Data Gathering Report
Trenton Area Storm Water Management Project
Butler County, Ohio

Prepared for:
Butler County Storm Water District
Hamilton, Ohio

July 27, 2005

July 27, 2005 O.1.1.CN2004074R01

Mr. Eric J. Pottenger, PE
Butler County Storm Water District
1921 Fairgrove Avenue
Hamilton, Ohio 45011

Re: Data Gathering Report
Trenton Area Storm Water Management Project
Butler County, Ohio

Dear Mr. Pottenger:

In February 2005, the consultant team of Fuller, Mossbarger, Scott and May Engineers, Inc. (FMSM); XCG Consultants, Inc. (XCG); and Eagon and Associates was retained to perform a watershed study and prepare a storm water management plan for a watershed located west of the City of Trenton, in Butler County, Ohio. The first stage of those efforts included data gathering and a preliminary assessment of conditions in the watershed. The project team has completed this data gathering stage of the project and enclosed is a report discussing the approach and findings from those efforts.

On behalf of the FMSM Project Team, we appreciate the opportunity to work with the Butler County Storm Water District on this project and to assist with storm water management efforts in the area. Please review the enclosed report and contact FMSM with any questions or comments.

Sincerely,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Erman L. Caudill, PE, CFM
Senior Project Engineer

James L. Rozelle, PE, PS
Senior Water Resources Engineer

/cmp

cc: XCG Consultants, Inc.
Eagon and Associates

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1. Introduction

The Butler County Engineer's Office retained the consultant team of Fuller, Mossbarger, Scott and May Engineers, Inc. (FMSM), XCG Consultants (XCG), and Eagon and Associates (EAGON) to perform a watershed study and prepare a storm water management plan for a developing watershed located on the west side of the City of Trenton in Wayne and St. Clair Townships of Butler County, Ohio. The study area is illustrated in the map provided in Appendix A. The majority of the area is underlain by the Lower Great Miami Valley Aquifer system, which serves as the primary potable water source for industrial and residential users in the area. There is concern that future development will adversely impact flooding conditions along Jackson Ditch and increase pollutant loading into the aquifer. The purpose of this study is to evaluate these impacts and develop a master plan of best management practices (BMP) to abate these impacts.

The watershed study is being performed in three-phases. The first phase is to gather data and collect information to evaluate the current conditions in the watershed. The second phase is to develop water quantity and quality models that will be used to evaluate the impacts of development and the effectiveness of proposed BMP elements. The third phase is development of the storm water master plan.

This report documents the work performed by the project team during the data gathering phase of the project. Included in this report is an overview of the conditions in the watershed based on field reconnaissance data, a web-based literature search, and meetings and interviews with local agencies and stakeholders. Components of a project geographic information system that was developed during this phase are discussed. Finally, recommendations for the modeling phase are provided based on findings resulting from the data gathering effort.

2. Data Gathering

Methods employed in the data collection included: field reconnaissance, web-based literature research and review, and meetings and interviews with federal, state, and local officials and stakeholders. Relevant reports, correspondence, and data obtained during the research are cited in the bibliography in Appendix B and much of that data is provided in digital format in Appendix C.

2.1. Field Reconnaissance

Members of the project team have made several site visits to the area to observe watershed conditions to support modeling efforts. Significant features and findings were logged using hand-held GPS units and digital photography. This data was compiled digitally and is included in the project GIS.

For flood modeling purposes, field reconnaissance efforts were focused primarily on the hydraulic structures located along the outlined portion of the Jackson Ditch drainage system illustrated on the map in Appendix A. Field review efforts focused on the channel conditions upstream and downstream of the structures, the entrance and exit configurations of the structures, and the extent to which debris build up appears to impede flow through the structures. Portions of the stream reaches between the structures were also observed to assess channel conditions.

In contrast to the detailed flood modeling along Jackson Ditch, the water quality and storm water runoff modeling will involve the entire watershed and not just the Jackson Ditch stream reach. Water quality and storm water runoff modeling efforts will be derived primarily from mapped sources of land use, land cover, soil characteristics, and topography. Field reconnaissance efforts for these purposes consisted of a "windshield" survey of the watershed to observe existing land use and topographic conditions.

Common to both flood and water quality modeling efforts are the low-lying areas where storm water is thought to infiltrate into the aquifer system. During the reconnaissance, several of these areas were observed and photographed. Of particular note are the marshy areas near the southern end of Jackson Ditch, just east of Gephardt Road; and the low-lying area southeast of the intersection of Wehr and Morganthaler Roads, just north of Riverside Drive. With the exception of large storm events, it appears the majority of flow in Jackson Ditch ends up in one of these two areas where it infiltrates into the groundwater system.

FMSM and XCG also observed many infiltration points in the drainage system within the City of Trenton in coordination with local officials. Aspects of that drainage system are described below. While a goal of the team's reconnaissance was to observe points of infiltration in the watershed, due to the large number of dry wells in the City of Trenton, pinpointing and modeling each of these was deemed to be cost prohibitive. For modeling purposes, groundwater recharge in this area will be assumed to occur at the large infiltration basin locations.

2.2. Web-based Literature Search

FMSM performed an internet search to locate information and reports for the area. A partial list of reviewed websites includes:

- The Ohio Department of Natural Resources (ODNR)
    - ODNR Division of Water
    - ODNR Division of Soil and Water Conservation
    - Division of Geological Survey
- U.S. Environmental Protection Agency (EPA) – Federal and Ohio Divisions
- U.S. Geological Survey (USGS) – Federal and Ohio Divisions
- Natural Resources Conservation Service (NRCS)
- National Oceanic and Atmospheric Administration (NOAA)

- National Weather Service (NWS)
- Ohio Emergency Management Agency
- Butler County Engineer's Office
- Butler County Storm Water District
- Butler County Soil and Water Conservation District
- Hamilton – New Baltimore Groundwater Consortium
- Miami Conservancy District
- City of Trenton
- Southwest Regional Water District

Appendix B contains a bibliography and reference list of the information found. Texts of reports, correspondence, and data of particular interest obtained from the search have been included in digital postscript (Adobe PDF) format in Appendix C.

2.3. Meetings and Interviews

FMSM conducted meetings with several state and local agencies during the data gathering efforts. Of particular note were the Ohio Department of Natural Resources, the US Geological Survey, the Miami Conservancy, the Southwest Regional Water District, the City of Trenton, St. Clair Township, the Butler County GIS Department, and the Butler County Engineer's Office. Particular items of interest are listed in the bibliography and references in Appendix B and the texts are included digitally in Appendix C.

For the City of Trenton, FMSM and XCG met with Robert Leichman, the city building inspector. Mr. Leichman provided a thorough overview of drainage characteristics within the City and visited several sites with FMSM and XCG.

FMSM and XCG also met with Jerry Lanich, the Zoning inspector for St. Clair Township. Mr. Lanich provided some historical perspective for the southern end of the watershed and described much of the development that is occurring in the area.

In addition to onsite meetings, FMSM also conducted phone interviews with several agencies including the Ohio EPA Southwest District Office, the Ohio EPA state office, and the Hamilton – New Baltimore Groundwater Consortium.

A meeting is currently being planned to facilitate further discussion and data gathering efforts with the major stakeholders and water withdrawal sources in the area including: Miller Brewing Company, the City of Trenton, Wayne and St. Claire Townships, the Cinergy Corporation, and the Southwest Regional Water District. Several local property owners have also expressed interest in the project and FMSM will contact these property owners subsequent to the stakeholder meetings to discuss the project.

2.4. Project GIS

Spatial data collected from the Butler County GIS Department and other sources during the data gathering phase of the project has been compiled into a project GIS. The map included in Appendix A was created to reflect the base GIS layers, which include among others:

- 2-foot contour topographic mapping
- Streets and roads
- Railroads
- Corporate and municipal boundaries
- Parcel data
- Building outlines
- Stream centerlines
- Hydraulic structures and drainage features with attributes
- Monitoring and observation wells
- Withdrawal sites
- Watershed delineation
- Subsurface conditions including:
    - Approximate aquifer boundary
    - Bedrock topography
- Aerial photography

The project GIS data is included in Appendix C. The majority of the data is in ESRI shapefile format along with supporting tabular data and index files or as AutoCAD drawing files. Photographic data has been presented via shapefiles that have embedded hyperlinks.

3. Watershed Characterization

The watershed west of the City of Trenton is changing from its historic rural agricultural base to higher density residential land and industrial uses. The Butler County Engineer's Office recognizes that with increased development comes an increased risk of flooding. Increased urbanization also increases pollutant loading to the stream and, potentially, the aquifer systems.

As with many streams in the area, the streams in this watershed appear to be directly connected to the groundwater and aquifer system, which serves as the area's primary water

supply source. After reviewing available literature for the area, it is apparent that understanding the interaction between surface drainage and groundwater is key to meeting the study goals. In order to understand the dynamics of flow between surface water and groundwater in the area it is important to understand the Jackson Ditch drainage system and the underlying Lower Great Miami River Aquifer System.

3.1. Surface Conditions

Jackson Ditch is actually a manmade channel that originated in the late 1800's. It was originally constructed to provide drainage to adjacent fields and farmlands. According to some historic accounts, the channel was originally intended to flow unabated to the Miami River. Apparently, due to property constraints, the full length of the channel was not completed and the stream was allowed to drain to low-lying areas and infiltrate directly into the groundwater aquifer system. The relatively thin surface soil layer and underlying upper aquifer layer of permeable sand and gravel made this approach adequate for the majority of the time, with only minor overflows occurring during major flood events that caused nuisance flooding of adjacent fields and downstream in the City of New Miami. At some point, it was recognized that the storm water would infiltrate if given the opportunity and several low lying areas were adapted to serve that purpose.

Following that precedent, several other smaller streams and drainage pathways in the area were constructed in a similar fashion. For instance, much of the drainage system in the City of Trenton makes use of dry wells for storm water infiltration purposes. Surface drainage within the City of Trenton is based predominantly on a surface collection system that conveys storm water to a series of infiltration basins and numerous dry wells. According to local officials, the dry well configuration commonly used in the City of Trenton is similar in size and depth to a large manhole. The structure is usually pre-cast concrete and circular with a diameter of 8-12 feet and a depth of 10-15 feet. The structure has slots in the sides and is typically installed with 2-3 feet of surrounding stone to permit storm water infiltration. According to reports, there are 250 or more of these structures within the City. There are also a few larger infiltration basins that function in a similar manner, but have varying outlet structures.

The combination of dry wells and infiltration basins in the City of Trenton area appears to minimize surface storm water outflow from within the Trenton city limits, but these facilities do contribute directly to the aquifer system. The effect is that storm water dissipates rather slowly and directly recharges the groundwater system. Consequently, the pollutant loading of the surface water system is believed to directly affect groundwater quality.

3.2. Subsurface Conditions

The Lower Great Miami River Buried Valley Aquifer system has been studied extensively in the past and several of those studies are included digitally in Appendix C. Most of the literature reviewed indicates the aquifer can be described as stratified layers divided into distinct upper and lower zones.

The upper aquifer zone extends from near the surface to an approximate depth of 60 feet. The layer is composed of glacial deposits of sand and gravel, and is overlain by a thin layer of topsoil and predominantly clayey soils. Water yields from the upper aquifer are fairly good for small-scale uses, but are insufficient to support large industrial users. Most of the wells in

the upper aquifer are for private residential use and can be susceptible to supply issues associated with fluctuations in groundwater levels due to their relatively shallow depths.

Beneath the upper aquifer zone at a depth of approximately 60-80 feet from the surface there appears to be a distinct and predominantly impermeable 10-15' thick clay layer that divides the aquifer. There does appear to be some debate concerning the thickness and continuity of the clay layer, but the majority of accounts indicate it is present throughout the area and serves as a distinct boundary layer.

The lower aquifer zone extends from approximately 80 feet to 200 feet beneath the surface and is confined and separated by the overlaying clay layer. The lower aquifer zone is also composed of glacial depositions of sand and gravel. The lower aquifer is characterized by tremendous transmissivities, and the available yields for withdrawal purposes are excellent. The large industrial and municipal withdrawals in the area are tapping this aquifer for their water withdrawal needs.

According to USGS bedrock geology and topography mapping, bedrock formations in the area generally follow the shape of the buried valley aquifer. The bedrock depths in the deepest portions of the aquifer are generally 150 to 200 feet, but vary greatly with topography. Bedrock is actually quite shallow as the topography rises in the upland areas in the northwest and southwest portions of the watershed. In these areas, bedrock depth is only on the order of 10-20 feet.

3.3. Potential Issues and Problems

As the watershed west of the City of Trenton has developed, the quantity and rate of runoff has increased and continues to increase. The Jackson Ditch stream system appears to be insufficient to drain the area, as evidenced by recent floods. Many of the structures along the reach appear to be undersized, improperly constructed, or poorly maintained due to the frequent overflows and problems with accumulation and clogging caused by debris. Erosion associated with upstream development also poses a threat to the stream system due to the sediment deposition that occurs. Increased sediment loading also impacts surface water quality. Discharge points, where infiltration normally would occur, appear to be inadequate as increased quantities and rates of flood waters flow to them. Flood waters cannot infiltrate at a rate fast enough to prevent overflow, so flooding of adjacent properties is becoming more common. Ultimately, the drainage system is slowly being overwhelmed. This is evident by the recent flooding at the southern end of the stream reach.

During a major storm event in January of 2004, a large area near the southwestern end of the watershed experienced flooding. It was reported that just east of Hamilton-Trenton Road, southwest of the intersection with Busenbark Road and the CSX Railroad, Jackson Ditch left its banks and overflowed into adjacent fields. The flood waters actually extended across Hamilton-Trenton Road, flooding the yards of several homes. The flow proceeded southward along Hamilton-Trenton Road where it rejoined the stream near Gephardt Road. Just east of Gephardt Road is a low-lying area on Miller Brewing Company's property where infiltration appears to normally occur. It was reported this area was inundated with flood waters that overflowed towards Gephardt Road. The downstream reach flooded extensively.

From a water quality perspective, the watershed is undergoing a significant transformation as rural agricultural areas are being replaced with relatively high density residential areas. Whereas nutrient problems associated with fertilizers and pesticides from agricultural

applications are the primary surface water concern today, in the near future pollutants such as oils and greases, metals, and different types of more persistent residentially applied fertilizers and pesticides will be common in the watershed. As these more persistent chemical constituents and metals become more prevalent, there is a legitimate concern that they may find their way into the groundwater system. Since most of the drainage in the area ultimately flows to a few low-lying areas, there is potential for pollutants to accumulate in these areas, forming a point-source pollution threat to the underlying aquifer.

4. Recommendations

The original intent of the watershed study was to develop a water quality model for the watershed using the HSPF software application. HSPF has a number of features that make it applicable for modeling the hydrologic and the water quality aspects of this area. One of the strengths of the HSPF application is the ability to model the interface between the surface and groundwater flow regimes. HSPF simulates the interactions between the ground's surface and the upper layers of the soil column and can even model ground freezing which greatly reduces infiltration during cold periods. As described above, understanding this interface is of critical importance to this study.

For water quality purposes, HSPF contains many useful tools and features that can be applied for this study. The most important capability is the ability to model nitrogen and phosphorus interactions on the ground surface and in the soil layers. The model can vary plant uptake as a function of time to simulate the changes to the nitrogen and phosphorus loading in the watershed throughout the year. The model can also simulate pollutant loading associated with fertilizer applications based on the time of year and/or ground temperature.

An HSPF model also can be manipulated to simulate anticipated future conditions to determine impacts of current/future land practices. This process would allow for identification of existing and potential pollutant issues and evaluation of various land use controls and BMP implementation scenarios to abate these issues. The model is particularly useful for simulations of the watershed with and without a particular BMP to evaluate the effectiveness of the BMP.

For hydraulic flood modeling purposes, the original intent was to use HEC-RAS to model the Jackson Ditch strea m reach. HEC-RAS is a good choice for modeling of this nature and it is recommended that the model be prepared to address the area outlined on the map in Appendix A. Hydrology for the HEC-RAS model will be derived from the HSPF modeling efforts. Geometric data for the HEC-RAS modeling can be prepared from the topographic mapping (2-foot contours) provided by the Butler County GIS Department, but the channel portions of the reach and model hydraulic structures must be surveyed to provide an accurate representation of the reach. FMSM has provided the Butler County Engineer's Office with a letter notifying affected property owners that the FMSM Project Team may require access to their property.

As with any model application, appropriate verification data is critical to achieving accurate results. One unfortunate result of the data gathering effort was the realization that calibration data is not available for the area for either the water quality or hydraulic modeling efforts.

For water quality modeling it is important to have background data to form a baseline condition for the area. Modeling can be used to evaluate differences between apparent

existing conditions and future conditions, but without adequate calibration data, the actual numeric results could be off by several orders of magnitude. The model could calculate abnormally high levels of a particular constituent, when in actuality that constituent may be common to the area and normal for the stream being studied. The lack of adequate calibration data greatly affects the model's sensitivity to various input parameters.

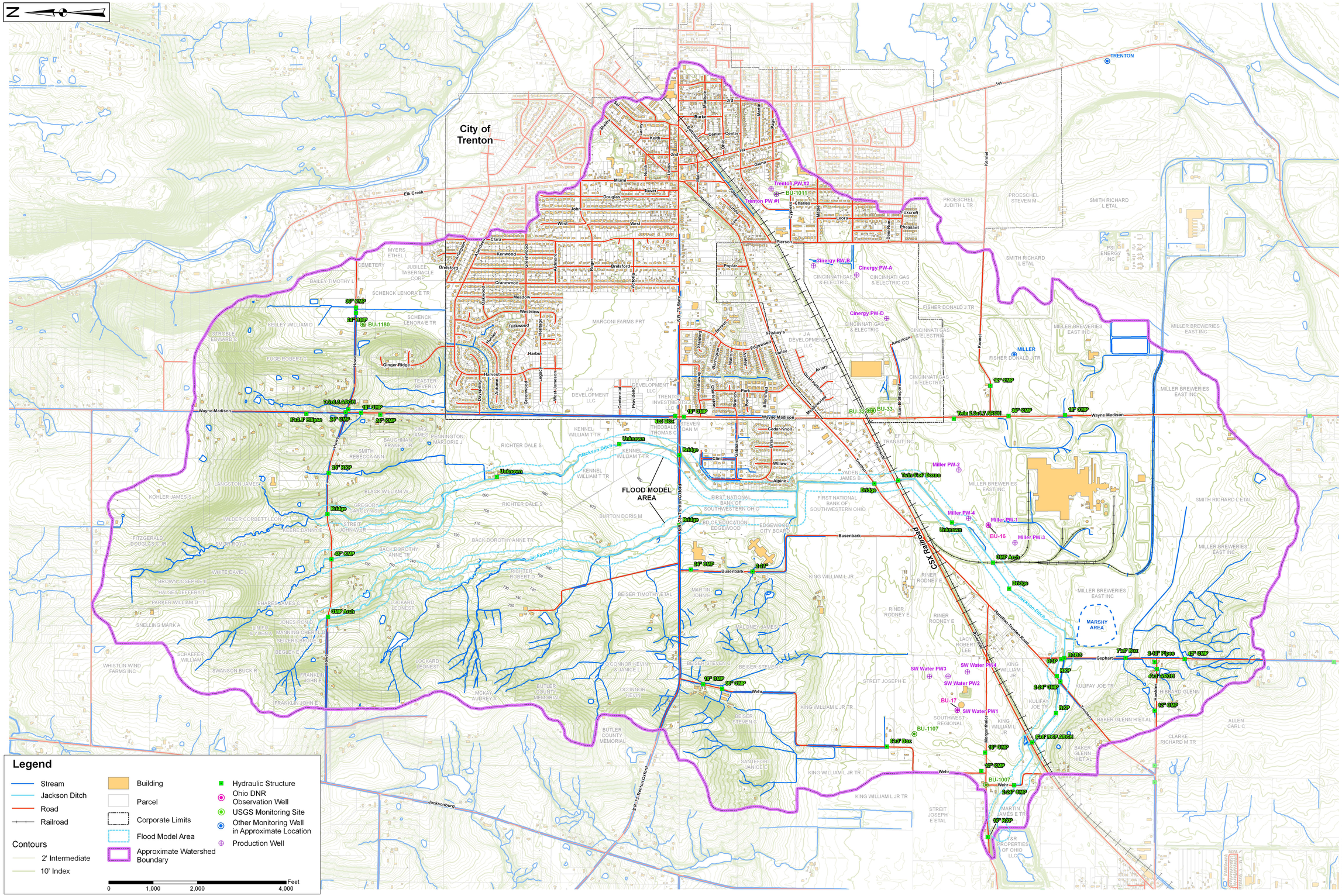
For hydraulic modeling, the ability to accurately calculate flood stages is a function of the applicability of model parameters and the input hydrologic results. Model parameters can be adjusted to vary the results slightly, but the discharge values applied to the model are one of the more sensitive parameters. Ideally, stage and flow measurements would be available for the stream during a given storm event for calibration purposes. There are nearby precipitation gages that can provide daily rainfall totals, but accompanying stream measurements are not available.

In order to better calibrate the water quality and quantity modeling that is going to be developed during phase two of the watershed study, it is recommended that a monitoring program be initiated in the watershed. At a minimum, the monitoring program should consist of baseline water quality sampling performed during low-flow and elevated flow events and a series of stage gages to measure varying water surface levels or peak flood heights. The goal is to collect a continuous set of data for a particular storm or series of events that will then become the calibration data for the modeling efforts.

Additional uncertainties that may affect the modeling are the characteristics of the infiltration points in the drainage system. These low-lying areas are a critical part of the system because they control the rate at which flows infiltrate into the groundwater system. These rates affect flooding characteristics and the fate of particular pollutants and constituents of concern to the water quality modeling efforts. In order to better understand the interface between the surface and subsurface conditions, it is recommended that a limited field investigation be performed in one or more of these low-lying areas. It is recommended that exploratory borings be made to determine the characteristics of near-surface soil layers and be accompanied by soil permeability testing to quantify the rate of infiltration capabilities of the surficial soils in the area.

Appendix A

Area Map



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FMSM ENGINEERS

LEXINGTON LOUISVILLE CINCINNATI COLUMBUS ST. LOUIS

Study Area

Watershed Study and Master Plan

Butler County Storm Water District

Butler County, Ohio

PROJECT NO.	CN2004074
DATE	JULY, 2005
DRAWN BY	MAE
CHECKED BY	ELC
CHECKED BY	
SCALE	1" = 1000'
REVISED	
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SHEET

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Appendix B

Bibliography and References

Appendix B - Bibliography and References

Source / Unique ID	Citation	Filename	Type of Document	Synopsis
Butler County Stormwater District				
1	"After the Storm, A Citizen's Guide to Understanding Stormwater", Publication No. EPA 833-B-03-002, January 2003, United States Environmental Protection Agency	AfterTheStorm.pdf	Poster	Stormwater pollution general info.
2	"Look Before You Buy", Butler Soil & Water Conservation District	LookBeforeYouBuy.pdf	Flyer	Butler Soil and Water Conservation District flyer for contacts concerning property purchases and new construction.
3	"Madison Township, Butler County, Ohio Proposed Landuse", Butler County Department of Development Planning Division	Madison_pro_lu.pdf	Map	Butler Dept. of Development Planning Proposed Landuse for Madison Township
4	"Madison Township, Zoning Map", Butler County Department of Development Planning Division	Madison_zoning.pdf	Map	Butler Dept. of Development Planning Current Zoning for Madison Township
5	"Make your home The Solution to Stormwater Pollution: A homeowner's guide to healthy habits for clean water", Publication No. 833-B-03-003, January 2003, United States Environmental Protection Agency	SolutionToPollution.pdf	Flyer	Butler County Stormwater guide for homeowners to prevent pollution.
6	"St. Clair Township Resolution No. _, Wellhead Protection Overlay District", St. Clair Township	St Clair Township Wellhead Protection Ordinance.pdf	Document	Wellhead protection ordinance for St. Clair Township
7	"St. Clair Township, Butler County, Ohio Proposed Landuse", Butler County Department of Development Planning Division	St_Clair_pro_lu.pdf	Map	Butler Dept. of Development Planning Proposed Landuse for St. Clair Township
8	"Butler County Storm Water District Map", Butler County Storm Water District, <http://www.stormwaterdistrict.org/districtmap.html>, (4/22/05)	SW District Map.pdf	Map	Map of the Butler County Stormwater District
9	"Butler County Storm Water District Overview", Butler County Engineer's Office, Feb. 6, 2003	SW Program Development.pdf	Document	Describes how and why the Butler Co. Stormwater District formed.
10	"Timeline for Butler County Storm Water District", Butler County Engineer's Office, Dec. 24, 2002	SW Program Evolution Timeline.pdf	Document	Timeline for the Butler Co. Stormwater District
11	"Wayne Township, Butler County, Ohio Proposed Landuse", Butler County Department of Development Planning Division	Wayne_pro_lu.pdf	Map	Butler Dept. of Development Planning Proposed Landuse for Wayne Township
City of Trenton				
12	"Trenton's History: Trenton's Legacy of Small-Town Life", City of Trenton Ohio, <http://www.ci.trenton.oh.us/history/history_trenton.asp>, (4/22/05)	History of Trenton.pdf	Webpage	Short narrative history of the City of Trenton
13	"Proposed Water Treatment Facility and Related Supply & Distribution Improvements", Presentation to the City of Trenton Council, January 31, 2004.	Water Treatment Plant Presentation.pdf	Presentation	Has information pertaining to the capacity and treatment facilities operated by the City of Trenton Public Water Works.
Miami Conservancy District				
14	M. Bamberger, D. Bean, M. Ekberg, and A. Belanger-Haas, July 2001, "Groundwater Elevation Trends in the Buried Valley Aquifer near Trenton, Ohio", Miami Conservancy District Aquifer Preservation Subdistrict.	GW Elevation Trends in Trenton Aquifer.pdf	Report	Illustrates water withdrawl statistics and general downward trend in aquifer water elevations due to major withdrawls.
15	"Miami Conservancy Watershed Initiative - 2002, Lower Great Miami River Watershed", Miami Conservancy	Lower Great Miami WQ Overview.pdf	Flyer	Describes general surface water quality trends in the Lower Great Miami River basin.
16	Sverdrup & Parcel Engineers, Architects, Planners, St. Louis, Missouri, May 1979, "Ground-water Exploration Report for Miller Brewing Company Mid-east Brewery Site Trenton, Ohio".	Report on Pumping Test Near Trenton at Mid-East Brewery.pdf	Report	Groundwater exploration report prepared by Sverdup Engineers for Miller Brewing Company. Discusses deep-well development and includes a detailed boring log.

Appendix B - Bibliography and References

Source / Unique ID	Citation	Filename	Type of Document	Synopsis
17	"Simulated Three Dimensional Ground Water Flow Model for The Buried Valley Aquifer Trenton, Ohio", Ohio Department of Natural Resources, November 1995	Simulated 3D GW Flow Model for Aquifer Trenton.pdf	Report	ODNR report on an effort to model the aquifer using MODFLOW.
18	"State of the Aquifer Report for the Lower Great Miami River Sub-basin", after 1997?, Miami Conservancy	State of the Aquifer Lower Miami Basin.pdf	Report	Describes general water quality trends (surface and subsurface) in the Lower Great Miami River basin.
19	Correspondence between A.M. Kinney Consulting Engineers and the Ohio Department of Natural Resources in the late 1960's and early 1970's.	Trenton Area Ground Water Studies.pdf	Letter	Submitted to ODNR, describes results of a limited investigation performed by AM Kinney Consultants.
Miami Valley Regional Planning Commission (MVRPC)				
20	"Petition Requesting Sole Source Aquifer Designation for Portions of the Buried Valley Aquifer System of the Great Miami / Little Miami Basins in the Valley Region of Southwestern Ohio. November, 1987"		Report	Contains extensive text with tables, figures, and maps, including Sole Source Aquifer Maps for each County.
Ohio Department of Natural Resources (ODNR)				
21	Jason Remich and Frank Fugitt, 2002, "Ohio's Water Withdrawal Facility Registration Program: 2002", Ohio Department of Natural Resources Division of Water.	2002 Annual Report on Water Withdrawl Sites.pdf	Document	Describes large scale trends for water withdrawls in Ohio based on state/county trends.
22	"Glacial Map of Ohio", Ohio Department of Natural Resources	Glacial Map of Ohio.pdf	Map	Large scale map of glacial history in Ohio.
23	"Shaded Bedrock-Topography Map of Ohio", Ohio Department of Natural Resources	Ohio Bedrock Topography Map.pdf	Map	Large scale map of bedrock topography in Ohio. Also has some information on bedrock contouring during glaciation.
24	"Shaded Drift-Thickness Map of Ohio", Ohio Department of Natural Resources	Ohio Drift Thickness.pdf	Map	Large scale map of drift thickness in Ohio. Also has some description of glacial deposition and aquifer formation.
25	Dennis N. Hull, Glenn E. Larsen, Ernie R. Slucher, 2004, "Generalized Column of Bedrock Units in Ohio", Ohio Department of Natural Resources, Division of Geological Survey	Ohio Generalized Column of Bedrock.pdf	Chart	Large scale generalized bedrock column for Ohio.
26	"Geologic Map and Cross Section of Ohio", Ohio Department of Natural Resources	Ohio Geologic Overview.pdf	Map	Large scale cross section and map of major geologic units in Ohio.
27	L. Wickstrom and M. Baranoski, "Industrial-waste-disposal Wells in Ohio", Ohio Department of Natural Resources, <http://www.dnr.state.oh.us/geosurvey/gen/environment/class1a.htm>, (4/21/05)	Ohio Industrial Waste Injection Wells.pdf	Webpage	Describes several wells in Ohio that are legally permitted to inject industrial wastes into the groundwater. AK Steel in Butler county northeast of Trenton is one of the permitted facilities.
28	"Oil and Gas Pipelines in Ohio, 1989", Ohio Department of Natural Resources Division of Geological Survey	Ohio Oil & Gas Pipelines.pdf	Map	Large scale map of major transmission lines and facilities associated with Oil & Gas production. No Oil or Gas wells are indicated in the watershed, but transmission facilities could exist.
29	C. S. Brockman, "Physiographic Regions of Ohio", Ohio Department of Natural Resources	Ohio Physiographic Regions.pdf	Map	Describes general land characteristics and soil types in various parts of Ohio on a large scale.
30	"Ohio Wetland Restoration and Mitigation Strategy Blueprint", August 5, 1999, Ohio Department of Natural Resources and Ohio Environmental Protection Agency	Ohio Wetland Strategy and Mgmt Blueprint.pdf	Report	ODNR Strategy and position document concerning wetlands.
31	"Ohio Pond Management Handbook, a guide to managing ponds for fishing and attracting wildlife", 1996, Division of Wildlife, Ohio Department of Natural Resources	Pond Management Guide.pdf	Booklet	Ohio Dept. of Fish and Wildlife guide for local owners of ponds to control ecology.
32	"Wetland Restoration Program", Ducks Unlimited and Division of Wildlife Ohio Department of Natural Resources	Wetland Restoration Program.pdf	Flyer	Ohio Dept. of Fish and Wildlife guidance on wetland restoration, mainly includes contacts.

Appendix B - Bibliography and References

Source / Unique ID	Citation	Filename	Type of Document	Synopsis
33	R.E. Sanders, R. J. Zimmerman, 2001, "A Guide to Ohio Streams", Streams Committee Ohio Chapter of the American Fisheries Society	A Guide to Ohio Streams	Booklet	Good general background info on ODNR stance on Ohio surface and ground waters and various programs in the state to protect and enhance them.
ODNR Division of Soil & Water Conservation				
34	"Estimating Load Reductions for Agricultural and Urban BMPs", June 1999, Michigan Department of Environmental Quality	BMP Load Reduction Application.xls	Spreadsheet	Prepared by Michigan DEQ, used to evaluate BMP load reduction and facilitate analyses of different BMP options.
35	"Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual", June 1999, Michican Department of Environmental Quality Surface Water Quality Division Nonpoint Source Unit	Pollutant Reduction Manual.pdf	Report	Guidance document prepared by Michigan DEQ that talks about how to determine and analyze BMP options for an impaired stream.
36	Sample Article, Ohio Department of Natural Resources Division of Soil & Water Conservation	Sample Newspaper Ad - Filter Strips.doc	Flyer	General informational outreach. Vegetated filter strips.
37	Sample Article, Ohio Department of Natural Resources Division of Soil & Water Conservation	Sample Newspaper Ad - Tillage.doc	Flyer	General informational outreach. Proper tillage procedures.
ODNR Division of Water				
38	J. J. Schmidt, 1993, "Ground-water Resources of Butler County", Ohio Department of Natural Resources Division of Water Groundwater Resources Section	Butler Groundwater Resource Map.pdf	Map	Highlight of potential yields from groundwater sources in Butler County.
39	"Ground Water Pollution Potential of Butler County, Ohio", 1991, Ground Water Resources Section Division of Water Ohio Department of Natural Resources and Groundwater Research Center University of Cincinnati	Butler_PP_report_wMap.pdf	Report	Exploration of Groundwater Pollution Potential in Butler County prepared by Univ. of Cincinnati.
40	"Ohio Department of Natural Resources Division of Water Fact Sheet - Dam Safety: Probable Maximum Flood", April 1995, Ohio Department of Natural Resources	Dam Safety PMP Factsheet.pdf	Document	Discussion of dam safety and development of probable maximum precipitation calculations throughout Ohio.
41	"Drift Thickness of Ohio", June 2000, Ohio Department of Natural Resources Division of Water	Drift Thickness of Ohio.pdf	Map	General overview of drift thickness trends throughout Ohio.
42	"Ohio Department of Natural Resources Division of Water Fact Sheet - Evaluating Ground Water Pollution Potential in Ohio", January 2005, Ohio Department of Natural Resources	Evaluating GW Pollution Potential Factsheet.pdf	Flyer	General discussion about how countywide groundwater pollution potential reports are developed.
43	"Ohio Department of Natural Resources Division of Water Fact Sheet - Ground Water Level Monitoring in Ohio", June 2004, Ohio Department of Natural Resources	Ground Water Level Monitoring Facts.pdf	Flyer	General discussion of groundwater monitoring in the State of Ohio.
44	"Ohio Department of Natural Resources Division of Water Fact Sheet - Ground Water Quality", October 1997, Ohio Department of Natural Resources	Ground Water Quality Facts.pdf	Flyer	General description of water quality constituents that are significant to groundwater.
45	"Ohio Department of Natural Resources Division of Water Fact Sheet - Ground Water Resource Mapping in Ohio", February 2004, Ohio Department of Natural Resources	Ground Water Resources Mapping Facts.pdf	Flyer	General guide to groundwater mapping programs in Ohio.
46	M.P. Angle, P.N. Spahr, F.L. Fugitt, M.P. Hallfrisch, and K.R. Pendley, May 2000, "Hydrogeologic Settings of the Unconsolidated Aquifers of Ohio", Ohio Department of Natural Resources Division of Water	Hydrogeologic Settings of the Unconsolidated Aquifers in Ohio.pdf	Map	General overview of aquifers throughout Ohio.
47	"Ohio Department of Natural Resources Division of Water Fact Sheet - What is Nonpoint Source Pollution?", October 1997, Ohio Department of Natural Resources	Nonpoint Source Pollution Facts.pdf	Flyer	General discussion on nonpoint source pollutants and their sources.

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Source / Unique ID	Citation	Filename	Type of Document	Synopsis
48	"Ohio Department of Natural Resources Division of Water Fact Sheet - Individual Practices to Protect Ground Water Quality", October 1997, Ohio Department of Natural Resources	Practices to Protect GW Quality Facts.pdf	Flyer	General discussion of practices used to protect groundwater sources.
49	"Primary Lithology of the Unconsolidated Deposits of Ohio", June 2000, Ohio Department of Natural Resources	Primary Lithology of the Unconsolidated Deposits of Ohio.pdf	Map	General overview of depositional layers throughout Ohio.
50	"Report on Phase 1 Study of Ground Water Conditions Near Trenton, Ohio", January 14, 1993, Ohio Department of Natural Resources Division of Water Ground Water Resources Section	Report on Phase I Study of GW Near Trenton.pdf	Report	ODNR exploration of groundwater trends in shallow wells around the Trenton Aquifer.
51	"Ohio Department of Natural Resources Division of Water Fact Sheet - Water Efficiency for Private Well Owners (What to Do Before the Well Goes Dry)", July 1992, Ohio Department of Natural Resources	Water Efficiency for Private Well Owners Factsheet.pdf	Flyer	General well protection for smaller wells in Ohio.
52	"Yields of the Unconsolidated Aquifers of Ohio", June 2000, Ohio Department of Natural Resources Division of Water	Yields of Unconsolidated Aquifers.pdf	Map	General yields of aquifer areas throughout Ohio.
53	"Ohio Stream Management Guide", Ohio Department of Natural Resources	Ohio Stream Management Guide	Booklet	Good general background info on ODNR stance on Ohio surface waters and various methods to protect and enhance them.
54	Misc. Data, Ohio Department of Natural Resources Division of Water Water Inventory System, <http://www.dnr.state.oh.us/water/waterobs/wellinfo.asp>, (4/21/05)	Observation Wells	Webpage	General information from ODNR concerning groundwater monitoring wells in the area. Includes site descriptions and sampling results.
55	"Ground Water for Planning in Southwest Ohio. Ohio Water Plan Inventory Report No. 23"		Report	Overview of ground water availability in Great Miami, Little Miami, and Mill Creek Basins. Provides feasibiltiy analysis of meeting projected water supply demands with ground water.
56	Hydrograph for ODNR Observation Well BU-16		Graph	Record of ground-water level fluctuations from well near Miller Brewing for period 1982 to present.
57	Hydrograph for ODNR Observation Well BU-17		Graph	Record of ground-water level fluctuations from well near SW Regional Water District Well Field for period 1993 to present.
Ohio Environmental Protection Agency				
58	"2002 305(b) Report Ohio's Ground Water Quality", May 2003, State of Ohio Environmental Protection Agency Division of Drinking and Ground Waters	2002_305b.pdf	Report	Statewide assessment of groundwater quality.
59	"Ohio 2004 Integrated Water Quality Monitoring and Assessment Report", March 2004, State of Ohio Environmental Protection Agency Division of Surface Water	2004 303d Surface Water.pdf	Report	Statewide assessment of surface water quality.
60	Yoder, C.O. and E.T. Rankin, 1996, "Assessing the condition and status of aquatic life designated uses in urban and suburban watersheds.", American Society of Civil Engineers, New York, NY.	Aquatic WQ Assesment Urban Areas .pdf	Report	Guidance document on how to assess aquatic water quality in urbanized areas.
61	Misc. Data, Ohio Environmental Protection Agency, March 2004	but00065 GW Site Summary.doc	Webpage	Monitoring well documentation and sample results.
62	Misc. Data, Ohio Environmental Protection Agency, March 2004	but00065 GW WQ Summary.pdf	Webpage	Monitoring well documentation and sample results.
63	Misc. Data, Ohio Environmental Protection Agency, March 2004	but00119 GW Site Summary.doc	Webpage	Monitoring well documentation and sample results.
64	Misc. Data, Ohio Environmental Protection Agency, March 2004	but00119 GW WQ Summary.pdf	Webpage	Monitoring well documentation and sample results.
65	Misc. Data, Environmental Protection Agency (April 2005)	EPA STORET Data.xls	Spreadsheet	Spreadsheet dump of information from EPA's Storet sampling data warehouse database.

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66	"Ohio EPA Ground Water Susceptibility Analysis: Attachment A Susceptibility Analysis and Proposed Consumer Confidence Report Language for the City of Fairfield", Ohio Environmental Protection Agency	Fairfield WHP.pdf	Document	Discusses vulnerability of water supply to groundwater contamination for the City of Fairfield.
67	"Ohio EPA Ground Water Susceptibility Analysis: Attachment A Susceptibility Analysis and Proposed Consumer Confidence Report Language for the City of Hamilton North and South Wellfields", Ohio Environmental Protection Agency	Hamilton North WHP.pdf	Document	Discusses vulnerability of water supply to groundwater contamination for the City of Hamilton.
68	"Ohio EPA Ground Water Susceptibility Analysis: Attachment A Susceptibility Analysis and Proposed Consumer Confidence Report Language for the City of Middletown", Ohio Environmental Protection Agency	Middletown Wellhead Protection Plan.pdf	Document	Discusses vulnerability of water supply to groundwater contamination for the City of Middletown.
69	"Ohio EPA Ground Water Susceptibility Analysis: Attachment A Susceptibility Analysis for the Miller Brewing Company's Wellfield", Ohio Environmental Protection Agency	Miller Brewing WHP.pdf	Document	Discusses vulnerability of water supply to groundwater contamination for the Miller Brewing Facility.
70	Ed Rankin, Bob Miltner, Chris Yoder, and Dennis Mishne, January 1999, "Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams: Ohio EPA Technical Bulletin MAS/1999-1-1", Ohio Environmental Protection Agency	Nutrients Habitat and Aquatic Biota .pdf	Booklet	Discusses relationship between nutrient loading and aquatic water quality in Ohio streams.
71	Ed Rankin, Bob Miltner, Chris Yoder, and Dennis Mishne, January 1999, "Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams: Ohio EPA Technical Bulletin MAS/1999-1-1", Ohio Environmental Protection Agency	Nutrients Habitat and Aquatic Biota Apdx .pdf	Booklet	Appendices that include sampling data.
72	"Justification and Rationale for Revisions to the Dissolved Oxygen Criteria in the Ohio Water Quality Standards: Ohio EPA Technical Bulletin MAS/1995-12-5", January 31, 1996, Ohio Environmental Protection Agency Division of Surface Water Monitoring & Assessment Section	Ohio Suface Water DO Stds.pdf	Report	Technical discussion of dissolved oxygen in Ohio Surface Waters.
73	Chris Yoder and Edward T. Rankin, February 23, 1995, "The Role of Biological Criteria in Water Quality Monitoring, Assessment, and Regulation: Ohio EPA Technical Report MAS/1995-1-3", State of Ohio Environmental Protection Agency Division of Surface Water Monitoring Assessment Section	Role of Biology in WQ Assessment.pdf	Report	Technical discussion of how biological indicators are used in surface water quality assessments.
74	Misc. Data, Ohio Environmental Protection Agency	SDR20050422_085605.txt	Document	Surface water sampling data.
75	Misc. Data, Ohio Environmental Protection Agency	SDS20050422_085307.txt	Document	Surface water sampling data.
76	Misc. Data, Ohio Environmental Protection Agency	SDS20050422_090034.txt	Document	Surface water sampling data.
77	"Summary of Drinking Water Source Protection Plans and Review Criteria", January 2004, Ohio Environmental Protection Agency Division of Drinking and Ground Waters	Summary of Wellhead Protection Program.pdf	Document	Describes ODNR wellhead protection program requirements.
78	"Ohio EPA Ground Water Susceptibility Analysis: Attachment A Susceptibility Analysis, Protective Strategies, and Proposed Consumer Confidence Report Language for the Southwest Regional Water District's North Wellfield", Ohio Environmental Protection Agency	SW Water Treatment Wellhead Protection Plan.pdf	Document	Discusses vulnerability of water supply to groundwater contamination for the Southwest Water District.

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Ohio Division of the US Geological Survey				
79	Misc. Data, US Geological Survey, <http://nwis.waterdata.usgs.gov/oh/nwis/inventory>, (4/22/05)	USGS Sites.txt	Document	Listing of USGS gage and monitoring sites in Butler County.
80	Bedrock Geology of Trenton, Ohio Quadrangle Open File Map BG-B5D4	Bedrock Geology Trenton Quad.tif	Map	Delineates bedrock formation contacts.
81	Bedrock Topography of Trenton, Ohio Quadrangle Open File Map BT-B5D4	Bedrock Topology Trenton Quad.tif	Map	Delineates contours on bedrock surface.
82	Bedrock Geology of Hamilton, Ohio Quadrangle Open File Map BG-B5D5	Bedrock Geology Hamilton Quad.tif	Map	Delineates bedrock formation contacts.
83	Bedrock Topography of Hamilton, Ohio Quadrangle Open File Map BT-B5D5	Bedrock Topology Hamilton Quad.tif	Map	Delineates contours on bedrock surface.
84	Bedrock Geology of Middletown, Ohio Quadrangle Open File Map BG-B5E4		Map	Delineates bedrock formation contacts.
85	Bedrock Topography of Middletown, Ohio Quadrangle Open File Map BT-B5E4	Bedrock Topology Middletown Quad.tif	Map	Delineates contours on bedrock surface.
86	Bedrock Geology of West Elkton, Ohio Quadrangle Open File Map BG-B5E5		Map	Delineates bedrock formation contacts.
87	Bedrock Topography of West Elkton, Ohio Quadrangle Open File Map BT-B5E5	Bedrock Topology West Elkton Quad.tif	Map	Delineates contours on bedrock surface.
Ohio - Kentucky - Indiana Regional Council of Government (OKI)				
88	"Petition of Sole Source Aquifer Designation of the Great Miami Buried Valley Aquifer System in Butler, Clermont, Hamilton and Warren Counties, Ohio. March 1988."		Report	Similar to MVRPC Petition with many of the same tables, figures and maps.
USDA - Soil Conservation Service (SCS) now called (NRCS)				
89	Soil Survey of Butler County, Ohio		Report	County soil survey with detailed maps.
US Geological Survey				
90	L.M. Debrewer, et.al., 2000, "Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana: National Water-Quality Assessment Program Water-Resources Investigations Report 99-4201", US Department of the Interior, US Geological Survey	Enviro Setting of Miami River Basin.pdf	Report	USGS Assessment of water quality in the Miami River Basin.
91	David C. Reutter, 2003, "Nitrogen and Phosphorus in Streams of the Great Miami River Basin, Ohio 1998-2000: Water-Resources Investigations Report 02-4297", US Geological Survey	Nitrogen & Phosphorus in Miami River Basin.pdf	Report	USGS Discussion on nitrogen and phosphorus loading for surface water associated with the Miami River Basin.
92	"Water Quality in the Great and Little Miami River Basins, Ohio and Indiana, 1999-2001", US Geological Survey	WQ in Miami River Basin.pdf	Report	USGS Assessment of water quality in the Miami River Basin.
93	"Results from Selected Sites in the Great Miami and Little Miami River Basin (National Water Quality Assessment Program) Agricultural Land-use Study", US Geological Survey	WY00_GWQW_AgLUS.pdf	Report	Sampling results for groundwater sites located in agricultural areas of Ohio.

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Source / Unique ID	Citation	Filename	Type of Document	Synopsis
94	"Results from Selected Sites in the Great Miami and Little Miami River Basin (National Water Quality Assessment Program) Surface Water Quality Stations", US Geological Survey	WY01_FixedSWQW.pdf	Report	Sampling results for surface water monitoring sites located throughout Ohio.
95	"Results from Selected Sites in the Great Miami and Little Miami River Basin (National Water Quality Assessment Program) Results from the Urban-Gradient Study", US Geological Survey	WY01_UrbanGradient_SWQW.pdf	Report	Sampling results for surface water monitoring sites located throughout Ohio and influenced by urban areas.
96	"Results from Selected Sites in the Great Miami and Little Miami River Basin (National Water Quality Assessment Program) Subunit Survey of the Buried Valley Aquifer System and Miami Conservancy District Groundwater 2000 Cooperative Project", US Geological Survey	WY99_GWQW.pdf	Report	Sampling results for groundwater sites located in agricultural areas of Ohio.
97	"Ground-Water Hydrology and Geology of the Lower Great Miami River Valley, Ohio. USGS Professional Paper 605-A"		Report	Comprehensive report describing aquifer characteristics and recharge potential for the buried valley. Includes maps showing various hydrogeologic environments.
98	"Seismic Refraction Survey of Pleistocene Drainage Channels in the Lower Great Miami River Valley, Ohio. USGS Professional Paper 605-B"		Report	Report includes maps showing bedrock topography for the buried valley aquifer.
99	"Future Development of the Ground-Water Resource in the Lower Great Miami River Valley, Ohio - Problems and Alternative Solutions. USGS Professional Paper 605-D"		Report	Report identifies areas of extensive development and local overdraft and discusses potential for future development.
Miscellaneous				
100	"Storm Drainage Report Harvest Acres Subdivision for Carl E. Gabbard Trenton, Ohio", August 1972, A.M. Kinney, Inc. Consulting Engineers Cincinnati, Ohio	AM Kinney Engineers Harvest Acres Dev Plan.pdf	Report	Plan for development of Harvest Acres subdivision.
101	Correspondence between A.M. Kinney Consulting Engineers and the Ohio Department of Natural Resources in the late 1960's and early 1970's.	AM Kinney Engineers Well Log.pdf	Document	Historic summary of well development for a few sites in the area.
102	Correspondence between the Southwest Regional Water District and the Ohio Department of Natural Resources in April of 2000.	OEPA Letter Re SW Water Wells.pdf	Letter	Letter from ODNR to SW Water District concerning wellhead protection and vulnerability for the SW Water District wellfield.
103	Misc. Data from Southwest Regional Water District, July 2004	SW Water Well Sample Results.pdf	Document	Sampling results from the Southwest Water District monitoring efforts.
104	Misc. Data from Miller Brewing Company		Logs	Boring logs from production wells and when available recent site borings
105	Misc. Data from Southwest Regional Water District		Logs	Boring logs from early site investigation
106	Misc. Data from Southwest Regional Water District		Document	Copy of Study outlining wellhead protection areas on site.
107	Misc. Data from Southwest Regional Water District		Data	Daily rainfall values maintained in operators daily logs. Can provide storm specific data
108	"Final Engineering Report for New Well Field in St. Clair Township: Prepared for The Water Association of Hamilton, Ohio", August 1991, SIECO, Inc. Columbus, Indiana and Lancaster, Ohio	SW Water Well Field Investigation.pdf	Report	Site investigation study for the proposed Southwest Water District Trenton area wellfield located northwest of the intersection of Morganthaler Road and Riverside Drive.
109	"Well Field Design and Wellhead Protection Area Delineation: Prepared for the Southwest Regional Water District", October 1992, CH2M Hill	SW Water Well Field Design.pdf	Report	Well field design and WHP plan creation for the Southwest Water District Trenton area wellfield located northwest of the intersection of Morganthaler Road and Riverside Drive.
110	"Wellhead Protection Plan, Miller Brewing Company Trenton, Ohio", December 2001, Burgess & Niple	MBC Wellhead Protection Plan.pdf	Report	Report on well head protection program provided by Miller Brewing Company
111	Results of National Urban Runoff Program		Report	Results of National Urban Runoff Program

Appendix C

Project GIS and Digital Data