 2.02 mgd. Miamisburg anticipates the need for 0.5 mgd additional production through 1998 while West Carrollton does not anticipate additional production needs. Therefore, the delineation run production rates were set at 3.72 mgd and 2.02 mgd for Miamisburg and West Carrollton. The average daily production rates were distributed among the production wells given the proportion of time each well was on as determined from available data or client estimates.

When production rates for the other (non-city) pumping wells in the model were maintained at calibration (i.e., March 1990) levels.

Precipitation for southwestern Ohio averages about 40 inches per year (ODNR 1992c). Recharge to the aquifer system was set at 0.003 feet/day (about 13 inches per year) for agricultural type areas. For industrial/residential type areas the recharge to the aquifer system was set at 0.001 feet/day (about 4 inches per year).

The river stage data evaluated for the mentioned period-of-record indicated that March 1990 (calibration) river levels were about 1 foot higher than average. Therefore, the calibration river package was modified by subtracting 1 foot from the stage data and recalculating the conductance value for each river cell. This modified calibration package was used for the final delineation run.

Groundwater elevation data evaluated for the period-of-record also indicated that March 1990 levels were higher—about 2 feet—than average levels. Again, this was incorporated into the final run model packages by subtracting 2 feet from the upper and lower layer starting groundwater elevations for each cell. This impacts the elevations at the constant head and general head boundaries. The general head boundary conductance terms were also recalculated based upon the average groundwater level conditions.

APPENDIX B
POTENTIAL SOURCE INVENTORY

Table B-1
Known Contamination and Potential Sources of Groundwater Contamination Near West Carrollton
Miamisburg/West Carrollton Wellhead Protection

Map ID	Protection Area[1]	Site Name/Address	Type of Activity	Status	Pollution Threats[2]/Comments	Relative Hazard Ranking[3]	Data Source
1	WHPA	Miami Shores Wellfield Moraine ,OH 45439	County wellfield	Inactive	**Known VOC and metals groundwater contamination.** Contact: Rick Westerfield.	High	Ohio EPA
2	WHPA	Moraine Air Park, Inc. 3800 Clearview Drive Dayton, OH 45439	Airport	Active	2 USTs (gasoline). Other potential sources include metals, pesticides, herbicides, solvents, and surfactants.	Medium to high	BUSTR[4]
3	WHPA	Speedway #1165 747 E. Central Lane West Carrollton, OH 45449	Gasoline vendor	Active	4 USTs (gasoline).	Medium to high	BUSTR
4	WHPA	Superamerica #5607 657 E. Dixie Drive West Carrollton, OH 45449	Gasoline vendor	Active	4 USTs (3 gasoline, 1 diesel).	Medium to high	BUSTR
5	IMZ	District Warehouse (W. Carrollton Schools) 669 E. Central Lane West Carrollton, OH 45449	Unknown	Closed?	2 USTs (gasoline).	Medium to high	BUSTR
6	WHPA	Mark's Furniture Stripping & Refinishing 637 E. Dixie Drive West Carrollton, OH 45449	Furniture stripping	Active	Potential sources include acids, bases, metals, and solvents.	Medium to low	Windshield Survey[5]
7	WHPA	W C Mobil 106 S. Alexandersville Road West Carrollton, OH 45449	Gasoline vendor	Active	5 USTs (3 gasoline, 1 diesel, 1 used oil).	Medium to high	BUSTR
8	IMZ	Jet Products Company 535 E. Dixie Drive West Carrollton, OH 45449	Machine shop	Active	55 gallon drums noted outside. Potential sources include acids and bases, metals, petroleum products, surfactants, and solvents.	Medium	Windshield Survey
9	IMZ	West Carrollton Car Wash 518 E. Dixie Drive West Carrollton, OH 45449	Car wash	Active	Potential sources include chloride, metals, petroleum products, solvents, and surfactants.	Medium to low	Windshield Survey
10	IMZ	E&E Tool and Cutter Grinding Co. 536 E. Dixie Drive West Carrollton,OH 45449	Sharpening of machine tools	Active	Potential sources include solvents, acids, bases, and surfactants.	Medium to low	Windshield Survey
11	IMZ	West Carrollton 76 429 E. Dixie Drive West Carrollton, OH 45449	Gasoline vendor	Active	6 USTs (gasoline).	Medium to high	Windshield Survey, W. Carrollton Business Directory[6]
12	IMZ	Mylawn Garden Center 456 E. Dixie Drive West Carrollton, OH 45449	Agricultural	Active	Potential sources include pesticides, nitrates, and herbicides.	Medium to low	Windshield Survey
13	IMZ	Mats Equipment Company Inc. 51 Pierce West Carrollton, OH 45449	Machine repair shop	Active	Potential sources include acids, bases, metals, solvents, and surfactants.	Medium to low	Windshield Survey

Table B-1
Known Contamination and Potential Sources of Groundwater Contamination Near West Carrollton
Miamisburg/West Carrollton Wellhead Protection

Map ID	Protection Area[1]	Site Name/Address	Type of Activity	Status	Pollution Threats[2]/Comments	Relative Hazard Ranking[3]	Data Source
14	IMZ	Brewer Plumbing/Littrell Brothers 47 Pierce West Carrollton, OH 45449	Unknown	Active	Unknown.	Medium to low	West Carrollton Business Directory
15	WHPA	Eighty-Four Lumber Co. 14 S. Alexandersville Road West Carrollton, OH 45449	Hardware store	Active	Lumberyard, tires, unidentified dumping in area behind store. Potential sources include solvents, acids, bases, pesticides, herbicides, and surfactants.	Medium	Windshield Survey, Aerial Photos
16	WHPA	Action Rubber and Plastics 237 S. Alexandersville Road West Carrollton, OH 45449	Molding rubber products, seals, and gaskets	Active	Potential sources include sulfur, peroxides, solvents.	Medium	Windshield Survey
17	WHPA	Putnam Plastics 255 S. Alexandersville Road West Carrollton, OH 45449	Printing paper bags and pressure-sensitive seals	Active	Potential sources include water-soluble dyes.	Medium to low	Windshield Survey
18	WHPA	Findlay Industries 217 S. Alexandersville Road West Carrollton, OH 45449	Assembling vehicle seats and door panels	Active	Unknown.	Medium to low	Windshield Survey
19	WHPA	Kettering Medical Center 209 S. Alexandersville Road West Carrollton, OH 45449	Equipment Storage/Warehouse	Active	Unknown.	Low	W. Carrollton[7]
20	WHPA	United Parcel Service 225 S. Alexandersville Road West Carrollton, OH 45449	Mail Service	Active	Reported spill. 2 USTs (1 gasoline, 1 diesel), 4 removed USTs.	Medium to high	BUSTR

References:

1. WHPA: Wellhead protection area (5-year time-of-travel area). IMZ: Inner management zone (1-year time-of-travel area).
2. Noake, Kimberly D., 1989: Guide to Contamination Sources for Wellhead Protection, Massachusetts Department of Environmental Engineering, Division of Water Supply, One Winter Street, Boston, MA.
3. Hazard ranking developed from Ohio EPA Wellhead Protection Program (1992).
4. BUSTR: Bureau of Underground Storage Tank Regulations - Division of State Fire Marshall.
5. Windshield Survey by CH2M HILL personnel, August 1993.
6. West Carrollton Business Directory, City of West Carrollton, 1993.
7. Personal communication with Donald Hill, West Carrollton Service Director, November 1993.

APPENDIX C
SAMPLING & ANALYSIS PLAN

Appendix C
Sampling and Analysis Plan

Frequency

Figure C-1 presents the proposed schedule of water quality testing and water level measurements for wellfield monitoring. The schedule is planned as a cycle to be repeated every 2 years. If possible, the proposed new monitoring wells should be installed prior to beginning the formal wellfield monitoring program. If the new monitoring wells are not installed until after the groundwater monitoring plan is implemented, they should be sampled for those analyses conducted during the ''year-1/month-1'' sampling event (Figure C-1) and sampled thereafter in accordance with the remainder of the groundwater monitoring plan. After the ''year-1/month-1'' sampling is completed (including the new wells), the sampling plan should be reviewed and revised, if necessary, based upon the analytical results.

Figure C-2 shows the wells included in the groundwater sampling program and the wells for which quarterly groundwater level measurements are recommended. The sampling schedule does not include special sampling that may be conducted as part of other site- and contaminant-specific groundwater investigations.

Quarterly Water Level Surveys

Water level measurements are an important tool in monitoring wellfield performance. These data can be used to evaluate how the aquifer responds during different recharge and production conditions. The data can also be useful for determining groundwater gradients in different parts of the wellfield; the gradients can then be used to evaluate monitoring well placement. Because the aquifer system is hydraulically connected to local surface water bodies, both surface water and groundwater measurements are necessary to evaluate groundwater gradients near the wellfield.

Water levels should be measured at the following locations:

- Each monitoring well
- Proposed Great Miami River Staff Gage

Groundwater levels may change rapidly in response to barometric pressure changes, river stage changes, or precipitation events. To reduce the impact of these external factors, water level measurements should be collected within a 2- to 4-hour interval.

Water levels should be measured at least 12 hours after the pumping cycle of the production wells has been rotated. This should allow the groundwater surface to equilibrate in response to a change in pumping. The production wells that are operating at the time of the water level survey should be noted.

Year	One												Two											
Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Water Level	●			●			●			●			●			●			●			●		
VOC Analyses	■			■			■			■			■			■			■			■		
General Chemistry Analyses	■												■											
Metals Analyses	■																							

Notes:

1) ● New locations A-E, Great Miami River Staff Gauge.
   ■ New locations A-E.
2) General chemistry analysis includes calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, iron, manganese, nitrate, COD, total dissolved solids, pH, and specific conductance.
3) Metal analysis includes arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc.
4) The sampling cycle is repeated every 2 years.

Figure C-1
Proposed Sampling Schedule
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

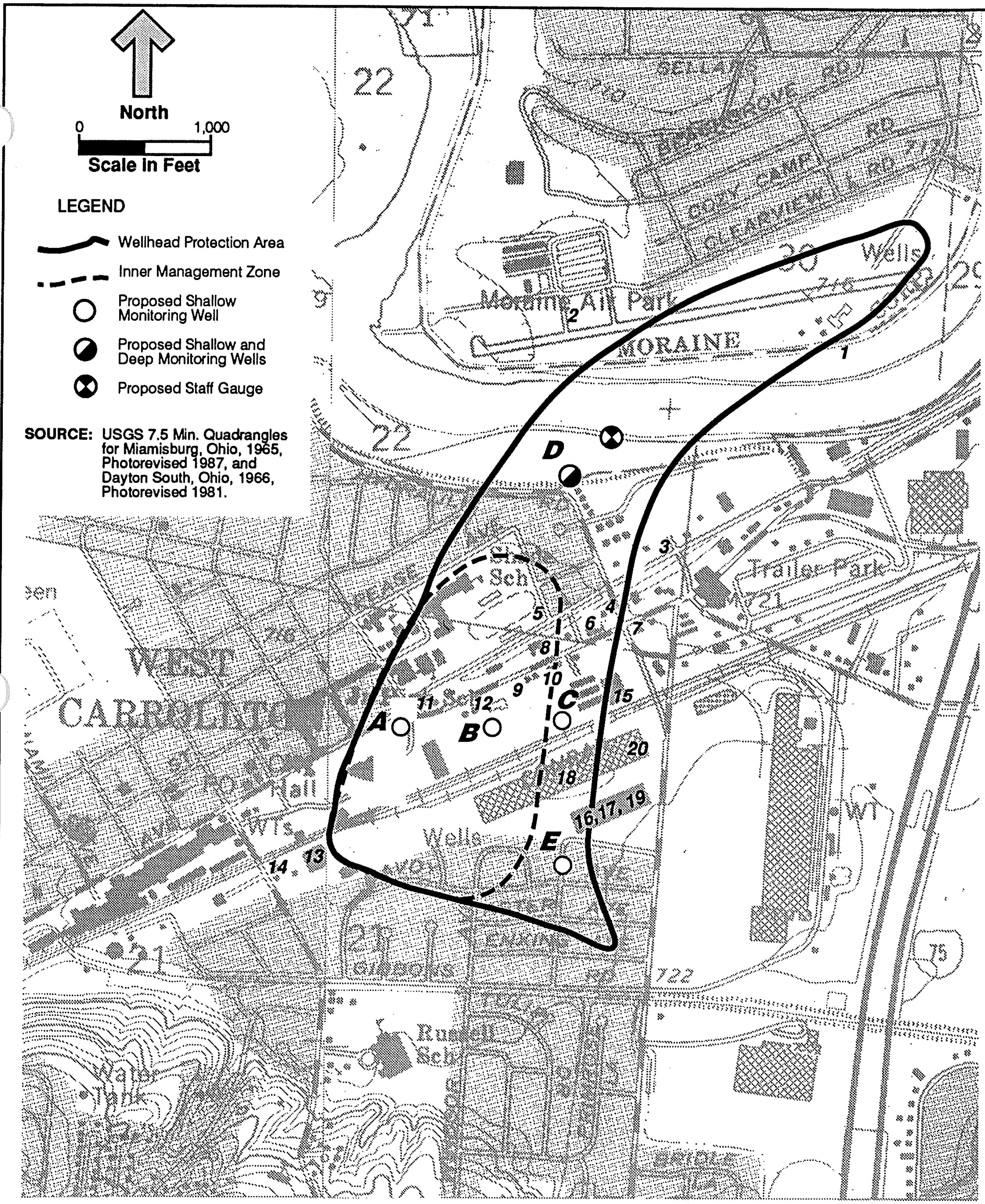


Figure C-2
Proposed Water Level Measuring Points and Sampling Locations
Miamisburg/West Carrollton Wellhead Protection

An electronic water level indicator should be used to measure water levels in the noted wells. The measurement of the depth of groundwater from the top of the PVC riser at the marked point should be recorded to the nearest 0.01 foot. The date and time of the measurement should be noted on a form such as that shown in Figure C-3.

Sampling Procedures

The goal of groundwater sampling is to collect samples that are representative of the water present in the water-bearing zone. Each well should be purged until the well is flushed of standing water and contains fresh water from the aquifer.

Monitoring wells can be purged and sampled using either a dedicated (permanently installed) sampling system or a non-dedicated sampling system such as a portable pump or bailer. If the wells are purged and sampled by bailing, the bailer should be lowered into the water column only as far as necessary to fully submerge the bailer. If a portable submersible pump is used, lower the pump into the well only far enough so that the intake of the pump is submerged during pump operation.

The City may consider purchasing dedicated sampling pumps to permanently install in each monitoring well. Dedicated systems decrease the potential for cross contamination between wells, and also decrease the labor costs required to sample the monitoring well network. For example, a dedicated sampling system would cost about $2,000 per well for a submersible pump system. Although the initial costs of installing a dedicated sampling system are high, savings in labor costs over several sampling events generally will justify the initial cost.

Well Purging

The depth to water in a well should be measured to determine the volume of water in the casing and then recorded on a form similar to that shown in Figure C-4. At least three casing volumes of water should be removed prior to sampling to remove stagnant water from the monitoring wells. Parameters such as pH, temperature, turbidity, and electrical conductivity should be measured and recorded after each casing volume is removed until purge water has stabilized.

Sample Collection and Preservation

The groundwater sample should be collected immediately after purging. Samples can be collected using a bailer or a pump. If a pump is used for sampling, lower the discharge rate to reduce splashing and aeration during sampling.

The water should be transferred from the bailer or discharge line directly into the container that has been specifically prepared for that constituent or set of constituents (preserved bottles should be obtained from the analytical laboratory). When collecting samples for VOC analyses, pour the water slowly down the inside wall of the container to minimize aeration. Determine that air bubbles are not present in the sample by

GLO35147.WP.RP Fig c-3 VERT 9-17-93mms/skb

City of West Carrollton
QUARTERLY WATER LEVEL SURVEY

Date:
Personnel:
Weather:

GROUNDWATER				
Measuring Point	Time	Depth to Water (A)	Measuring Point Elevation (B)	Ground Water Elevation (B-A)

SURFACE WATER			
Location	Water Elevation	Measuring Point Elevation	Water Level Elevation

REMARKS:

Figure C-3
Proposed Water Level Data Collection Form
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

City of West Carrollton
GROUNDWATER SAMPLING RECORD

Well Number:	Date:
Personnel:	
Weather:	
Beginning Time:	Ending Time:

PURGE VOLUME INFORMATION	
(1) Total Depth of Well (ft):	(2) Depth to Water (ft):
(3) Height of Water in Well [(1)-(2)]:	(4) One Purge Volume [see NOTE]:

FIELD PARAMETER DATA

Purge Volume	Time	pH	Temperature	Turbidity	Electrical Conductivity
1					
2					
3					
4					
5					

EQUIPMENT AND METHOD INFORMATION	
Purging Equipment:	
Purging Rate:	
Sample Withdrawal Method:	
Field Parameter Instruments:	
Sample Duplicated (Y/N)?:	Duplicate Sample ID

SAMPLE INFORMATION

Sample ID	Analysis	Time	Container Type and Volume	Filtered?	Preservative

REMARKS:

NOTE:
One purge volume (gallons) for a 2-inch well: (Height of Water in Well) x 0.16 gal/ft
One purge volume (gallons) for a 4-inch well: (Height of Water in Well) x 0.65 gal/ft
One purge volume (gallons) for a 6-inch well: (Height of Water in Well) x 1.5 gal/ft
One purge volume (gallons) for a 12-inch well: (Height of Water in Well) x 5.9 gal/ft

Figure C-4
Proposed Groundwater Sample Collection Form
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

capping the container, inverting it, and tapping it firmly against the sampler's palm. Table C-1 summarizes sample container types, filtering requirements, preservation, and holding times.

Chain-of-Custody

A chain-of-custody form is used to record the transfer of sample possession and documents the laboratory analyses requested (Figure C-5). Custody documentation is necessary to maintain the legal defensibility of the data. Each time the sample containers change custody, both parties involved should sign and date the chain-of-custody form. Custody of a sample is defined as being:

- In the possession of an individual
- Within view of an individual after being in the physical possession of the individual
- Secured by an individual who has possession of it
- In a designated secure area

Sample Analysis

Table C-1 includes the recommended analyses for samples collected during wellfield protection monitoring. Sample analyses may be performed at a commercial laboratory or at the water treatment plant laboratory, if the treatment plant laboratory has the appropriate equipment.

When conducting the annual sampling event, 10 percent of the total samples collected should be duplicated as a quality assurance check on the reproducibility of the laboratory results. If a sample is duplicated, a separate sample identifier is used and noted in the sample collection record so the duplication is not obvious to the laboratory. Duplicate samples should be sent to either the same laboratory as the regular samples or to a second laboratory.

Data Review

After the results are received from the laboratory, the data should be entered into the groundwater quality tables (see Data Management section below) for further evaluation. Changes in concentration of constituents, trends in increasing or decreasing concentrations, or variance from the range of background values may require action by the City. Depending on the degree and nature of the observed groundwater quality changes over time, actions described in the Contingency Plans (Section 5 of the main report) may be activated.

Table C-1
Sample Preservation, Container, and Holding Time Requirements
Miamisburg/West Carrollton Wellhead Protection

Analysis	Container[1]	Quantity[2]	Preservative[3]	Filtered	Maximum Holding Time	Recommended Analytical Method (U.S. EPA)
Alkalinity	P or G	250 mL	4°C	No	14 days	310.1
Chloride	P or G	250 mL	4°C	No	28 days	325.1
COD	P or G	100 mL	4°C, H_2SO_4 to pH <2	No	28 days	410.1
Nitrate	P or G	100 mL	4°C, H_2SO_4 to pH<2	No	28 days	352.1
pH	P or G	100 mL	4°C	No	field	150.1
Metals	P	1 L	4°C,HNO_3 to pH <2	Yes	6 months	200.7
Specific Conductance	P or G	500 mL	4°C	No	field	120.1
Sulfate	P or G	500 mL	4°C	No	28 days	375.3
Total Dissolved Solids	P or G	250 mL	4°C	No	7 days	160.1
Volatile Organic Compounds	G	3-40 mL	4°C HCl to pH<2	No	14 days	524.2

[1]P = polyethylene
G = glass
[2]mL = milliliters
L = liters
[3]H_2SO_4 = Sulfuric Acid
HNO_3 = Nitric Acid
HCl = Hydrochloric Acid
°C = degrees Celcius

CHAIN OF CUSTODY RECORD

PROJECT MANAGER					COPY TO:	# OF CONTAINERS	ANALYSES REQUESTED	LAB ID	FOR LAB USE ONLY LAB# LAB# PROJECT NO. ACK / VERIFIED QUOTE# / B$ NO. OF SAMP / PG / OF
REQUESTED COMP. DATE					SAMPLING REQUIREMENTS SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____				
STA NO.	DATE	TIME	COMP	GRAB	SOIL	SAMPLE DESCRIPTIONS (12 CHARACTERS)			REMARKS

SAMPLED BY AND TITLE	DATE/TIME	RELINQUISHED BY	DATE/TIME
RECEIVED BY:	DATE/TIME	RELINQUISHED BY:	DATE/TIME
RECEIVED BY:	DATE/TIME	RELINQUISHED BY:	DATE/TIME
RECEIVED BY LAB:	DATE/TIME	SAMPLE SHIPPED VIA UPS BUS FED-EX HAND OTHER ____	AIR BILL#
REMARKS			

HAZWRAP/NEESA Y N	
QC LEVEL 1 2 3	
COC	ICE
ANA REQ	TEMP
CUST SEAL	Ph
SAMPLE COND.	
ENTERED INTO LIMS ____	COC REVIEWED ____

Figure C-5
Proposed Chain of Custody Record
Miamisburg/West Carrollton Wellhead Protection

CH2M HILL

A potentiometric surface map for both the shallow and deep aquifers should be prepared with each quarterly set of groundwater elevations. These maps should note those production wells that were active during the water level survey.

Data Management

Groundwater Quality Data

The water level and water quality data should be maintained in a series of spreadsheets where the data on each spreadsheet is of a similar nature. For example, VOC data could be kept on one spreadsheet, metals on another, and general chemical data on a third. By splitting the data, the size of each spreadsheet should be manageable and should allow easy evaluation. A spreadsheet software program such as Microsoft EXCEL allows data from multiple spreadsheets to be easily combined into a master spreadsheet.

Information to be maintained in the spreadsheets includes date of sample collection (enter dates as numerical values to facilitate plotting), the analytical laboratory, and the analytical results.

Water Level Data

Groundwater level measurements, surface water level measurements, and calculated elevations should be maintained in an additional spreadsheet file. As with the water quality data, each measurement should be associated with a specific date (entered as a numerical value) that will allow data to be plotted versus time.

Data Security

Original copies of the laboratory data and the field logs should be filed in an organized manner at the water treatment plant. As a backup, photocopies of this information should be filed in another location or at an outside data storage facility. Computer files should be stored on floppy disks rather than on a computer hard disk to minimize the risk of data loss by hard disk failure. A backup set of floppy disks should also be stored in a remote location to reduce the risk of data loss. Backup disks should be updated on a regular schedule. All computer files should be password-protected to prevent data tampering by unauthorized personnel.

APPENDIX D
EXCERPTS FROM CITY'S WATER SUPPLY CONTINGENCY PLAN

CONTINGENCY PLAN

FOR

EMERGENCY OPERATIONS FOR THE

CITY OF WEST CARROLLTON, OHIO

WATER SYSTEM

Prepared by:

THE WEST CARROLLTON SERVICE DEPARTMENT

ASSISTED BY PAMELA S. JONES,

M.A. IN PUBLIC ADMINISTRATION

AUGUST 1993

INTRODUCTION

This Contingency Plan was prepared in accordance with the Rules and Regulations of the Ohio Environmental Protection Agency, Office of Public Water Supply, Section 3745-85.

It is the purpose of this Plan to describe the characteristics of natural and man made disasters and their impact on the City of West Carrollton's water utility operations and under disaster conditions, who does what, when, with what existing resources.

This Plan shall be reviewed annually and updated to ensure all information contained herein is applicable to the current equipment and operating conditions.

EMERGENCY RESPONSE PROGRAM

The development of an Emergency Response Program (ERP) is necessary to minimize disaster effects by ensuring effective continued operation of the water system under emergency conditions. The objectives of an ERP can be achieved only with trained personnel and with sufficient emergency equipment and materials.

Emergency Funds:

Currently there is an emergency contingency fund (4-000-98) in the water utility fund. In addition, our bond agency for water works improvement bonds contains a water trust account (4-000-68). These surplus funds could be used for emergency purchases. The following actions must occur before these funds can be expended.

1. The City Council would have to appropriate monies from these funds for emergency purchases.

2. After the monies have been appropriated, the City Manager would then authorize purchases below $5000 from the account.

3. If amounts for individual items needed is above $5000, City Council would be required to approve expenditures before purchases. In the case of an emergency condition, this will probably require a special session of City Council.

ORGANIZATION'S EMERGENCY PROCEDURES

If an emergency was to occur within the water system, it could be caused by a problem which affected only the water system or it could be caused by a problem which affects other aspects of the City as well. If the major problem affects only the water system, Page 15 shows the order of responsibility for correcting the situation. However, if the City is affected by an emergency which affects more than the water system, this document shall be worked within the City's disaster plan and adapted accordingly. See Page 14.

Emergency Operation Center:

In the event of an emergency, the City has designated two E.O.C.'s.

1. West Carrollton Civic Center, 300 E. Central Avenue, (primary center).
2. Fire Station #2, 1700 S. Alex Road (secondary center).

All official decisions and actions will come from the E.O.C. The City Manager has the responsibility for making all decisions; however, in the initial onset of an emergency, the Service Director must make immediate decisions which will limit the effects of the disaster.

Emergency Purchases:

The department heads can authorize expenditures up to $500 without the City Manager's approval. The following procedure is followed for emergency purchases:

> In the case of an actual emergency and with the City Manager's permission, if possible, a department head may purchase any supplies or services whose immediate procurement is essential to prevent delays in work which may vitally affect the life, health, or safety of the City of West Carrollton's citizens. For a recorded explanation, the department head shall send to accounts payable a purchase order, a copy of the delivery record, and a brief report of the circumstances of the emergency.

Notification:

The City Manager is responsible for notifying the Mayor and Council members and all Federal and State officials who should be aware of the situation. The flow chart on Page 16 (issued by Ohio EPA) shows the necessary steps in notification.

PUBLIC NOTIFICATION

Informing the general public is a vital operation in emergency water situations. By keeping the citizens informed of the problems, the steps being taken to correct them, and the part they may play in the solution, the City can better protect the health and safety of the water consumers and provide a speedier solution. It is therefore essential that every customer understand the situation and comply with the City's requests, such as limiting water unsafe or boiling water before usage.

Methods:

The basic methods which may be used for immediate notification include:

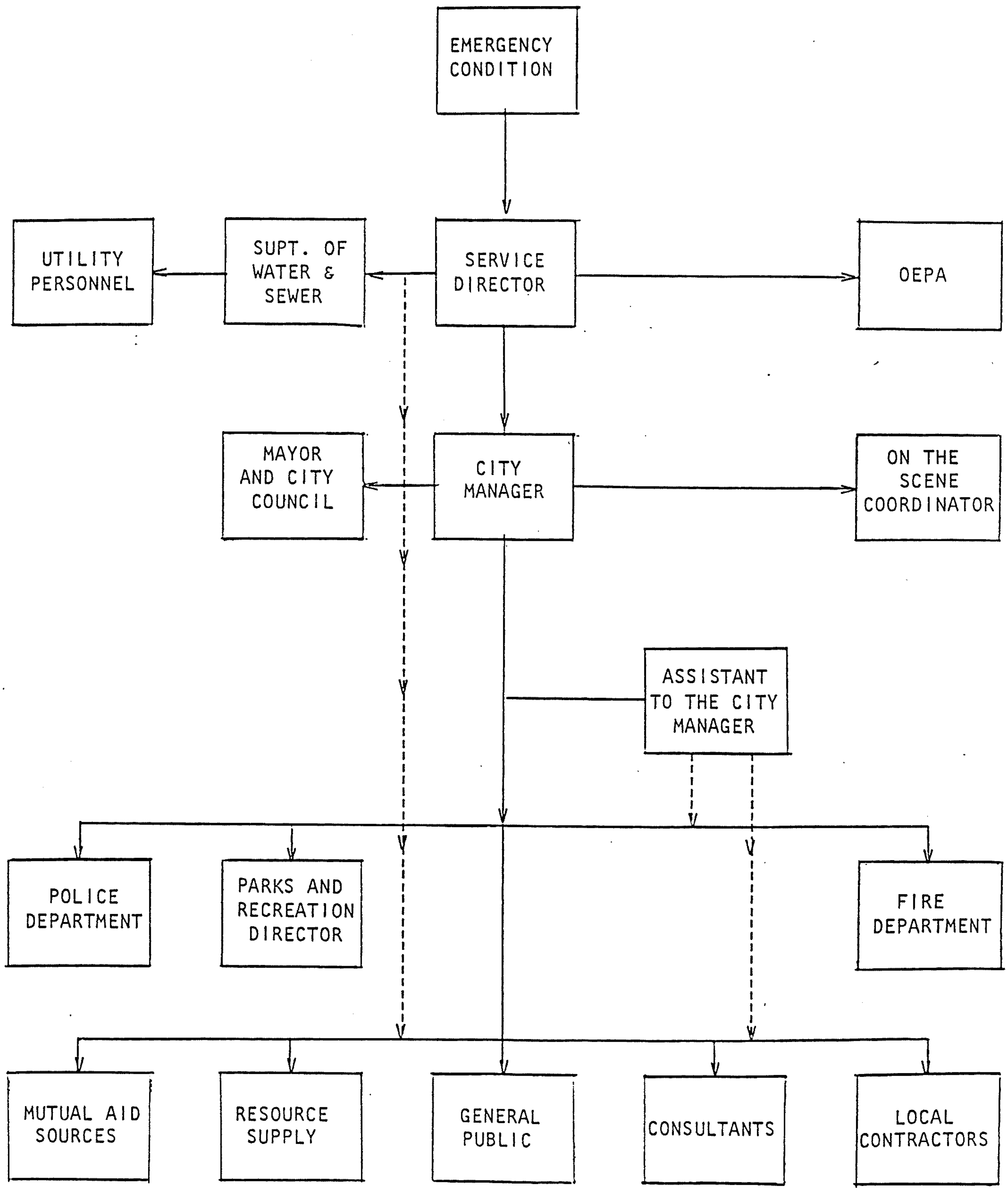
1. Cable Television Emergency Alert.
2. Broadcast Notices.
3. Newspaper Notification.

If the emergency is confined to a small area, phone calls could also be appropriate. If time is not of an essence, mail notices or the weekly newspapers are also available options.

However, during emergency situations, time is limited and the largest number of people can be notified through the mass media. The Cable Council maintains an emergency alert system which over-rides the audio portion of the television broadcast and allows a person to broadcast to all cable viewers. There are two daily papers, three TV stations, and seven radio stations which can be notified.

The City Manager will act as the Public Information Officer. All media contact will be conducted through him or his designated assistant. The media should be given all essential information such as:

Who: The Name of System.
What: The Reason Behind the Notice.
When: The Effective Date or Time.
Emergency: A Brief Description of the Emergency.
Health Significance: A Discussion of the Possible Effect.
Precautions: Any Actions the Consumers Should Take.
Efforts being made to correct the problem: On Pages 5, 6, and 7 are samples of news releases.



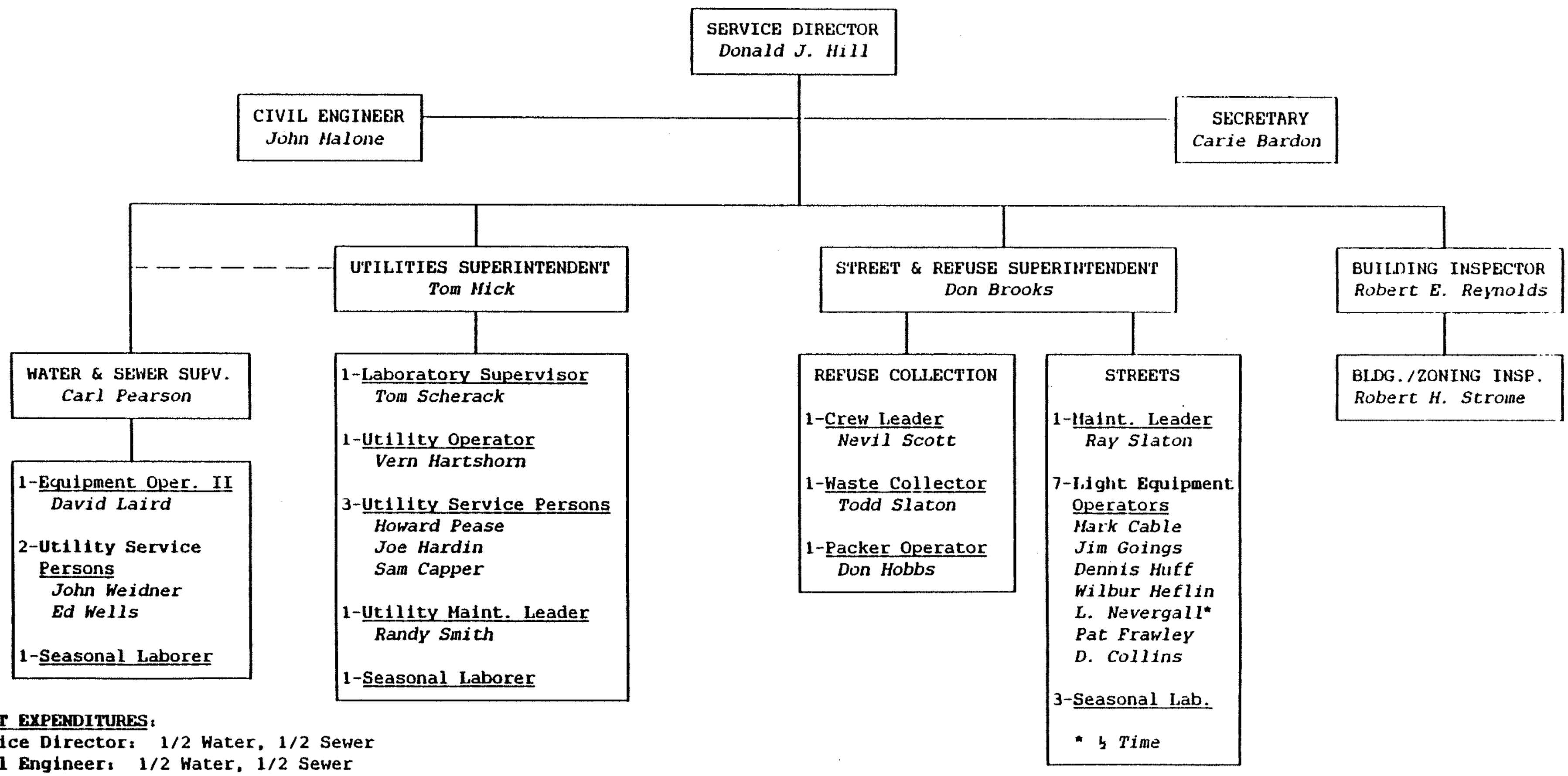
CITY OF WEST CARROLLTON

WATER SUPPLY SYSTEM

EMERGENCY CONDITION FLOW DIAGRAM

CITY OF WEST CARROLLTON

Service Department



BUDGET EXPENDITURES:
Service Director: 1/2 Water, 1/2 Sewer
Civil Engineer: 1/2 Water, 1/2 Sewer
Secretary: Building Inspection
Utilities Superintendent: Sewer
Street & Refuse Superintendent: Streets
Utility Maintenance Leader: 1/2 Water, 1/2 Sewer

Revised 7/15/92

<u>RESPONSE A</u>:

To be implemented when controls and/or parts of the system are without power. May be short or long term.

Monitor tank levels closely - Skyview Reservoir can only supply 24 hours of normal use without well pump operation. Water can be released from High Service to Low Service area as required. This response is adequate for 24 hours only if power is unavailable at well field. If power <u>is</u> available at well field, manually start and stop pumps to provide water to Skyview Reservoir during the emergency. When power is available to the Skyview pumps (but without automatic controls) they may be manually controlled while monitoring the Imperial Reservoir.

<u>RESPONSE B</u>:

To be used when total power failures or other complications prevent use of well pumps or the Skyview pumps. Monitor tank levels continuously and open the valves as required from Montgomery and/or Miamisburg water systems. Water pressures in the system must be monitored closely to prevent over pressurization.

<u>RESPONSE C</u>:

To be used where contamination is a threat. Notify residents of the dangers at once. Isolate contaminated areas. Flow hydrants in contaminated areas to expel contaminated water where possible. Valve off area to prevent spread of contaminants to other areas. Add HTH or other sanitizers when required. In extreme cases it may be necessary to haul water for residential use. See appropriate notes on this operation.

EMERGENCY ALTERNATE WATER SOURCES

ALTERNATE WATER SOURCES

The City of West Carrollton has a number of alternatives available for water supply during emergency conditions. They vary from hauling water from another location to direct connections with Montgomery County, Ohio and Miamisburg, Ohio Water Systems. The following alternatives were reviewed and rated:

First Choice	-	Montgomery County, Ohio - Direct Connection
Second Choice	-	City of Miamisburg, Ohio - Direct Connection
Third Choice	-	Water Hauling

First Choice (A):

The first choice for an alternate source of water during emergency conditions is the Montgomery County Water System. There are two (2) tie connections between West Carrollton and Montgomery County water systems. The valves are located on:

(1) Alex-Bell Road at Interstate 75, and
(2) Sidneywood Drive at Water Tower Lane in Meter Pit.

All of the tie connections are eight (8) inch and are maintained by the City of West Carrollton. (see pages 25 and 26 for details).

To obtain water from the Montgomery County System during emergency conditions, the following steps should be followed:

1. Notify the Montgomery county Sanitary Department concerning the emergency condition.

Richard Brinkman, Superintendent Water Distribution	Office 496-7000
After Hours (night) Dispatch	Office 496-7004

2. Open tie valves as required. The City of West Carrollton is allowed to open tie valves. Montgomery County should be notified immediately when valves are opened and closed.

On different occasions the Montgomery County Water System has supplied West Carrollton with water with no serious problems encountered. This has been done without a formal written agreement on an as needed basis.

Montgomery County obtains their water supply from wells and disinfects according to Ohio EPA rules and regulations. Therefore, additional disinfection should not be required. Chlorine residuals should be checked daily at the extremities of the system to insure proper disinfection.

Hydraulically, Montgomery County can supply the City of West Carrollton's Low and High Service Areas with limited service. West Carrollton is fortunate to be tied into two separate systems for emergency needs. Therefore, adequate quantities of potable water appear to be available.

Second Choice (B):

The second choice for an alternate source of water during emergency conditions is the City of Miamisburg Water System.

The valves are located at:

1) King Richard Parkway and Robinhood Drive, and
2) Sherwood Forest Drive, south of Elm Street.
3) Robinhood Drive and Royal Archer Drive.
4) Wilson Park Drive and Tall Timbers.
5) End of Beau View.

These valves are all six inch (6") and are maintained by West Carrollton. (see page 28 for details).

To obtain water from Miamisburg the following steps should be taken:

1. Notify the City of Miamisburg immediately concerning the emergency condition.

Claude Berry, Water and Sewer Superintendent	Office 866-3303
After Hours (night)	Police 866-3344 (ask for dispatch in this emergency)

Opening these valves should provide adequate water for the High Service System. Pressure should be monitored closely to prevent over pressurization. Since no connection to Miamisburg exists to Low Service, water must be periodically valved to the low level manually.

Third Choice (C):

The third method of providing water would be by truck transport. We could haul from the City of Dayton during emergency conditions. The following steps should be taken:

1) Notify the City of Dayton Office of Water Utility Director — Office 443-3725

   After Hours (night) — 443-4905

2) Select points and/or hydrants where water may be hauled from.

3) Coordinate loading, disinfection and distribution of the water with all entities involved.

4) Distribute the water to the public. Notify the public that water will be distributed and that all containers must be cleaned and sanitized. Distribution points and times should be posted at the Emergency Operations Centers as well as general news releases to avoid conjecture and confusion.

Utilizing what is termed Level 2 Service, potable water for human consumption and general sanitation is estimated at 25 gallon per day/ per person. At the estimated population of 12,500 people, a total of .312 mgd will be required to meet this level of service. This assumes that the entire system is incapacitated. Again, each service area will need to be evaluated to determine proper course of action to take during an emergency condition.

WATER HAULING PROCEDURE

Water to be hauled must be taken from a municipal water supply or from a supply approved by the Ohio EPA or Ohio Department of Health. A negligent or misinformed water hauler could cause serious illness among customers if the water were taken from a contaminated source.

The following list are items that are important to remember concerning the proper use of water hauling equipment:

1) Filling points must be protected against contamination when not in use.

2) Tanks, pipes, hoses, valves, and fittings must be constructed of non-corrosive and non-toxic materials. Their surfaces must be made smooth for easy cleaning and sanitizing.

3) Inlet opening must be kept closed except when filling or cleaning.

4) Flexible delivery pipe, connectors and ends are to be protected at all times.

5) Trucks, tanks, and all appurtenances are to be kept clean at all times.

6) All water contact surfaces including the tank must never have been used to transport or handle toxic or noxious substances.

7) The tank and appurtenances shall be used to transport or handle edible products only.

Hauling equipment must be cleaned and sanitized:

1) Before being used for the first time or after a period of non-use.

2) After any portion of the equipment has been dismantled or repaired.

3) After known errors in sanitary procedures by the operator.

4) At least weekly.

Equipment should be cleaned by scrubbing with normal cleaning aids, being careful to flush away any foreign material.

Equipment can be sanitized by exposing it to:

1) Steam at 170°F for 15 minutes, or
2) Steam at 200°F for 5 minutes, or
3) Chlorine, iodine or other approved sanitizers at recommended strength and contact time.

Application of chemical sanitizer can be done by fogging, spraying, jet flow or any other procedure approved by the Ohio EPA or Ohio Department of Health.

For disinfection purposes, dose each load with enough chlorine to produce a free residual chlorine of 0.4 mg/l. The hauler should have or be provided with test kits to check the chlorine residual in a manner acceptable to the Ohio EPA. The chlorine residual should be checked by City personnel before distribution to the general public. This will ensure proper disinfection has been accomplished.

There are a number of milk haulers in the Dayton area. Contact the following organization to obtain assistance in contacting owners of stainless steel tankers:

Milk Marketing, Inc. 135 S. Perry Street Dayton, OH 45402		223-0614
Robert L. Moran Division Manager	Home	433-7540
Gary Michael Supervisor of Field Services	Home	1-492-7121

<u>SUMMARY</u>

During an emergency condition alternate sources of water supply are a very important emergency resource. Should the use of these alternate sources become necessary, the City should evaluate how best to utilize these sources of water supply.

Water hauling should be utilized as a last resort.

As can be seen, there are a number of options available to the City when selecting an alternate water supply source during an emergency condition. The emergency condition and the quantity of water required will dictate how each source is ultimately used.

It should be noted that the Great Miami River was not overlooked as an alternate source of water supply. This important source of water could be used for fire defense proposed. Because of the varying water quality characteristics involved with a surface supply, such as the Great Miami River, it would require extensive disinfection and monitoring to ensure a safe potable water for human consumption plus mobile pumping capacity to obtain sufficient quantity. Therefore, this was not considered for an alternate potable supply.

C

CONTAMINATION OF SUPPLY

System Component	Response
Wells	1. Contact Ohio EPA to survey individual wells for contamination. 2. Isolate any well which is contaminated and take appropriate action to restore acceptable parameters. 3. Notify general public of situation and what steps must be taken before water can be utilized for human consumption, follow Ohio EPA's instructions.
Low Service Area and High Service Area	1. Survey tanks for possible contamination; look for possible vandalism and evidence of type of contamination. 2. Notify Ohio EPA for assistance. 3. Isolate contaminated tank(s) from system. 4. Follow Ohio EPA's instruction for decontamination of tank. 5. Following Ohio EPA's instructions, notify general public of situation and what steps to take before water can be utilized for human consumption. 6. Provide alternate source of potable water. Will probably require water hauling and distribution.
Distribution System	1. Survey entire system for extent of contamination. 2. Survey system for possible source of contamination; inspect any backflow devices in the system for proper operation. 3. Isolate areas found to be contaminated from those areas not affected. 4. Contact Ohio EPA for assistance. 5. Notify general public of situation and what steps to take before water can be utilized for human consumption. 6. Provide alternate source of potable water as required. Will probably require water hauling and distribution of water for human consumption. Notify public of same.

CONTAMINATION OF SUPPLY

System Component	Response
Distribution System (con't)	7. Follow Ohio EPA's instructions for decontamination of system. 8. Notify general public when water system has been declared safe for human consumption.
Personnel	1. Educate personnel how to respond to this particular emergency. 2. Assign personnel to carry out tasks at each system component. 3. Maintain close contact with personnel to determine proper course of action.

EMERGENCY RESPONSE

NUCLEAR ACCIDENT OR MALICIOUS CONTAMINATION

During this type of emergency, radiation exposure is very critical. Mound Laboratory in Miamisburg has the expertise to monitor and advise possible actions. They should be utilized to the fullest extent possible in this situation.

Radiation contamination or "spill" should be isolated as early as possible. This situation cannot be handled at the local level without expert advise. This must be solicited immediately.

The well and reservoirs would be critical facilities. Any penetration of radioactive substances into the aquifer at or near the well field would be distributed to the low level service area within several hours and would in turn be forced into the low service reservoir. It would then be picked up by the booster pumps and distributed to the high service system. Speedy monitoring and immediate expert advice is imperative.

Extreme martial security and rigid transportation safeguards are the only preventive measures that seem applicable.

RESPONSE TO EMERGENCY TO PROTECT AS MUCH OF WATER SOURCE AS POSSIBLE

Monitor all components of the system immediately when contamination is suspected. When area is isolated dispose of contaminated water or equipment according to instructions from Mound Laboratory personnel.

WELL FIELD

1. Monitor each well for radioactivity.
2. Isolate contaminated wells. Be prepared to provide discharge from contaminated wells to an area for safe disposal.
3. Solicit expert advice (Mound Laboratory or other agency) and carry out instructions without delay.

CHEMICAL TREATMENT

Normal maintenance - probably not critical.

LOW SERVICE RESERVOIR

If this reservoir should become contaminated, water may be removed thru the drain vault after it is determined that it will not pose a threat to Miami Paper's property. The valve at the base of the reservoir can be closed to prevent contamination of the entire low service system.

HIGH SERVICE RESERVOIR

If this reservoir should become contaminated, water may be removed at a fire hydrant in the fenced area or released thru the drain valve after it is determined that it will not pose a problem to the Lyons Farm to the north.

DISTRIBUTION SYSTEM

If contaminated, hydrants may be opened at such locations as necessary to expel pollution to storm drains, after it is determined that this operation will not cause other problems in the storm sewers. Close valves in the system as necessary to pocket and isolate the contamination until it can be removed.

PERSONNEL

The danger connected with this material cannot be overstressed. Expert advise and supervision must be available before any major action can be taken. Expose personnel only as absolutely necessary and provide protective clothing as required. Be aware of radiation systems of exposure.

EMERGENCY RESPONSE

RAILROAD DERAILMENT

A railroad derailment is a possibility in the City and the well fields are located directly adjacent to the railroad.

Effects of Emergency on System:

- A railroad derailment could spread railcars into the area housing, the well fields, and could cause possible contamination, knocking out the electrical supply, and destroy pumping and chemical equipment.

Procedures for Responding:

- Follow steps in Response A, if electrical power supply is destroyed.

- Follow steps in Response C, if contamination exists.

Special Consideration:

- Quick response by railroad to remove debris is necessary.

- Quick response also required by Fire Department to prevent fire and contamination from any debris or spillage.

- Quick response by water personnel and/or DP&L to restore electrical power as required.

EMERGENCY RESPONSE

CONTAMINATION

Accidental or deliberate contamination could result from various causes and would create a serious health hazard to our water users.

<u>Effect of Emergency on System</u>:

- Well field or reservoirs are the most vulnerable components for possible contamination. All affected areas must be valved off of the system so as to prevent contamination of the rest of the supply.

<u>Procedures for Responding</u>:

- Involve Police and public immediately.

- Follow steps in Response C.

<u>Special Consideration</u>:

- Special attention must be given to public awareness and providing relief for any problems the contaminated water may have caused.

EMERGENCY RESPONSE

EXTENDED PERIODS OF DROUGHT

During an extended period of drought, the City would take the steps listed below:

1) Increase the drawdown testing on the wells to once a week or more frequently in order to monitor the water table levels very closely.

2) Notify and keep the West Carrollton residents informed of the severity of the drought situation and its effect on the water supply.

3) Educate all consumers about voluntary or mandatory water conservation measures.

4) Work closely with commercial and industrial water customers in order to minimize their consumption of water.

5) Use the local newspaper and the City of West Carrollton Newsletter to keep the residents up-to-date on the status of the water supply situation.

6) Consider the use of tie-ins we now have with the Montgomery County/Dayton and Miamisburg water systems. These connections are already in place.

7) Evaluate possible use of "water saving kits" for consumers.

Depending on the severity of the drought situation, water use restrictions would be decided by the City at that time. Being a City of smaller size we can work closely with the residents in confronting an extended period of drought and City Council can have an immediate reaction to address emergency conditions.