WELL WATER MANAGEMENT ASSESSMENT
FOR THE CITY OF OSSEO, WISCONSIN

by
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A Research Paper

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ABSTRACT

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Well Water Management Assessment for the City of Osseo, Wisconsin

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The purpose of this study was to identify the extent that effective wellhead protection-related activities are being performed or promoted in Osseo. A review of current literature was conducted to determine the risks associated with municipal wells depending on potential sources of contamination. The review of literature covered three main areas including; groundwater characteristics and contamination analysis, losses associated with groundwater contamination, and contamination control methods. Groundwater quality is dependent on many factors such as contamination susceptibility, movement, and types of contaminants introduced.   The potential for human exposure and health effects associated with potential contamination are discussed in detail. The study collected a great deal of data about the City's water resources. Finally, recommendations were made based on the contamination inventory and assessment of current wellhead protection activities.

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CHAPTER 1

Research Problem and Objectives

Introduction

Groundwater… it's used to fight fires, clean streets, fill the local pool, sprinkle lawns, cook, clean, satisfy the needs of thirsty residents at home, and supply water to many manufacturing processes. The groundwater that supplies municipal wells in Wisconsin comes mostly from rain or snow that generally falls within a short distance from the well. This water seeps into the ground and moves in the direction of the well (or wellhead), sometimes carrying harmful contaminants with it (Mecozzi, 1989). Sources of potential contaminants would probably include; chemical storage areas, animal feedlots, landfills, use/spillage of fertilizers, septic tanks, and underground storage tanks. Once these contaminants or pollutants are in the groundwater, it becomes very difficult to almost impossible to remove them. When a well becomes contaminated, a community could be faced with costs to clean up groundwater, treat groundwater, drill a new well, or provide an alternate source of water to its residents. A wellhead protection plan may be one way to minimize the risk of incurring contamination-based problems and would likely ensure that groundwater remains free of potential contamination.

The 1986 amendments to the Federal Safe Drinking Water Act (SDWA) provided a nationwide program to protect groundwater used for public water supplies through the establishment of state wellhead protection programs. Wisconsin Department of Natural Resources (WDNR) has the authority for delegation of public water supply systems and supervisory programs in Wisconsin under the SDWA (WDNR, 1993). To facilitate the implementation of the wellhead protection program, WDNR included language into

Chapter NR 811, 1989, Wisconsin Administrative Code, regarding requirements for proposed new municipal wells (WDNR, 1993). Consequently, this relatively new wellhead protection standard does not affect numerous existing wells already serving Wisconsin communities.

Communities, such as the City of Osseo, Wisconsin, which have two operating wells are not required to prepare and implement a formalized wellhead protection plan such as would be required with proposed new wells under requirements set forth by NR 811. It is likely that many smaller communities, such as Osseo, have very limited formal wellhead protection plans in place that would address inventorying potential contamination sources, contingency plans, water conservation or public education programs and thus place their underground water supply at risk of contamination.

Purpose of the Study

The purpose of the study will be to identify the extent that effective wellhead protection-related activities (i.e., tracking, testing, controls, etc.) are being performed or promoted in Osseo, Wisconsin.

Goals of the Study

The objectives of this study are to:

1. Identify wellhead protection activities that are currently in place and the persons (and their qualifications) responsible for them.
2. Perform a physical characteristics inventory of areas surrounding the wellhead(s) in Osseo, WI, such as groundwater flow direction, potential contamination sources or spills, land-use, etc.

Background and Significance

Since water use in Wisconsin continues to grow, the supply must be able to meet the demand. Excessive water use or the presence of contaminated water supplies (which limit the water resources available) create significant costs to communities. The average cost of water for a family of four in 1998 was 55 cents per day (Mecozzi, 1989). With the need for new wells and associated infrastructure, due to excessive use or contaminated wells, it is likely that these costs may significantly increase.

Groundwater contamination can often be the end result of the normal, day-to-day activities that occur in communities. For example, farmers have been known to use substantial amounts of atrazine as a crop herbicide. In response to contamination of groundwater by atrazine, the Wisconsin Department of Agriculture, Trade and Consumer Protection has set up atrazine prohibition areas around wells where the level has exceeded the enforcement standard of 3 ppb (parts per billion). In 1997, there were 96 prohibition areas in Wisconsin covering over 1.2 million acres. In addition, researchers have recently reported finding higher rates of reproductive problems, thyroid disorders, and cancer among people whose drinking water supplies are high in nitrates (Mecozzi, 1989).

In Osseo, Wisconsin there are at least 23 EPA (Environmental Protection Agency) regulated facilities. These facilities are regulated because they are operating as a hazardous waste handler. In addition, there are at least 8 monitoring wells that were installed within the past few years to monitor the groundwater for contamination due to hazardous chemical spills or leaking underground storage tanks (EnviroSearch, 2000). It is probable that without adequate monitoring and controls, these contaminated sites could affect the municipal wells serving Osseo, Wisconsin.

Much information and planning is needed to make decisions that will protect groundwater resources. An analysis of current wellhead protection activities currently in place in Osseo may be critical to long-term prevention of groundwater contamination. The research following in this paper may help to organize current information about groundwater resources and aid in planning activities for a continually safe water source for local communities, including Osseo, Wisconsin.

Definitions

The following terms used in this study have been adapted from definitions presented in the federal Safe Drinking Water Act (SDWA).

Aquifer: a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Cone of depression: a depression in the surface around a well, or group of wells, from which water is being withdrawn.

Dissolved solids: minerals and organic material dissolved in water.

Groundwater: subsurface water, as distinct from surface water; that part of the subsurface water in the saturated zone.

Hardness: a property of water causing formation of an insoluble residue when the water is used with soap and forms a scale in containers in which water has be allowed to evaporate. It is primarily due to the presence of ions of calcium and magnesium.

Hazardous waste handler: (EPA designation)

Nonpoint source of pollution: pollution from broad areas rather than from specific points, such as areas of fertilizer and pesticide application and leaking sewer systems.

Percolation: Slow movement of water through openings within a porous earth material.

Permeability: the measure or capacity of a rock structure for transmitting fluid.

Point source of pollution: pollution originating from any specific sources, such as the outflow from a pipe, ditch, or concentrated animal-feeding lot.

Potable water: Water that is safe for and palatable for human use.

Recharge area: An area in which water infiltrates the ground and reaches the zone of saturation.

Saturated zone: a subsurface zone in which all the tiny spaces and voids within that subsurface level are filled with water under pressure greater than that of the atmosphere.

Wellhead: surface and subsurface area surrounding a water well or well field.

Wellhead protection area: surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonable likely to move toward and reach such water well or well field.

WDNR: Wisconsin Department of Natural Resources; an environmental and natural resources regulatory agency.

CHAPTER 2

Review of Literature

Introduction

The purpose of this chapter is to examine and evaluate literature relevant to the potential risk of groundwater contamination and effective protection-related activities and controls. The literature review is divided into the following sub-parts:

1. Groundwater characteristics and contamination analysis
2. Losses associated with groundwater contamination
3. Control methods

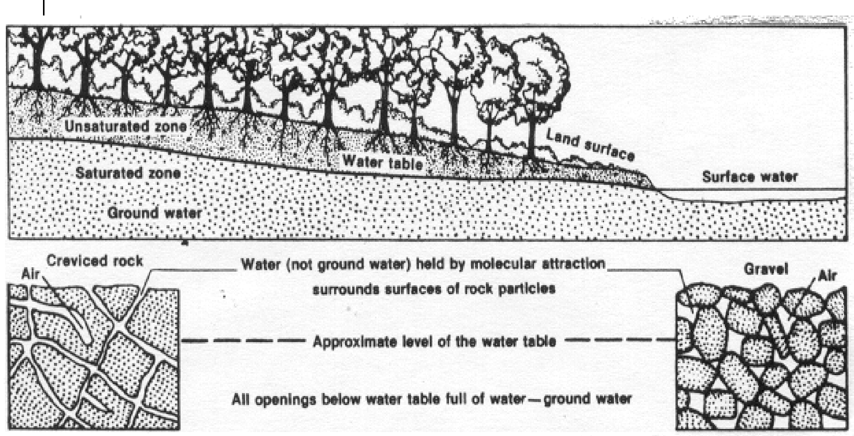
Groundwater Characteristics and Contamination Analysis

Groundwater Occurrence

As long as water is clear, tastes good and tests safe for bacteria, most people feel their water is safe and pure. Statements about water coming all the way from Canada, Lake Superior, from pure artesian springs or from glaciers when humans did not inhabit the area encouraged people to believe their own actions would have little or no effect on the quality of their drinking water (Shaw, 1985). In reality, most groundwater originates within a few miles of the wells where it is pumped from and usually has been in the ground less than fifty years. Most precipitation seeping into the soil moves only a few miles to the discharge point (Mecozzi, 1989).

Of all the available fresh water in the United States, 96 percent is groundwater. Water is evaporated from oceans, lakes, streams and the leaves of plants, and eventually returns to earth in the form of precipitation. Basically, groundwater is precipitation that percolates down into soil and fills the spaces in the rock below the land surface similar to how water fills a sponge. The first water traveling into the soil replaces that used by plants or was previously evaporated. Remaining precipitation or water that has leached from surface water, such as lakes or rivers, travels through an upper portion of soil and rock called the unsaturated zone. Depending on the amount of precipitation, the unsaturated zone is characterized by water and air in the smaller pores or spaces of rock and soil. Water not continuing to cling to those pores or spaces (due to molecular attraction) will be encouraged by gravity to drain from the unsaturated zone down to the water table. The water table can be described as the boundary between the unsaturated and saturated zones which can fluctuate depending on the season. In the saturated zone the pores and cracks of rocks and soils are filled only with water (Jorgensen, 1989).

Figure 2.1
How Groundwater Occurs in Rocks

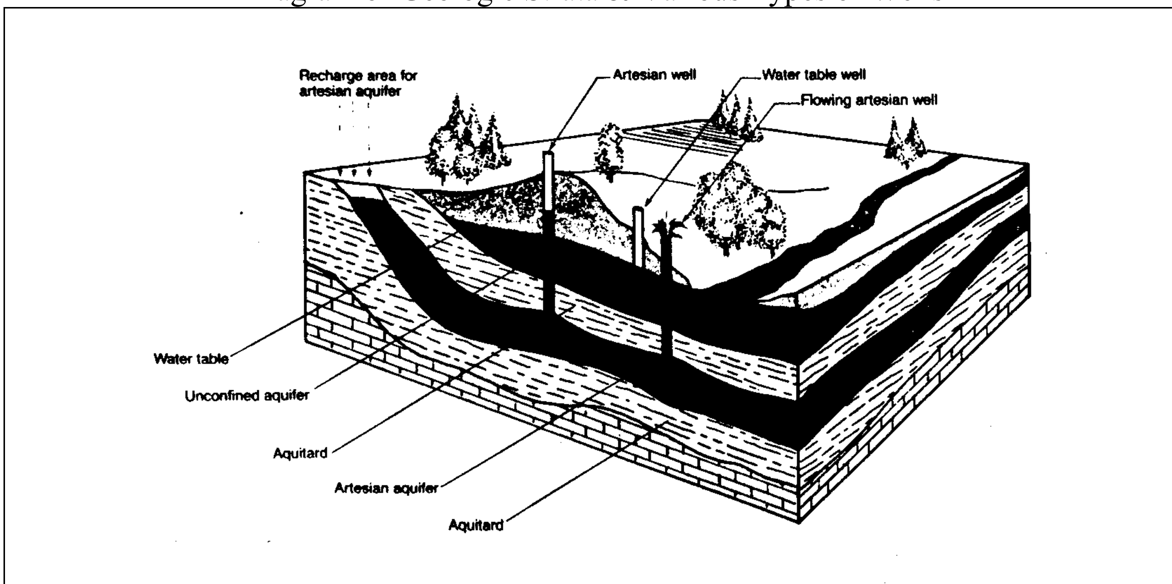


*Source: *The Poisoned Well* (1989) via USGS, Groundwater 1981.

Aquifers are underground saturated rock formations that store water. A rock formation's ability to supply water to wells depends on its porosity and permeability. Porosity is the percentage of the rock's volume (the pores or cracks) that does not include the rock itself. Therefore, the amount of water a rock formation can hold depends on its porosity. Permeability describes the interconnection between pores between which water can move. Aquifers are created and described based on varying layers of permeable and impermeable materials. Figure 2.1 above illustrates the relationship between permeability and porosity.

There are two basic types of aquifers; the unconsolidated aquifer (confined or unconfined) and the consolidated (or bedrock) aquifer. An unconsolidated aquifer is generally composed of sand and gravel and is always underlain by a layer of impermeable material called an aquitard. An unconfined unconsolidated aquifer has only the bottom aquitard layer versus the confined unconsolidated aquifer (or artesian aquifer) which has both a bottom and top aquitard layer. Consolidated aquifers, such as hard crystalline bedrock or karst limestone, do not absorb water in pore spaces but may contain water in fractures or holes in the rock (Jorgensen, 1989). In some cases, aquifers may be stacked in layers as is illustrated in Figure 2.2 below.

Figure 2.2
Diagram of Geologic Strata & Various Types of Wells



Source: *The Poisoned Well* (1989) reprinted with permission from "Groundwater Information Pamphlet." Copyright 1983, the American Chemical Society.

The University of Wisconsin Extension - Geological and Natural History Survey (UWEX, 1983) produced a map (located in Appendix A1) of the thickness of unconsolidated material in Wisconsin. A color-coding system shows the levels from 0 to 600 feet of unconsolidated material thickness in different regions of the state. Osseo, Wisconsin, which is in the northeast corner of Trempealeau County apparently consists primarily of unconsolidated material with a thickness of 0-50 feet. In some places it reaches a maximum depth of 100 feet. In addition, based on the map located in Appendix A2 (UWEX, 1993), these unconsolidated materials or soils in the northeast corner of Trempealeau County consist of forested sandy soils and forested soils over sandstone. From this information, it may be possible to analyze groundwater occurrence and potential contamination movement in the land area of Osseo, Wisconsin.

Contamination Source Overview

Sources of groundwater pollution are usually divided into point and nonpoint sources. Point sources enter the environment at specific, identifiable locations. Types of point sources may include landfills, underground storage tanks, or spills. Examples of nonpoint sources may include seepage from septic tanks, pesticides from fields and lawns, or automobile emissions. The difference between point and non-point sources of pollution is not always clear. Pollution resulting from land-sources is often spread, even at the source. Airborne pollution is generally produced at point sources, but quickly disperses and settles over large geographical areas (Ashley, 1999).

Point and non-point pollution sources enter bodies of water in distinctly different ways. Pollution from land-based point sources usually is delivered to water bodies in generally the same concentrations as when it was released. Delivery paths of non-point pollution may follow winding or scattered pathways, resulting in re-deposition of pollutants on land areas before ending up in the receiving water. For example, 10-40 percent of pesticide runoff from farmers' fields may end up in a nearby river whereas runoff from a paved parking lot into a river via a storm sewer may be 100 percent (Chesters, 1985). Common sources of groundwater contamination include; nitrates, pesticides, gasoline, volatile chemicals, toxic metals, household chemicals, leaking landfills, bacteria and viruses in the water, and some naturally occurring problems. Contamination of groundwater is not new. Nitrate levels have exceeded the 10 mg/l water standard in many wells for over thirty years. However, the discovery of pesticides problems in 1980 and volatile organic chemicals from gasoline and various cleaning and degreasing agents around 1982 in groundwater sparked the need for a more urgent response in addressing groundwater contamination (Shaw, 1985).

Groundwater Quality and Types of Potential Contamination

Groundwater quality varies greatly in Wisconsin, depending on the rocks and minerals with which the water comes into contact. Usually groundwater from deep aquifers contains higher mineral concentrations because the water is in contact with naturally occurring minerals longer. Below, Table 2.1 lists most common substances polluting Wisconsin groundwater while Table 2.2 lists the major sources of those substances. The most common problem constituents in Wisconsin municipal water supplies are hardness (calcium, magnesium, etc), iron, radon, total dissolved solids, manganese, sulfate, and radium. However, examples of contamination types attracting more governmental and public attention because of their devastating effects to human health and the environment would include pesticides, agricultural chemicals, bacteria, nitrates and organic chemicals (Turville-Heitz, 1994).

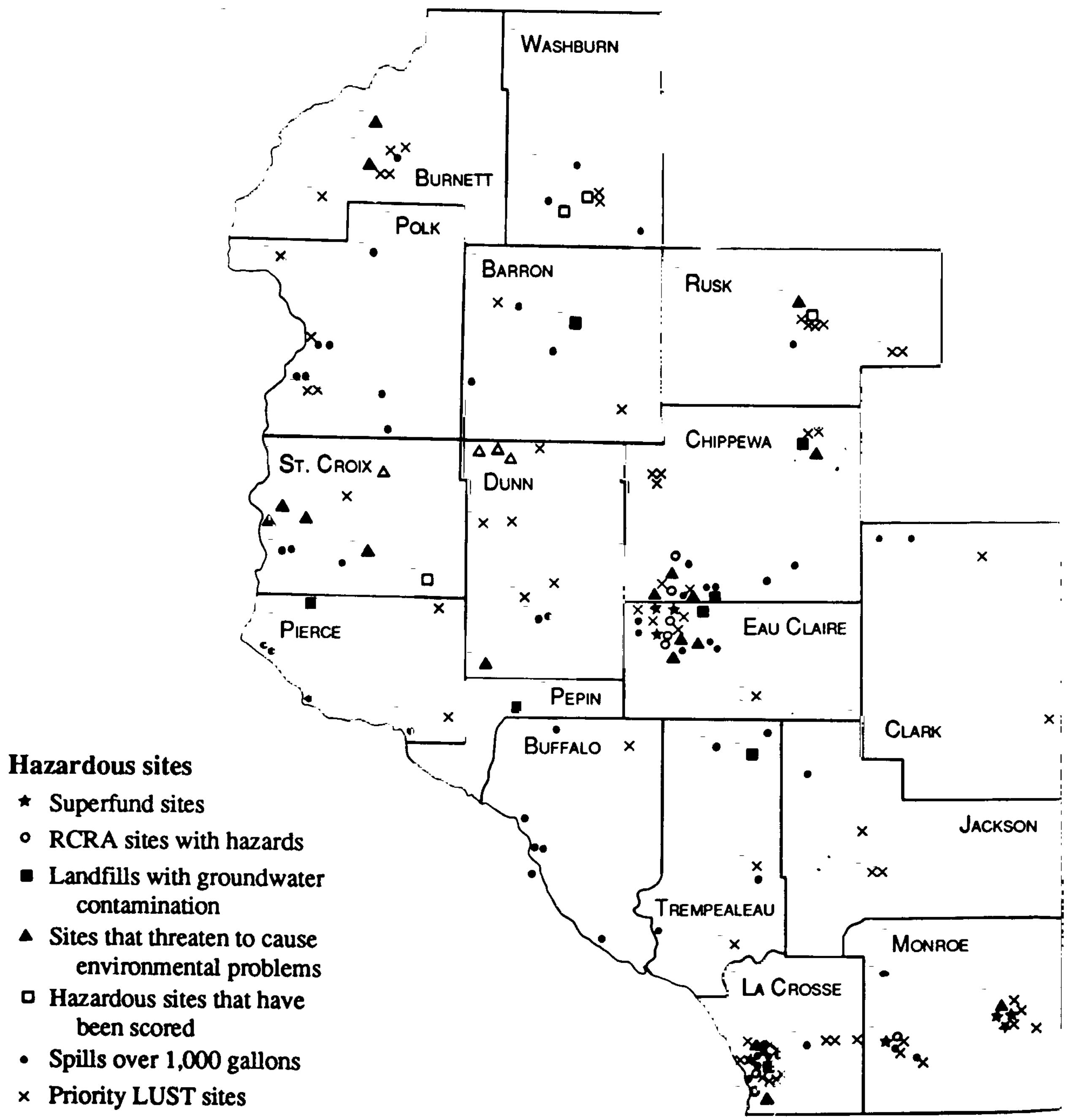
Table 2.1 Wisconsin Groundwater Contaminants		
Contaminant Category	Relative Priority	Factors
Organic Contaminants	H	2,4
Pesticides	H	2,4
Petroleum Compounds	H	2,4
Other Organic Chemicals:		
Volatile	H	2,4
Semi-volatile	H	2,4
Miscellaneous	H	2,4
Microbial Contaminants (bacteria, protozoa, & viruses)	H	2,4
Inorganic Contaminants	H	2,4
Nitrates	H	2,4
Fluorides	H	2,4,5
Brine/Salinity	H	2,4,5
Arsenic	H	2,4,5
Radionuclides	H	2,4,5

*Information obtained from Table 43 Groundwater Contaminants. Wisconsin Water Quality Assessment Report to Congress (Turville-Heitz, 1994).
Relative priority: H=high, M=medium, L=low
Factors: These are the factors used to establish the priority ranking. (1) areal extent of contamination; (2) location of contamination relative to groundwater used as drinking water, (3) size of the population at risk from contaminated drinking water from the contaminant, (4) risk posed to human health and/or the environmental from this contaminant, (5) high priority in localized areas of the state, but not over the majority of the state, (6) hydrogeologic sensitivity to this contaminant, (7) findings of the state's groundwater protection strategy or other reports, (8) other criteria.

Table 2.2 Major Sources of Contamination in Wisconsin	
Animal Feedlots	Containers
Septic Tanks	De-icing Salt Storage Piles
Fertilizer Applications	Irrigation Practices
Land Application	Landfills (permitted and unpermitted)
Materials Transfer Operations	Material Stockpiles
Mining and Mine Drainage	Pesticide Applications
Pipelines and Sewer Lines	Shallow Injection Wells
Storage Tanks (above & below ground)	Storm Water Drainage Wells
Surface Impoundments	Transportation of Materials
Urban Runoff	Waste Tailings
Waste Pipes	

*Information obtained from Table 40 Groundwater Contaminants. Wisconsin Water Quality Assessment Report to Congress (Turville-Heitz, 1994).

Figure 2.3
Potential Environmental Public Health Threats
Western Region of Wisconsin



Since public water supply wells are engineered to be least susceptible to groundwater contamination, it is highly probable that using strictly public water supply system data as a groundwater indicator will give the citizens of a community a false sense of security and may not accurately indicate actual groundwater quality. Because of this, the U.S. Environmental Protection Agency has required states to report information regarding potential environmental public health threats called indicators (see Figure 2.3 above). More accurate conclusions regarding groundwater quality may be made using groundwater indicators and maximum contaminant levels. However, knowing groundwater susceptibility for the land area being analyzed could create a more complete picture.

Contamination Susceptibility and Groundwater Movement

The susceptibility of groundwater to contamination has been evaluated at a statewide scale of 1:1,000,000. These evaluations compare the physical and chemical characteristics of soils and subsurface geologic materials, but they do not include an assessment of the presence and location of known or potentially hazardous materials that could contaminate groundwater. Using the color coded scale on the Groundwater Contamination Susceptibility in Wisconsin map (UWEX, 1989) located in Appendix A3, it appears the western region of Wisconsin, including the northeast corner of Trempealeau County where Osseo is located, is deemed to be moderately to most susceptible to contamination. It is important to remember, however, that general comparisons of groundwater contamination susceptibility maps with recorded groundwater problems are more likely to occur where populations are more dense, such as in cities or towns, regardless of the degree of natural protection the soil or subsurface materials provide for the groundwater (Turville-Heitz, 1994). In addition, susceptibility to contamination depends not only on the above-described criteria, but also on the type of contaminant being introduced and the rate of movement into the groundwater system (UWEX, 1989).

From a movement standpoint through most soils, water travels through an area called the recharge area and then into an aquifer. From the recharge area through the aquifer, the water passes out to the discharge area. Discharge areas can be wells, lakes, springs, rivers or oceans (Mecozzi, 1989). The merging between groundwater and surface water in recharge and discharge areas is very important. Recharge areas are the links between surface contamination and groundwater supplies.

In an unconfined aquifer, the recharge area is usually located immediately above and adjacent to the wellhead, so contamination occurring near the wellhead could be disastrous. In contrast, a confined or artesian aquifer is protected by an overlying aquitard, thereby being less susceptible to contamination entering from above. However, recharge areas for confined aquifers can be located at substantial distances from the wellhead, where faraway land uses or other activities can have an impact. Therefore, knowing the type of aquifer and other subsurface geologic information could be very useful in potential contamination analysis (Jorgensen, 1989).

Direction of flow from areas of recharge to areas of discharge is dependent on gravity, pressure, and friction. Generally, groundwater moves in response to a hydraulic gradient from areas of high elevation and pressure to areas of low elevation and pressure. Therefore, when looking at large areas of land, one should note that surface topography does not always exactly correspond with elevation. Points of higher elevation are usually drainage area divides or watershed boundaries. Watersheds or drainage basins are those areas of land that drain runoff water to surface water bodies. The high elevations or watershed boundaries may also be the aquifer boundary because aquifers are often found beneath the surface of drainage basins. If the groundwater becomes contaminated, generally the only part of the aquifer to be affected is down-gradient of the contamination source site. Tracking contaminate movement, however, may not always be so simple. Unpredictable flows (because of bedrock obstruction) or large irrigation or municipal wells that pull large volumes of groundwater can create problems when trying to determine flow (Jorgensen, 1989).

In unconsolidated aquifers, groundwater travel is very slow, generally measured in feet or inches per year. It follows distinct pathways and seldom mixes, therefore, allowing contaminants to act in the same way. A plume of contaminates in groundwater, unlike contaminates in surface waters, would be subject to very little dispersion by mixing, sun exposure, temperature differences, or bacteria (Jorgensen, 1989). Therefore, very little physical, chemical, or biological breakdown of contaminants occurs in the short-run. Ultimately, contamination plume shape and concentration are dependent on local geology, elevation profiles, physical and chemical properties of the contaminant, rate of pollution by the source, and flow deviation because of pumping or large volume wells.

Losses Associated With Groundwater Contamination

Health Effects and Exposure Potential

In the United States today, industry uses over 60,000 chemicals and produces between 500 and 1000 new chemicals each year (Jorgensen, 1989). Yet only a very small amount of these have been tested to determine their effects on human health and the environment. The little information that is known is the result of animal, epidemiological, and microbiological laboratory studies (Frei, 1983).

In 1984, the Office of Technology Assessment (OTA) assembled a list of over 200 contaminants known to occur in groundwater. Because of increased well monitoring, the current list is probably more than three times as large (Jorgensen, 1989). The list gets longer with the addition of biological agents that could contaminate groundwater. Following is a brief description of common groundwater contaminants, their sources found in the west-central region of Wisconsin, and some associated health effects.

The presence of biological contamination

Biological contaminants include bacteria, viruses, algae, and other microscopic creatures. Generally, groundwater is likely to have fewer microorganisms than surface water, however, sizable numbers of biological contaminants can flourish due to the natural decomposition of plants, animals, and animal wastes that serve as their food source. In addition, certain microorganisms flourish because of abundant moisture and the lack of light and air (Shaw, 1985)

In 1985, about 13 percent of drinking water samples submitted to the Wisconsin State Lab of Hygiene and 9 percent of samples to the UW-Stevens Point Environmental Task Force Lab are positive for coliform bacteria. The coliform group of bacteria, used as an index of bacteriological safety, are not disease-causing bacteria, but indicate whether soil runoff or animal or human waste is reaching the water supply. Little is known about the possible occurrence of viruses in drinking water. However, the absence of coliform bacteria probably indicates the absence of viruses. Actual contamination of groundwater with bacteria is generally more likely to occur in areas of shallow, fractured bedrock or limestone, or where very coarse sands and gravels occur (Shaw, 1985).

Dangerously high levels of bacteria and viruses may be the result of leaking septic tanks and animal feedlots. Leaching of fecal material into the ground can result in outbreaks of gastrointestinal illnesses, typhoid, infectious hepatitis, cholera, and tuberculosis. Statistics show biological contamination to be the most common form of groundwater contamination affecting human health, but this could change when people become more aware of the effects of chemical contamination (Jorgensen, 1989).

The occurrence of nitrates

Nitrates from septic tanks, animal wastes, fertilizers, landfills, decomposing vegetation, and geologic deposits may be the single most common cause of groundwater contamination. Overall, about 10 percent of Wisconsin drinking water wells exceed the state groundwater nitrate standard (Mecozzi, 1989). When as much as ten inches of rainfall per year recharges the groundwater, it takes only 25 lbs. of nitrogen to raise groundwater concentrations to the 10 mg/l standard. Agricultural fertilization rates often exceed 200 lbs./acre for corn or potatoes. Most of the nitrogen not used by plants leaches down to the groundwater (Shaw, 1985). Nitrates in drinking water supplies have been linked to nervous system impairments, cancer, birth defects, and methemoglobinemia or blue baby syndrome (Jorgensen, 1989).

The good news is nitrates are not usually harmful to healthy adults or older children. However, drinking water high in nitrates does threaten infants under the age of six months. Their stomach acid isn't strong enough to kill certain types of bacteria capable of converting nitrates to harmful nitrites. Nitrites bind hemoglobin in the blood, preventing oxygen from getting to the rest of the body; the baby may lose its natural color and turn blue. “Blue baby syndrome” or methemoglobinemia simply causes suffocation (Mecozzi, 1989).

<u>The incidence of inorganic contaminants</u>

Inorganic contaminants such as metals and salts, reach groundwater because of both natural and human sources. Adverse health effects from heavy metals exposure are the best documented of inorganic contaminants. Common heavy metal contaminants include arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, and zinc. Because these metals do not breakdown easily, buildup over time in the body, and are excreted very slowly, they can cause a range of severe health conditions. Central nervous system disorders, lung, kidney, and liver damage, gastrointestinal disturbances, birth defects, and cancer are some of these conditions (Jorgensen, 1989).

<u>The incidence of organic contaminants</u>

Common organic contaminants found in groundwater include pesticides, solvents, and gasoline-related compounds. Of these, man-made or synthetic compounds are increasingly being detected in groundwater. Many of the synthetic organic compounds, especially volatile organic compounds, are more mobile and less susceptible to biological and chemical degradation than microbiological and inorganic contaminants (Shaw, 1985).

Over 500 pesticides (including insecticides, herbicides, and fungicides) are used in Wisconsin, with many having breakdown products as toxic as the parent compounds. In a survey conducted in the mid 1980s, the EPA found at least 17 kinds of pesticides contaminating the groundwater supplies of 23 states just from normal agricultural use

(Shaw, 1985). Since then, there have been two major attempts to assemble available data on the detection of pesticides in the groundwater of the United States. The 1988 Survey of State Lead Agencies summarized data on the occurrence of pesticides in the groundwater of 35 states. The more extensive Pesticides in Ground Water Database, or PGWDB compiled by the U.S. Environmental Protection Agency in 1992, contains data from 45 states (Barbash, 1996). Appendix A4 contains charts showing the number of pesticide compounds from different chemical classes detected in ground waters of the United States based on these studies. Appendix A5 contains diagrams of annual herbicide, insecticide, and fungicide use on individual crops expressed as pounds of active ingredient applied per treated acre and contains non-agricultural pesticide annual use on turf grass maintenance in the United States. Long-term exposure to certain organic pesticides has been linked to liver damage, birth defects, sterility, genetic mutations, spontaneous abortions, and cancer. However, drinking water standards exist for only a few pesticide chemicals. In addition, analytical methods for testing are complex and very costly (Shaw, 1985).

In addition to pesticides, solvents are leaking into groundwater at alarming rates because of improper storage and disposal methods used by plating and electronic industries, airports, chemical waste handlers, gas stations, dry cleaners, and many other businesses. Although health information on organic chemicals is just beginning to emerge, exposure to common solvents such as TCE (trichloroethylene), benzene, toluene, methylene chloride, and acetone has been linked to impairments of the central nervous and circulatory systems as well as to skin, nose, throat, and lung damage (Jorgensen, 1989).

Contaminants associated with landfills

Wastes that can't be recycled must be stored in properly sited, designed, constructed and maintained landfills to minimize the amount of leachate that percolates through the solid waste down to the groundwater. There are about 150 of these such *engineered*, licensed landfills operating in Wisconsin and most do a good job protecting groundwater. However, another 200 licensed landfills are required to monitor groundwater and over 700 *unengineered* dumps were "grandfathered" and can't meet the strict leachate collection standards. In addition, there are 2,700 known (not including the hidden) abandoned dumps in the state. These abandoned sites were deserted before stiff regulations went into effect in the 1970s and these sites continue to leach contaminants into the groundwater. Many unengineered landfills are scheduled to close within the next decade, but, until then and for decades to come, unengineered and abandoned landfills will allow toxic fluids to seep into groundwater. (Mecozzi, 1989).

The Wisconsin DNR (Department of Natural Resources) has identified 198 abandoned waste disposal sites as high priority candidates for follow-up study of groundwater contamination. However, clean-up of old sites is expensive and depends mainly on federal superfund for financial support. Newly engineered sites are much less likely to cause problems, but require extensive monitoring to be sure the installation is operating correctly. Chemicals reaching groundwater from landfills are as varied as the multitude of chemicals disposed of in them. It is nearly impossible to inspect all refuse being disposed at a landfill to be sure toxic chemicals are not being discarded at sites not approved for hazardous waste (Shaw, 1985).

In summary, even though it is possible to discuss in general some of the health effects associated with certain types of contaminants, it is very difficult to predict the health effects that might be caused by a particular contaminant in a particular case of groundwater contamination. There are many factors affecting a contaminant's potential to effect humans and the environment. People may experience many varying health effects depending on the quantity, frequency, duration of exposure, and individual susceptibility to contaminants (Shaw, 1985). In addition, environmental conditions such as soil or bedrock types or how new chemicals introduced to the environment react with potentially toxic chemicals already existing, may alter or increase exposure and effects.

There is a growing amount of literature showing the effective solubility of organic compounds is changed by the presence of other organic molecules. The presence of naturally occurring (or previously introduced) organic compounds has been shown to increase the solubility of polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), DDT, and pyrene (Grundl, 1997). Therefore, with these potential combinations, the likelihood of some very dangerous chemicals reaching the groundwater may increase.

Research is increasing the knowledge about groundwater and potential contamination but as yet has solved a limited amount of problems. It is apparent that much more monitoring and health effects testing must be done to help in prevention of contamination and loss. Involvement at the local level will be very beneficial in this effort to prevent illness and other types of loss.

<u>Economic and Resource Loss</u>

The majority of sites associated with the United States $15.6 billion Superfund program have groundwater contamination. This program, which deals with only the worst cases of contamination as identified by the national priorities list, has insufficient funds to clean up all the contamination. Therefore, at the local level where remediation efforts are taking place, groundwater contamination is having significant impacts on property value and local government agencies.

Most research on the costs of groundwater contamination regarding the expense and results of remedial action indicate that municipalities and industry both suffer huge costs due to groundwater contamination. A survey of groundwater contamination in Minnesota found a major loss to the tax base because of real estate devaluations and lack of business development. Five cities in this study together lost over $8 million dollars in tax revenues (Page & Rabinowitz, 1993).

Following the lead of the CERCLA law, an EPA enforced federal legislation that established the Superfund program, many states have enacted laws that require parties to clean up the contamination under conditions of "joint and several liability". This allows the state to conduct the cleanup and attempt to recover the costs from the responsible parties. The current landowner, who may not have caused the pollution, may be the only party with assets and thus be held liable for cleanup costs (Page & Rabinowitz, 1993).

Properties ideally located and most likely to be developed commercially are generally in urban areas or towns. Local governments must be aware that with industry comes a potential groundwater contamination source. Therefore, governments must take their responsibility for protecting public health and the environment very seriously. A case study (Page & Rabinowitz, 1993) was performed to assess the effects on property values and cities due to groundwater contamination. Six properties were evaluated; three in Pittsburgh, two in Milwaukee, and one in Santa Fe Springs, California. The cases

(Table 2.3 below) show that groundwater contamination significantly influenced the value of commercial property.

Table 2.3
Property Value Case Studies of Commercial Real Estate

Location	Size of Property	Contaminant	% Decrease after Cleanup	Change in Value
Herr's Island Pittsburgh, PA	44 acres	PCBs	27-37	- $2.7 million
Jones & Laughlin Pittsburgh, PA	14 acres	Iron-cyanide	--	Project on hold
Public Safety Building Pittsburgh, PA	3.8 acres	TPH	30-40	- $2 million
Commerce Center Santa Fe Springs, CA	75 acres	Petrochemicals	10-20	- $3 million
Kroeger Building Milwaukee, WI	60,000 square feet	Chromium and cyanide	50	- $100,000
Badger Boiler and Burner, Milwaukee, WI	--	Methylene Chloride	--	Project on hold

Source: Page, G. William and Rabinowitz, Harvey (1993). Groundwater contamination: Its effects on property value and cities. Journal of American Planning Association, 59, p473.

The above case study properties are abandoned industrial properties, known as temporarily obsolete abandoned derelict sites (TOADS), which possess serious toxic chemical contamination of the groundwater. Cities and other local governments face a potential crisis in dealing with TOADS. Some local governments that have taken tax delinquent property in lieu of taxes have had to pay twenty times the value of the property to cover cleanup costs. Because of potential involvement in third-party lawsuits, some cities have stopped taking tax delinquent contaminated properties if not required by the state. As a result, these properties remain in a state of limbo as does the public health consequences to the community from the contamination.

In 1992, the City of Milwaukee, Wisconsin listed 175 sites that it refused to acquire in lieu of taxes owed. The list was mostly made up of small parcels that formerly housed gas stations and dry cleaners, but also included some large industrial production sites. Small sites sometimes contained as much or more contamination as the large sites. In almost all cases, previous owners could not afford cleanup costs. Milwaukee estimated a potential cleanup cost of $30-40 million for these sites (Page & Rabinowitz, 1993).

Even when municipalities take ownership of the property, they may decide not to fence off contaminated properties to protect the public because such an action may imply “active management” of the site and make them liable for cleanup costs even if they were not responsible for causing the contamination. Children may be playing on abandoned, tax delinquent, and contaminated sites known to threaten their health, but the city refuses to take the property in lieu of taxes or fence it because of legal or financial consequences. This creates a dilemma for the community and the municipality, and as a result of this type of quandary, the EPA is developing guidelines that will clarify federal policy regarding this issue (Page & Rabinowitz, 1993).

In addition to remediation and liability problems, contaminated properties could cause problems for municipal governments regarding assessments for property taxes. Many believe a property with a significant defect should not be valued at the same amount as a comparable property nearby. If the contaminated property has a lesser value, the owners would most likely pay less property tax. In a related situation, the valuation assessment of a major New York office building was significantly reduced due to the presence of asbestos fireproofing. The assessment of the building was reduced for a number of reasons, but many millions of the total reduction of $360 million was attributable to the presence of asbestos. In two Michigan cases, assessments were reduced for homes that were near heavily contaminated landfills. However, the Supreme

Court held that the cleanup costs were a part of an ongoing business and not part of the value of the site. Thus it is likely that inconsistencies in court decisions make it possible for other types of case decisions which would reduce assessment values (Page & Rabinowitz, 1995).

Control Methods

Regulatory Control

The protection of groundwater is complicated and requires research, planning, law and rule promulgation, programs and actions at various levels of government (federal, state, and local). However, the main responsibility for groundwater management lies with state and local government and their agencies delegated to address it. Following is a breakdown (acquired from Eau Claire County; Groundwater Management Plan, 1994) of federal, state and local regulations affecting groundwater management.

Federal Government

1. Safe Drinking Water Act of 1974 (SDWA)

   This law authorizes the United States Environmental Protection Agency (EPA) to establish maximum contaminant levels and monitoring requirements for public water systems.

2. Resource Conservation and Recovery Act of 1976 (RCRA)

   This law authorized the EPA to set guidelines and standards for solid waste facilities and a hazardous waste program with standards for the transport, treatment, storage and disposal of hazardous waste. The main focus of this program is groundwater protection.

3. Toxic Substances Control Act of 1976 (TSCA)

By this law, EPA is authorized to prohibit or restrict the manufacture, distribution and use of products that present unreasonable risks of injury to public health or the environment. Groundwater is included in the definition of "environment".

4. Clean Water Act of 1977 (CWA)

   Regulatory program focus of this law is on surface water. However, it also refers to groundwater protection in municipal wastewater treatment programs and in research and planning activities.

5. Federal Insecticide, Fungicide and Rodenticide Act of 1978 (FIFRA)

   This act gives the EPA responsibility to consider the environmental impacts of pesticides and to control their use. Pesticide use that affects groundwater is controlled by the EPA.

6. Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA or Superfund)

   The EPA is authorized by this act to address the release into the environment, including groundwater, any contaminant, pollutant or hazardous material that presents an impending danger to the public health, safety, or environment.

As indicated by the previous review of regulations, the principal federal agency addressing groundwater quality management is the EPA. The EPA developed a Groundwater Protection Strategy in an attempt to coordinate federal and state laws and regulatory efforts. The strategy incorporates four main parts regarding important groundwater management needs (list acquired from Eau Claire County; Groundwater Management Plan, 1994):

1. Short-term buildup of institutions at the State level;
2. Assessing the problems that may exist from unaddressed sources of contamination. In particular, leaking underground storage tanks, surface impoundments, and landfills;
3. Issuing guidelines for EPA decisions affecting groundwater protection and cleanup; and
4. Strengthening EPA's organization for groundwater management at the Headquarter and Regional levels, and strengthening EPA's cooperation with Federal and State agencies.

The groundwater management approaches identified in the Strategy included:

1. Initiation of state groundwater protection strategies by 1985 and the implementation of these strategies by 1990;
2. State classification of aquifers by categories of use (the EPA is to develop a uniform set of categories for the states to use); and
3. Adoption of regulatory programs by the EPA to control groundwater contamination from high priority problems, such as leaking underground storage tanks and the disposal of toxic and hazardous materials.

The above groundwater management approaches indicate, that state and local governments have the principal role in groundwater protection and management. States in partnership with local governments, are best suited to undertake direct implementation and enforcement of groundwater protection programs (National Groundwater Policy Forum, 1985).

The 1986 and 1996 amendments to the 1974 Federal Safe Drinking Water Act (SDWA) established a nationwide program to protect groundwater used for public water supplies. As part of the amendments, states were required to adopt wellhead protection zone programs providing protection from a wide range of contaminants. In order to qualify for funding authorized under these amendments, states were to submit their programs for EPA approval by 1989. In addition, the DNR received EPA approval of Wisconsin's Source Water Assessment Program (SWAP) Plan in November 1999. The plan was submitted to meet the requirements of the 1996 SDWA Amendments. In the next four years the program will: 1) delineate source water protection areas for all public water systems in the state, 2) conduct inventories of significant potential contaminant sources within those areas, 3) perform analysis of susceptibility for each system, and 4) make the results of the assessments available to the public (Eau Claire, 1994).

On February 19, 1993, a new national sewage sludge regulation (40 CFR, part 503) was published in the Code of Federal Regulations. This regulation placed additional requirements on the land application of municipal sewage sludge, including monitoring, pollutant limits, cropping standards, vector control, and public access restrictions and reporting. These requirements exceeded those that were satisfied by the Wisconsin Department of Natural Resources WPDES (Wisconsin Permit Discharge Elimination System) permitting process in place at that time (Eau Claire, 1994). Consequently, the 1992 Federal Worker Protection Standard was developed by EPA and USDA (United States Department of Agriculture) Extension Service. Under the provisions of this law, employers must provide workers with information and equipment necessary to protect themselves from pesticides during agricultural practices. This includes workers on farms and in forests, nurseries, and greenhouses. The educational component of the law is handled by UW-Extension and includes required postings regarding the law in areas where workers can see them.

<u>State Government</u>

In May, 1984, Wisconsin Act 410 (The Groundwater Law) was signed into law, expanding Wisconsin's legal, organizational and financial capabilities for groundwater protection. This important legislation created Wisconsin Statutes Chapter 160. As a result, the DNR was required to adopt statewide groundwater quality standards. All state agencies which regulate the potential sources of groundwater contamination must comply with these standards. The six major components that make up The Groundwater Law are as follows:

1. A two-tiered system of groundwater quality standards, one public health related, the other public welfare related, to address all potential sources of pollution and all of the states regulatory programs.
2. A well replacement program to compensate owners of polluted wells.
3. A groundwater monitoring program.
4. An environmental repair fund similar to federal Superfund for cleaning up landfills and hazardous waste sites.
5. Expanded regulations for the bulk storage of fertilizer, pesticides, flammable liquids and road salt.
6. A Groundwater Coordinating Council, comprised of representatives from the Governor's office and all State agencies with groundwater management

responsibilities, to coordinate groundwater research, education, and planning data.

In Wisconsin, there are many state regulations which address potential groundwater pollution. A summary of the major state regulations for various groundwater contamination sources is presented in Appendix A6 State Regulatory Groundwater Management Tools of Wisconsin.

Local Government

Local units of government typically possess or are required to have controls which effect the management and protection of the groundwater resource. Local zoning ordinances which prescribe the location, extent and intensity of various land use practices are important in the site of potential groundwater contamination sources. For example, the Eau Claire County Zoning Ordinance, Title 18 has provisions for conditional use permits that address animal waste handling, pesticide and fertilizer storage, junkyards and non-sewered development. Title 17 of this ordinance contains the manure storage requirements for Eau Claire County. Conditional uses also require plans for water and sewer use and best management practices for erosion and storm water control. In addition, development densities and subdivisions have restrictions regarding on-site wastewater systems. The enforcement of a county sanitary code (Eau Claire County Code Chapter 8.12), such as on-site wastewater permitting and sanctions on illegal dumping, gives local government additional regulatory capabilities to protect groundwater. The state authorizes local governments to administer portions of certain state regulatory programs relating to groundwater protection, such as private well construction codes and septage disposal (Eau Claire County, 1994).

Non-regulatory and Community Educational Programs

Local governments can also have a significant influence in promoting non-regulatory approaches to groundwater protection. Examples of these measures include groundwater public education and information programs, promotion of best management practices for fertilizer and pesticide application, the establishment of recycling and household hazardous waste disposal programs, and local incentives to improve groundwater quality (Eau Claire County, 1994). However, the coordination of information generally starts at the state level and filters down to the local governments.

The Wisconsin Groundwater Coordinating Council (GCC) was formed in 1984 to help state agencies coordinate non-regulatory activities and exchange information on groundwater. The GCC prepares an annual report which summarizes the operations and activities of the council and includes a description of the current groundwater quality of the state, an assessment of groundwater management programs, information on the implementation of Chapter 160, Wisconsin Statutes, and a list and description of current and anticipated groundwater problems. In addition, the GCC supports groundwater research and monitoring proposals throughout the state. Many times from these studies, in cooperation with the Department of Natural Resources and Department of Health & Family Services, GCC will sponsor and endorse the development of brochures for the public regarding groundwater public health concerns.

The University of Wisconsin – Extension Service is another source of community educational and research information. The UW-Extension Service has offices in each county of Wisconsin that support studies and promote education as required by the state or that are specific to the county's assessed needs. In 1990, the University of Wisconsin conducted an extensive study to examine current and future water management issues and to determine the Extension's role in water management issues. Trempealeau County was one of three Wisconsin Counties that was selected as a pilot county to demonstrate a water management needs assessment process. This process was designed so counties could identify local water management issues and develop and implement action plans to address local priority water issues. Trempealeau County was selected because of its diverse geology and land uses, and the interest from the local Extension Office in this effort (Malone, 1990).

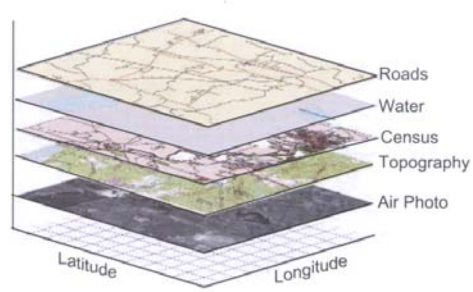
Many Wisconsin state and local agencies, including the agencies listed above, are involved in non-regulatory activities to promote safe drinking in communities throughout the state. State agencies such as the Department of Natural Resources (DNR), Commerce, Agriculture, Trade and Consumer Protection (DATCP); Health and Family Services (DHFS); Department of Transportation (DOT); and Wisconsin Geological and Natural History Survey lead and supplement the efforts by local government and local agencies. In order to be effective, all of these agencies (federal, state, and local) must continue to take part in the research, monitoring and dissemination of information in order to have an impact on groundwater protection (GCC, 2000)

Use of Graphical Information Systems

A geographic information system (GIS) is a combination of computer hardware and software that stores, links, analyzes and displays information identified according to geographic location. GIS technology is capable of performing a wide range of information processing and display operations such as map production, data analysis, and statistical modeling. For example, an area feature of the earth (e.g., a lake shoreline) can be linked to salinity or depth of lake characteristics data. GIS is also capable of integrating layers of information as is demonstrated in Figure 2.4 below.

Figure 2.4

Source: U.S. Department of Health and Human Services-ATSDR (2000). Special Issue on Geographic Information Systems. Hazardous Substances & Public Health, Vol. 10, no. 2.



The Agency For Toxic Substances and Disease Registry (ATSDR) provides a variety of GIS-based products and services to support site-specific activities conducted by ATSDR staff and employees of health departments in 28 states. Some activities include demographic mapping for Superfund sites, using spatial analyses to generate site-specific demographic estimates, and using a GIS for characterization of a population living near a hazardous waste site for risk analysis. ATSDR is currently using a wide range of small area demographic-based data to create community profiles as a logical first step in assessing public health issues near hazardous waste sites (ATSDR, 2000).

In addition to the work conducted by ATSDR, the Wisconsin Department of Natural Resources (DNR) is currently conducting a pilot program for an environmental inventory using GIS in the northeast region of the state. Computerized maps have been created which link all potential groundwater impact site locations with their respective data. Many consultants, county agencies, state agencies and realtors have utilized this information for environmental management and land transactions. The chief benefits to the public have been the ability to rapidly access information and provide greater purchasing confidence when buying property. Landowners also experience an increase in their known responsibility as they become aware of how readily available this information is. In this way, use of GIS has heightened awareness of the importance of wise land use (GCC, 2000).

Other studies are also being conducted around the state using GIS technology. The U.S. Geological Survey is developing and testing a water-balance model linked to a geographic information system to estimate annual recharge rates in the Pheasant Branch watershed near Middleton, Wisconsin. The water-balance method is based on mapped soils information, and accounts for gains (precipitation), losses (runoff, evapotranspiration), and changes in groundwater storage over individual soil units. In order to maintain some semblance of effective groundwater resource management, solid understanding of the chronological and spatial distribution of groundwater recharge is needed (Bradbury and Hankley, 2000).

Non-point source groundwater contamination by agricultural chemicals has led to the development and use of simulation models to help assess ground water vulnerability to pesticides and nitrate contamination. Graduate students from the College of Natural Resources at UW-Stevens Point are developing a system using a popular pesticide and nitrate modeling program for running simulations over large areas such as watersheds. The system will also be linked with non-spatial databases such as pesticide and crop management databases. The goal is to have a model where users can input data and create output data in the form of tables, charts, and maps (Akbar and DeGroote, 2000).

It is likely that GIS use will make it possible to compare federal, state, and local activities involving economic development, demographics, environmental issues, and public health. The benefits will be more cost-effective and comprehensive planning of community development, social services, and future public health services. A steadily growing source of data suitable for GIS applications is easily accessible on the internet, from federal, state, and local agencies. Since this information is spread out among many sources, it becomes necessary to collect and integrate this information specific to a particular communities management needs.

Summary

Wisconsin relies on groundwater for many uses. Of Wisconsin's cities and villages, 94 percent use groundwater for drinking purposes, with a total of 75 percent of Wisconsin's residents relying on groundwater for their only water supply (Turville-Heitze, 1994). Because of this widespread use, Wisconsin as well as the federal government has adopted many codes designed to protect groundwater. However, because of the continued use of high volumes of water and the lack of information on the many chemicals introduced into the environment every year, it seems probable that more must be done.

Agencies such as the Wisconsin Groundwater Coordinating Council and the University of Wisconsin Extension Service continue to provide public education and fund studies to assess the risks associated with different land-use. In addition, other funded studies try to determine the effects of certain processes or chemicals on the environment and human health. These studies, in addition to other agencies studies, help communities to plan for groundwater protection above and beyond what the regulations cover. As the population and therefore water use continues to increase, it becomes even more important to plan for and implement controls to ensure a safe drinking water source.

Controls such as local and state regulations, land-use plans, and public education are essential parts of groundwater management systems. Information programs introducing best management practices for fertilizer and pesticide application and storage, water conservation, and correct disposal or recycling of hazardous substances will likely result in the prevention of potential contamination to Wisconsin's groundwater system. In addition, it seems apparent that basic land-use and groundwater protection ordinances should be developed and continually updated as more information (regarding risks to groundwater) becomes available in order to meet specific communities needs.

Ultimately, every community will likely need to perform some type of needs assessment and research current regulations and other data available from many different agencies. Once information is collected, it can be input to a geographical or database type of system. From this information local planners, regulatory officials and community members can make informed decisions regarding groundwater use and protection.

CHAPTER 3

Methodology

Introduction

The purpose of this study was to identify the extent that effective wellhead protection-related activities are being performed/promoted in Osseo, Wisconsin. This chapter will attempt to explain the process by which this study was conducted. The following approach was used:

1. **A review of current literature to determine the risks associated with municipal wells depending on potential sources of contamination.**

   The review of literature covered three main areas including; groundwater characteristics and contamination analysis, losses associated with groundwater contamination, and contamination control methods. Groundwater quality is dependent on many factors such as contamination susceptibility, movement, and types of contaminants introduced. Chapter 2 outlined these factors in detail and discussed the potential for human exposure and health effects associated with potential contamination.

2. **An evaluation of basic hydrogeology and features of the land area surrounding the City of Osseo.**

   Five characteristics associated with groundwater susceptibility are: type of bedrock (or aquitard), depth to bedrock, depth to water table, soil characteristics, and characteristics of municipal well construction. Data collected as a result of contact with City of Osseo officials, review of municipal well construction records, and Wisconsin geological-based information were used to determine those physical characteristics.

3. **Review of City records, maps, local ordinances (with comparison to state requirements) and wellhead protection activities being conducted by City personnel.**

Permits obtained by Osseo residents for sand point wells, monitoring wells data, local ordinances, and past water sampling results were obtained for analysis. Personnel responsible for wellhead protection activities (i.e., sampling, community notices and newsletters, data collection, etc.) were contacted for further information. In addition, wellhead protection activities were compared with Wisconsin requirements and surrounding communities' activities.

4. **Use of a graphical information system to inventory and analyze data and information obtained in order to evaluate risks to groundwater.**

A potential source contamination inventory was completed. Locations of potential sources of contamination, including zoning information were mapped. These locations were linked to a database including a description of the location, sampling data (where applicable), and exact coordinates relating to an aerial photograph of the City of Osseo. Analysis of this information was then performed to evaluate risks to groundwater serving the City.

Procedures Followed

The following steps were followed to conduct this study:

1. Informal discussions were conducted with staff from the City of Osseo Office of Public Works, Trempealeau County-University of Wisconsin Extension Service, and Wisconsin Department of Natural Resources to determine if there was interest in a study regarding groundwater quality for the City of Osseo.
2. The purpose of the study and significance was reviewed and approved in July, 2000 by the City of Osseo City Council. (See Appendix B3).
3. All research study forms required by the UW-Stout Graduate College were completed and approved.
4. A review of literature was completed during the fall, 2000.
5. Public records and data were obtained from Osseo and Wisconsin state offices for use in groundwater quality and contamination susceptibility in Osseo, Wisconsin.
6. Data entry into an Archview GIS was performed and further analysis was conducted on such information during the winter, 2000.
7. Conclusions and recommendations were presented to officials with the City of Osseo, Trempealeau County-University of Wisconsin Extension Service, and other County agencies as appropriate.

Summary

The methodology reviewed the steps in preparing for and conducting the research. Review of literature, local, and state records were used to obtain and analyze information regarding groundwater quality and contamination potential for the City of Osseo. Recommendations and conclusions were made based on the research information analyzed.

CHAPTER 4

Results and Discussion

Restatement of the Problem

The purpose of this study is to identify the extent that effective wellhead protection related activities, i.e., tracking, testing, controls, etc., are being performed or promoted in Osseo, Wisconsin.

The objectives of this study are to:

1. Identify wellhead protection activities that are currently in place and the persons (and their qualifications) responsible for them.
2. Perform a physical characteristics inventory of areas surrounding the wellheads(s) in Osseo, Wisconsin; such as groundwater flow direction, soil types, potential contamination sources or spills, land-use, etc.

Information was obtained through a literature and local and state records review for analysis of groundwater quality and contamination potential for the City of Osseo, Wisconsin. This chapter is divided into four main areas including; (1) basic hydrogeology and groundwater use, (2) land-use, (3) current wellhead protection activities, and (4) a GIS source contamination inventory. Conclusions and recommendations and conclusions will be made in Chapter 5 based on this information and results.

Basic Hydrogeology & Groundwater Use

The City of Osseo, Wisconsin has a population of 1,649. According to Jim Deich, City of Osseo Water Works Director, most of the population is connected to City water with the exception of a few industrial users. From an average consumption standpoint, current water use by each resident in Osseo is approximately 144 gal/day. The population is expected to continue to grow at a slightly increased rate. Between 1990 and 2020, Osseo's population is expected to increase 17% (Walkey, 1999).

Osseo water sources are from two municipal wells pumping from the Eau Claire and Mt. Simon Sandstone aquifers. One well is located at 9th and Charles Streets (Well #3) and a second is at 12th Street and Rose Lane (Well #2). Well #3 has a water treatment filter to remove iron and manganese before it is pumped into the water distribution system. These minerals are generally not a health concern and are removed because they can discolor the water and create a slight taste of iron. The water is also chlorinated at both wells for disinfection before it is pumped into the water system. Following are two tables with specific information relating to wells #2 and #3 (ECG, 1996).

Table 4.1
Osseo Municipal Wells Information

Characteristic	Well #2	Well #3
Well depth	170 feet	217 feet
Depth to water table	95 feet – static 120 feet - pumping	88 feet – static 94 feet - pumping
Year of construction	1951	1964
Last interior inspection date	1990	1990
Aquifer type	Sandstone	Sandstone
Chemical additions	Caustic soda beads (pH adjustment), chlorine	Caustic soda beads (pH adjustment), chlorine

Table 4.2
Osseo Municipal Well Water Consumption

Year	Average Day	Maximum Day	Per Capita/Day
1990	182,068 gallons	346,000 gallons	117 gal/day
1985	159,313 gallons	534,600 gallons	108 gal/day

Soils

As was discussed in Chapter 2, unconsolidated materials, which include soils, have a thickness of 0-100 feet in the land area of Osseo, Wisconsin (See Appendix A1). The soils in and around the City of Osseo were mainly formed from glacial deposits and water-laid sandy material. The soils of this area are an association of Billett-Sparta-Gotham, which are well drained to excessively drained soils that have a subsoil of sandy loam to loamy sand over sand. These are well-drained soils that are erosive on slopes. They are also subject to wind erosion, a factor that may be considered during any construction on these soils. Agriculturally they have severe limitations for crops because of the erosive sandy conditions, but they are moderately suitable for pastures and woodlots. Therefore, the urban suitability of these soils is fortunately somewhat better than the agricultural suitability (Osseo, 1973).

Beneath the unconsolidated materials is the consolidated material (or bedrock), which consists of sandstone with some dolomite and shale. Specifically, Wells #2 and #3 pass through the Eau Claire (0-130 feet) and the Mount Simon (130-170+ feet) formations. Categories of classification allow people to organize and apply knowledge regarding managing of farms, fields, and woodlands, in developing rural areas, and in engineering work (Langton, 1976).

Land-Use

The Trempealeau County Zoning Department is working with individual towns within Trempealeau County to develop land use plans that will ultimately guide future development. The County Zoning Department will work with three towns at a time over the next several years until land use plans are completed for all fifteen towns in the county (Osseo, 1973). However, this planning does not apply to incorporated cities or villages in the county, which are basically responsible for all their own land-use or development and enforcement of those plans.

Since the City of Osseo is incorporated, it is governed by a plan independent of Trempealeau County plans. The Osseo Comprehensive Plan developed in 1973 is the most current plan available. Topics such as soils, economic and population factors, community facilities, land use, and general development are covered in the Osseo Comprehensive Plan. In the fall of 1972, the Osseo City Council adopted a Comprehensive Zoning Ordinance based on a Land Use Map developed by the City Planning Commission. This ordinance has and continues to function in guiding development in the city. Prior to the Zoning Ordinance, the City had a Building Permit System, which required all building construction to have a permit issued by the City Clerk. However, this was primarily for assessment purposes and did not regulate building materials, type of construction or use of the property (Osseo, 1973).

The intent of the Osseo Zoning Ordinance is to regulate and restrict the use of all structures, lands, and waters with the purpose of "promoting the health, safety, prosperity, aesthetics, and general welfare of the community." This is accomplished through restricted lot coverage, zoning districts, conditional uses, traffic and parking requirements, performance standards, and other activities that implement the community's comprehensive plan. One of the focus areas of the Osseo Zoning Ordinance relating to land use would be the section on zoning districts (Osseo, 1973). The zoning districts are divided into seven types listed as follows.

1. Residential (R) 5. Industrial (I)

2.	Residential	(R-1)	6. Agriculture	(A)
3.	Business	(B)	7. Conservancy	(C)
4.	Business	(B-1)		

A copy of the zoning district map for Osseo and the descriptions of the district types are located in Appendix A7. The boundaries of these districts are shown on the map. The boundaries were designed to follow Osseo corporate limits, U. S. Public Land Survey Lines, streets, easements, and railroad right of ways. These districts will be discussed and compared to a current aerial photo of the City of Osseo later in this chapter.

The second Osseo Zoning Ordinance section with the closest relationship to land-use as it relates to groundwater protection would be the Performance Standards section. This section states that no structure, land, or water shall be used except in compliance with the specific district regulations and performance standards subsection requirements (which include, sound, vibration, radioactivity, toxic or noxious matter, glare, and heat). Of those requirements, the toxic and noxious matter subsection is of most interest in relation to groundwater protection (Osseo, 1973). Subsection 9.6 Toxic or Noxious Matter states "No discharge beyond lot lines of any toxic or noxious matter in such a quantity as to be detrimental to or endanger the public health, safety, comfort, or welfare, or cause injury or damage to property or business, shall be permitted." This statement will be discussed further in Chapter 5 because of its lack of focus on what is discharged inside property lines.

Land Use and Zoning Comparisons

The City of Osseo is located in the Town of Sumner, which is one of fifteen townships in Trempealeau County with a completed land use plan developed by the

County Zoning Department. The County Zoning Department encouraged public participation in the planning of the Town of Sumner Land Use Plan through the use of public informational meetings and town questionnaires. From these questionnaires, County staff was able to identify items community members liked and disliked about the township. Items that were important to the community included a rural atmosphere, clean water/air, good roads, adequate property rights and maintenance, and a small variety of other items. A copy of the Town of Sumner Land Use Map is located in Appendix A8 (Fletcher, 1999).

All the individual town land use plans will be assembled to create a County Land Use Plan. However, as was stated previously, these do not apply to incorporated cities or towns in the county. It is anticipated by the Trempealeau County Zoning Department that upon completion of township land use plan development, a comprehensive revision of the Trempealeau County Zoning Code will be considered. With a comprehensive County Zoning Code in place, the county would have enforcement authority for all the township land-use plans.

Land-use plans developed for the unincorporated townships plan for restrictions "'Environmental Significant" districts. These districts designate areas of environmental significance such as wetlands, floodplains, lakes, streams, etc. for certain protection. Development of these areas would be discouraged but not prohibited unless federal, state or local ordinances that prohibit development regulate the areas. As discussed previously in Chapter 2, there are regulations that would require environmental assessments and restrictions for development on these types of areas – granted these areas have been identified (Fletcher, 1999). In addition, a large portion of the Town of Sumner is tentatively zoned for 'transitional agriculture', which means it is expected that more and more people in the future will be building in areas that were once designated for agricultural uses. As is shown on the Town of Sumner Land Use map, a large portion of the township will be developed and circle the City of Osseo. This type of development will most likely have significant effects on the City of Osseo development and operation, particularly that of potential municipal water use.

Current Wellhead Protection Activities

One of the goals of this study was to identify the person(s) and their qualifications responsible for municipal well protection activities in the City of Osseo, Wisconsin. Data collected as a result of contact with City of Osseo Officials indicates that there are mainly two people in charge of the municipal well activities. There are two employees with the City of Osseo with primary responsibility for the day-to-day operation and protection of the City's two municipals wells.

Based on telephone contact with City of Osseo City staff, the qualifications and background of responsible staff was obtained. Jim Deich is the Director of Public Works and has been with the City of Osseo for approximately four years. Prior to that, he has worked with engineering firms and another county gaining an additional sixteen years of experience. He has an Associates degree in Land Surveying from the Madison, Wisconsin Technical School and a Bachelor's of Science in Urban Planning from the University of Wisconsin-Oshkosh. Dale Olson assists Mr. Deich with Osseo municipal well operations. He is a Licensed Water Systems Operator and has been with the City of Osseo for approximately sixteen years.

In addition to the management, planning, fieldwork and other tasks accomplished by qualified City of Osseo staff there are other protection activities currently in progress. Table 4.3 provides a list and a description of the major activities that City of Osseo staff is involved in. Additional protection activities that may need to be considered will be discussed in Chapter 5.

Table 4.3
City of Osseo Groundwater Protection Activities

Item/Activity of Groundwater Protection	**Description**	**Source of Information**
Planned upgrade of the Osseo Wastewater Treatment Plant	The City of Osseo is planning to make substantial (possibly costing over 1 million dollars) upgrades to the wastewater treatment plant in order to reduce BOD (Biological Oxygen Demand), nitrates, and phosphorus. It is hoped that these reductions will not only improve surface water quality but groundwater quality as well.	Telephone contact with Jim Deich, City of Osseo (January, 2001).
Graphical Information System Updates (GIS)	The City of Osseo received new aerial photos with the accuracy and resolution capabilities to identify a person that may have been present during the photo shoot. In addition, aerial photographs were enhanced to provide two layers (2 feet and 10 feet) resolution topographic maps. These maps are in their infancy for use as planning tools, but are a large step forward in the planning process.	Computer Compact Disks (CDs) provided by City of Osseo staff. CDs created by Aero-Metric, Inc. of Sheboygan, WI
Permitting of private wells within City limits	Private wells are permitted within a municipality as long as they are determined free of bacteriological contamination. This requirement must be met for both potable and nonpotable well uses since both types are capable of contaminating municipal supplies. The City of Osseo permits these wells and requires routine bacteriological testing.	Wisconsin Administrative Code NR 112
Water Utility Regulations and Rates Ordinance	This Ordinance provides guidance enforcement capabilities regarding public fire protection service, general water utility	Osseo Water Utility Regulations and

	service and maintenance, well abandonment, and cross connection controls.	Rates Ordinance (1988)
Cross Connection Control Inspection Program	The Water Utility Regulation Ordinance Section 9-1-49 defines and prohibits cross connections between the City water system and possible contamination connections/sources. This section of the Ordinance also authorizes the City of Osseo to perform inspections of facilities where cross connections are deemed possible – of which inspection reports are available upon request of Osseo City Hall.	Osseo Water Utility Regulations and Rates Ordinance Section 9-1-49 (1988) See Appendix A9 for Cross Connection Survey example
Well Abandonment Ordinance	The purpose of this Ordinance is to prevent unused and/or improperly constructed wells from serving as a passage for contaminated surface or near-surface waters or other materials to reach the usable ground water. These wells are to be properly filled and sealed.	Osseo Water Utility Regulations and Rates Ordinance Section 9-1-52 (1988).
Routine groundwater sampling and laboratory analysis	The U. S. and Wisconsin regulations require routine testing of municipal drinking water for certain contaminants. See Appendix A11 for Primary Drinking Water Standards.	WI Administrative Code Chapter NR 809
Consumer Confidence Reports	The 1996 Amendment to the Safe Drinking Water Act created a new public information requirement for municipal water systems. The City of Osseo annually publishes and distributes results of water quality testing to water utility customers.	Osseo Municipal Water Quality Report (2000) See Appendix A11

GIS Source Contamination Inventory

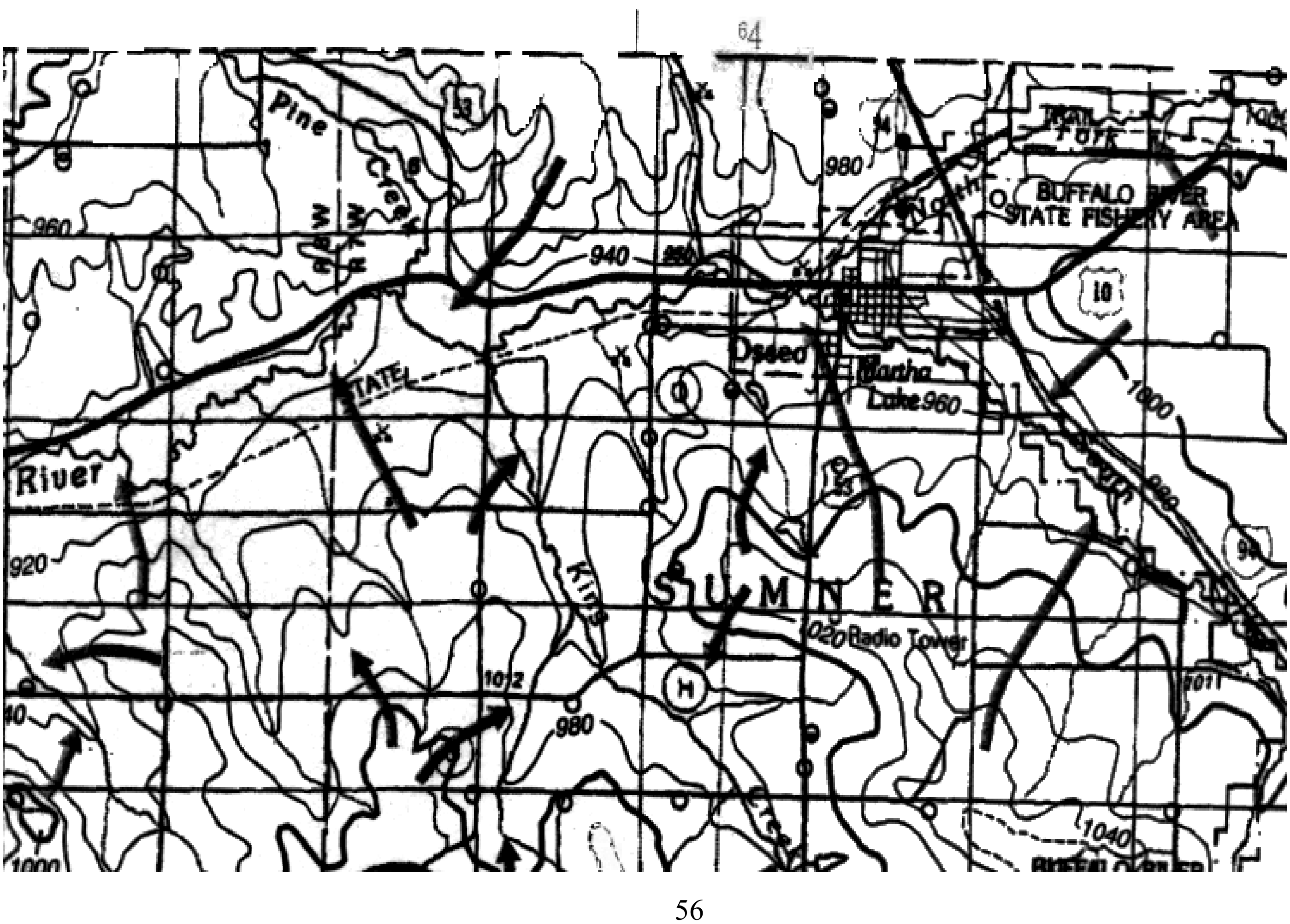
Currently, the City of Osseo does not have a formalized potential contamination source inventory. In order to analyze the potential contamination sources and evaluate the public health risks, a graphical information system (GIS) was utilized. Using the aerial maps available, the GIS software program used was Archview. In addition to applying the use of this graphical information for potential risks as it applies to this research, it is intended to be a resource for future groundwater protection efforts for the City of Osseo and other responsible agencies. Located in Appendix A12 is a graphical source contamination inventory. Attention should be focused on the circles surrounding wells #2 and #3 which represent wellhead protection boundaries. The wellhead protection boundaries are important for current and future groundwater contamination prevention efforts. The red circles have a ½ mile radius surrounding the City of Osseo municipal wells. The Department of Natural Resources recommends using this type of boundary if a more formal wellhead protection delineation area has not been calculated. Limited potential contamination source inventories conducted by the City of Osseo in the past used a radius of 1200 feet.

Due to time restraints and the lack of available information, not all potential contamination sources have been added to the map. However, much information can be obtained from the potential point contamination sources that are represented. The orange points indicated the locations of gasoline underground storage tanks – some known to leak in the past. Three of the four have monitoring wells. Limited information regarding past monitoring for gasoline contamination associated with the leaking underground storage tanks indicate improvement in groundwater quality over the years, which current information shows is in compliance with Wisconsin groundwater protection rules. However, the limited information was obtained directly from the companies associated with those specific monitoring wells. The City of Osseo staff did not have this information at City Hall. In the future, monitoring well information should go directly to the City of Osseo staff responsible for wellhead protection activities.

Planning efforts might also discourage future gas stations to be located within the wellhead protection areas. As is shown on the map, four gas stations are located relatively close to municipal wells. In addition, information is either not available or is extremely limited regarding water test results of private wells next to these gas stations. It is important to note that in most cases, private wells are drawing from a much more shallow aquifer (versus municipal wells which are deeper).

Abandoned landfills also present potential contamination concerns, as was discussed in Chapter 2. Even though the mapped landfill is not within the wellhead protection boundary it still could be a significant source of contamination if a combination of groundwater flow and municipal wellhead pumping encouraged migration of the contaminants. Figure 2.5 is a map of groundwater (UW-Extension, 1985) flow for the City of Osseo and surrounding areas which can be compared to the following graphical potential contamination source inventory map for the City of Osseo.

Figure 2.5
Northeast Corner of Trempealeau County - Groundwater Flow Diagram



From a review of the source inventory map, it is interesting to note that the wellhead protection boundary of one well overlaps with the I-94 interstate freeway. Potential for contamination at this location might include, hazardous or flammable chemical spills. Thousands of motor vehicles pass by on the interstate everyday carrying a variety of potentially hazardous substances. Emergency planning for this type of potential contamination is an important part of wellhead protection planning and management. In addition, most industry prefers to be located next to a major transportation route, such as interstate I-94. Future wellhead protection activities must also monitor the location and land-use associated with a variety of industries.

Summary

Health implications associated with improper disposal, storage, or spills of hazardous materials into the environment could have a big impact on a municipal well water source. A better understanding of land-use, groundwater flow and direction, potential contamination sources, and groundwater use is very useful in protecting groundwater. Although the City of Osseo has made some strides, such as the Cross Connection Control Program, the Well Abandonment Ordinance, and issues Consumer Confidence Reports towards planning for a safe municipal water source, much more information and planning is needed. Areas of improvement include; integration of the new graphical information system with current planning strategies, consistent permitting and testing of private wells within City limits, and updating of water utility regulations on a continual basis. Recommendations associated with areas of additional needs will be discussed further in Chapter 5.

CHAPTER 5

Summary, Conclusions, and Recommendations

Restatement of the Problem

Groundwater contamination can often be the end result of the normal, day-to-day activities that occur in communities. Wellhead protection activities currently being utilized in Osseo, Wisconsin will be critical to long-term prevention of groundwater contamination. The purpose of this study is to identify the extent that effective wellhead protection-related activities (i.e., tracking, testing, controls, etc.) are being performed or promoted in Osseo, Wisconsin.

The objectives of this study were to:

3. Identify wellhead protection activities that are currently in place and the persons (and their qualifications) responsible for them.
4. Perform a physical characteristics inventory of areas surrounding the wellheads(s) in Osseo, Wisconsin; such as groundwater flow direction, soil types, potential contamination sources or spills, land-use, etc.

Conclusions

Studies by others have concluded that more than 200 contaminants have been known to exist in groundwater. Because of increased well monitoring, the current list is probably more than three times as large (Jorgensen, 1989). The list gets longer with the addition of biological agents that could contaminate groundwater.

Much information and planning is needed to make decisions that will protect groundwater resources in the City of Osseo, Wisconsin. An analysis of current wellhead protection activities currently in place in Osseo, Wisconsin revealed that the quality of groundwater in Osseo might suffer without additional and updated protection efforts. Specifically, land-use and water use planning, including graphical information source mapping, should be focused on.

Based on available information, the City of Osseo will see an increase of 17% in population by 2020. In addition to increased in residential water demand will come increased commercial demands as well. Osseo is conveniently located on Interstate 94 which is a main transportation artery utilized by industry. Commercial establishments consume much greater amounts of water than individual households. Shortages in the water supply because of potential contamination or inadequate planning could cause substantial economic hardship to the community.

Increased population means much more human activity on the land surface above municipal wells. As discussed in Chapter 2, the potential for well water contamination increases in proportion to human activity. Wastewater treatment plants must be able to affectively treat greater amounts of wastewater to reduce contaminants such as BOD, nitrates, and phosphorus. Larger residential developments with many acres of lawns may be treated with many types of fertilizers or pesticides, which may also impact groundwater supplies. Increased lawn irrigation may result in the drilling of more private wells, which should be monitored for proper construction and possible contamination.

All of the concerns can be addressed and planned for by a comprehensive land-use plan. The Osseo Comprehensive Plan, which is 28 years old, is being used today. The Plan was based on economic and population factors that are now almost three decades old. Updates and additions are needed for the a comprehensive planning tool to ensure the health, safety, and general welfare of the community, as well as proper zoning, construction and traffic needs.

When contamination occurs, communities can suffer substantial losses, including; loss in property value, human illness, large clean-up costs, and many more. It is apparent that much more monitoring and health effects testing must be done to help in prevention of contamination and loss. Involvement at the local level will be very beneficial in the effort to prevent illness and other types of loss. Following are recommendations, as they relate to these conclusions, for continued and improved local wellhead protection activities for the City of Osseo.

Recommendations

The following recommendations for the City of Osseo, Wisconsin, are based upon the literature review regarding groundwater pollution sources and resulting loss, current state, county, and City of Osseo records and regulations analysis, and evaluation of information organized via Archview (a graphical information system). The order of the following recommendations is not based on potential risk or priority. Instead, recommendations are presented for each potential groundwater contamination source or prevention activity.

Land-Use Planning and Updates

The Trempealeau County land-use plan, which is the most up-to-date land-use plan for the county, does not apply to the City of Osseo. However, the land-use planning activities conducted by the Trempealeau County Zoning Department and the Township of Sumner should not be considered independent of the City of Osseo. The City of Osseo should partner with these two agencies to prepare for future land-use changes and increased population expected for those areas. As is shown on the Town of Sumner Land Use Map (Appendix A8), an increase in residential and industrial development surrounding the city limits of Osseo, Wisconsin should be expected. This type of development will likely have significant effects on the City of Osseo, such as increased water consumption and more potential contamination sources. It is recommended that the City of Osseo in partnership with Trempealeau County Zoning Department and the Township of Sumner, update the current (1973) Osseo Comprehensive Plan.

Well Water Quality Monitoring

The monitoring of groundwater using private, public and monitoring wells produces necessary information to determine existing water quality. Currently, the City of Osseo routinely tests the municipal groundwater supply for many contaminants as outlined in Wisconsin Administrative Code Chapter NR 809. The results of this information are available on the Wisconsin Department of Natural Resources web site. However, even though private wells within Osseo city limits are permitted, they are randomly tested for coliform bacteria.

In order to ensure a water supply that is free of potential contamination hazards, it is recommended that the City of Osseo require owners of private wells within city limits to test for a minimum of bacteria and nitrates at least once per year. In addition, this data should be input to a database software program where results and trends can be analyzed. In most cases, private wells are not as deep as municipal water wells. Therefore, an adequate amount of testing for a variety of potential contamination is very important to the private water sources which may be more susceptible to potential contamination. This information not only benefits private well owners, but also the City of Osseo which can use this information as indicators of possible contamination sources that might also affect the municipal water supply.

Underground Storage Tanks

Leaks from underground storage tanks represent a significant hazard to groundwater quality. In the City of Osseo, some underground storage tanks (particularly gasoline) have been documented as leaking. Effective and coordinated risk management strategies should be developed. State regulations for underground tanks contain permitting, testing and on-site inspection requirements that will help lessen the threat of groundwater quality degradation if actively enforced. However, private non-commercial tanks under 1100 gallons (which may include tanks along city limit boundaries in the Town of Sumner) remain unregulated.

Under current regulations, tank testing may not be of sufficient frequency to adequately detect and respond to leaks. Consequently, frequent testing requirements should be established for tanks within wellhead protection areas (shown as circles around wells on the City of Osseo aerial photo) and in areas of greatest pollution susceptibility. Existing tanks in these areas determined to not be providing adequate corrosion protection or leak containment should be replaced or properly abandoned.

Aboveground Storage Tanks

Chemicals leaking from aboveground storage tanks may infiltrate the soil and reach groundwater. Since, spills from above ground tanks have been documented in Trempealeau County, effective and coordinated location and leak prevention strategies of underground storage tanks should be developed. While, regulations for large aboveground tanks storing petroleum products should help minimize adverse environmental impacts from leaks or spills, small private non-commercial tanks remain unregulated and thus should be controlled in a similar manner. In addition, storage of pesticides and fertilizers should be monitored and applicable regulations enforced to minimize groundwater quality threats from these sites. Strict design and enforcement criteria should be required for spill or leak containment for aboveground tanks storing hazardous or flammable materials within wellhead protection areas and in areas of greatest pollution susceptibility.

Salt Storage and Road Deicing

Sodium and chloride concentrations have been known to increase in municipal water supplies due to excessive road salt use (Eau Claire, 1994). Salt storage sites are currently regulated under Department of Transportation administrative rules and thus do not pose a threat of contamination for the City of Osseo. Even so, the City of Osseo should not only limit the use of salt applied to roadways, but great care should be taken in the use and storage of road salt and sand/salt mixtures to reduce spillage and subsequent groundwater contamination.. In addition, current salt storage sites existing before current rules went into effect as well as snow removal sites should be studied to determine possible groundwater impacts.

Stormwater Management

Erosion and runoff have been documented to seriously degrade surface water quality. This causes concern, particularly for Osseo, where soils types are classified as being very erosive on slopes. The management of stormwater to affect surface water quality improvements has gained more emphasis recently in the state. Consequently, the Wisconsin DNR is promoting model construction site erosion control and stormwater management ordinances. Through the Non-Point Source Pollution Program, the DNR helps fund best management practices to protect surface waters from stormwater impacts. However, some stormwater best management practices, while improving surface water quality, can degrade groundwater (Eau Claire, 1994). In the implementation of federal, state, and local programs, a balance between the management goals for surface water quality and groundwater quality should be achieved so that the management goals of one are not accomplished at the expense of the other in the City of Osseo, Wisconsin.

Pesticide Use and Educational Efforts

Groundwater monitoring for pesticides has been limited around the state of Wisconsin. As discusses in Chapter 2 of this study, pesticides from various sources reaching groundwater has been documented. Applicators of restricted-use pesticides are required to be trained and certified, though applicators of general use pesticides have no training requirements. To limit and ensure correct use of pesticides, best management practices should be emphasized to county farmers. The Wisconsin Department of Agriculture, Trade and Consumer Protection and University of Wisconsin-Extension should intensify existing educational efforts. The City of Osseo must be aware of and promote these efforts by other agencies because of the potential impact on municipal well water.

Overall Wellhead Protection

The most important elements of an effective groundwater protection program are those aimed at preventing potential sources of contamination of groundwater. The 1986 amendments to the federal Safe Drinking Water Act established a nationwide program to protect groundwater used for public water supplies. It provides protection from a wide range of potential sources of contamination through the establishment of state wellhead protection programs. The specific goal of Wisconsin's Wellhead Protection Program is to achieve additional groundwater pollution prevention measures within public water supply wellhead areas. However, as stated in earlier chapters, only new water supplies introduced since 1996 are required to develop a formalized Wellhead Protection Plan. It is recommended that the City of Osseo develop a Wellhead Protection Plan not only for new wells, but for existing wells also. A template for wellhead protection plans that can be used as a guide in the development of plans, is available from the Wisconsin DNR (DNR, 1993). The components of a wellhead protection plan include:

1. Recharge area surveys
2. Zone of influence calculations
3. Direction of groundwater flow
4. Inventory of potential contamination sources within ½ mile
5. Wellhead protection area delineation
6. Public education program
7. Water conservation program
8. Contingency plan
9. Management plan in location of potential contamination sources

The template discusses each component in more detail. This study attempted to address some of the components, such as direction of groundwater flow and an inventory of potential contamination. However, the work done is this study should only be considered as the beginning. More information must be gathered by the City of Osseo and other responsible agencies in order for these items to be a useful planning tool for groundwater protection.

Recommendations for University of Wisconsin-Extension

The UW-Extension of Trempealeau County was a financial contributor to this study effort. This agency is in a unique position to add and continue on with the research presented in this study. Following are focus areas for recommended involvement by the UW-Extension agency.

1. Expand the use of the Archview-GIS in inventorying potential contamination sources for the rest of the county. As was discussed before, the City of Osseo should not be considered independent of the rest of the surrounding (county) area. Much data has already been collected regarding bacteria and nitrate levels throughout the county. In cooperation with the Trempealeau County Land Records Department, this information can be input to a GIS system and used to direct educational efforts regarding reduction and prevention of nitrate and other types of contaminates to groundwater. The Trempealeau County Health Department should assist UW-Extension efforts in monitoring and planning for safe groundwater in the county.
2. Studies have suggested that fertilizers and pesticides are commonly over-applied. For example, farmers may not take into account the nutrient loading from manure land spreading when calculating amounts of packaged fertilizer to use. It is recommended that UW-Extension expand pesticide and fertilizer training and education in Trempealeau County. In addition, educational materials can be developed for urban fertilizer and pesticide users on the proper storage, use and disposal of fertilizers and pesticides, and alternatives to commercial chemical fertilizers and pesticides, particularly for point of sale distribution.

3. Additional educational campaigns can be used to address many other types of potential contamination to groundwater. Prevention techniques for reducing the number and amounts of contaminants reaching groundwater can be promoted. Health effects associated with certain types of contamination can also be discussed. Target issues might include the improper disposal of household chemicals and waste oil as well as failing septic systems.
4. In addition to a partnership with the Trempealeau County Health Department, UW-Extension should also encourage a community-coordinated response with Trempealeau County Emergency Management for hazardous spill cleanup.

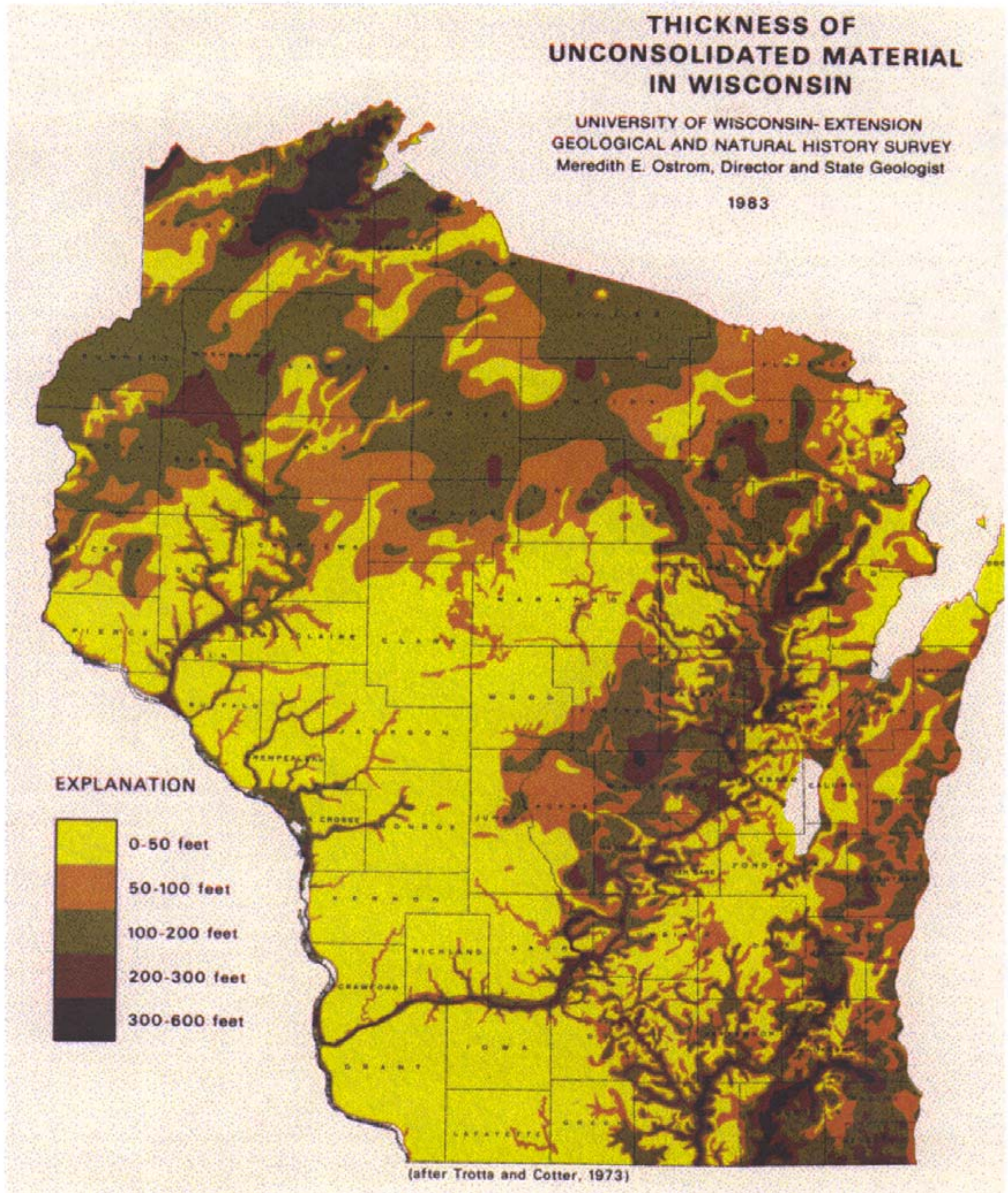
Summary

The inventory of pollution sources and groundwater quality data of this study identified some areas of concern where adequate data and information to make sound groundwater management and protection decisions may be lacking. Much groundwater data is being gathered by separate federal, state, and local agencies and filed in such a manner that it is difficult to extract and utilize. Easy access to available geologic and groundwater information is essential if this information is to be useful in day-to-day management decisions.

Once contaminants or pollutants are in the groundwater, it becomes very difficult to almost impossible to remove them. When a well becomes contaminated, a community could be faced with substantial health risks, costs to clean up or treat groundwater, drill a new well, or provide an alternate source of water to its residents. A wellhead protection plan is one way to minimize the risk of incurring contamination-based problems and would likely ensure that groundwater remains free of potential contamination.

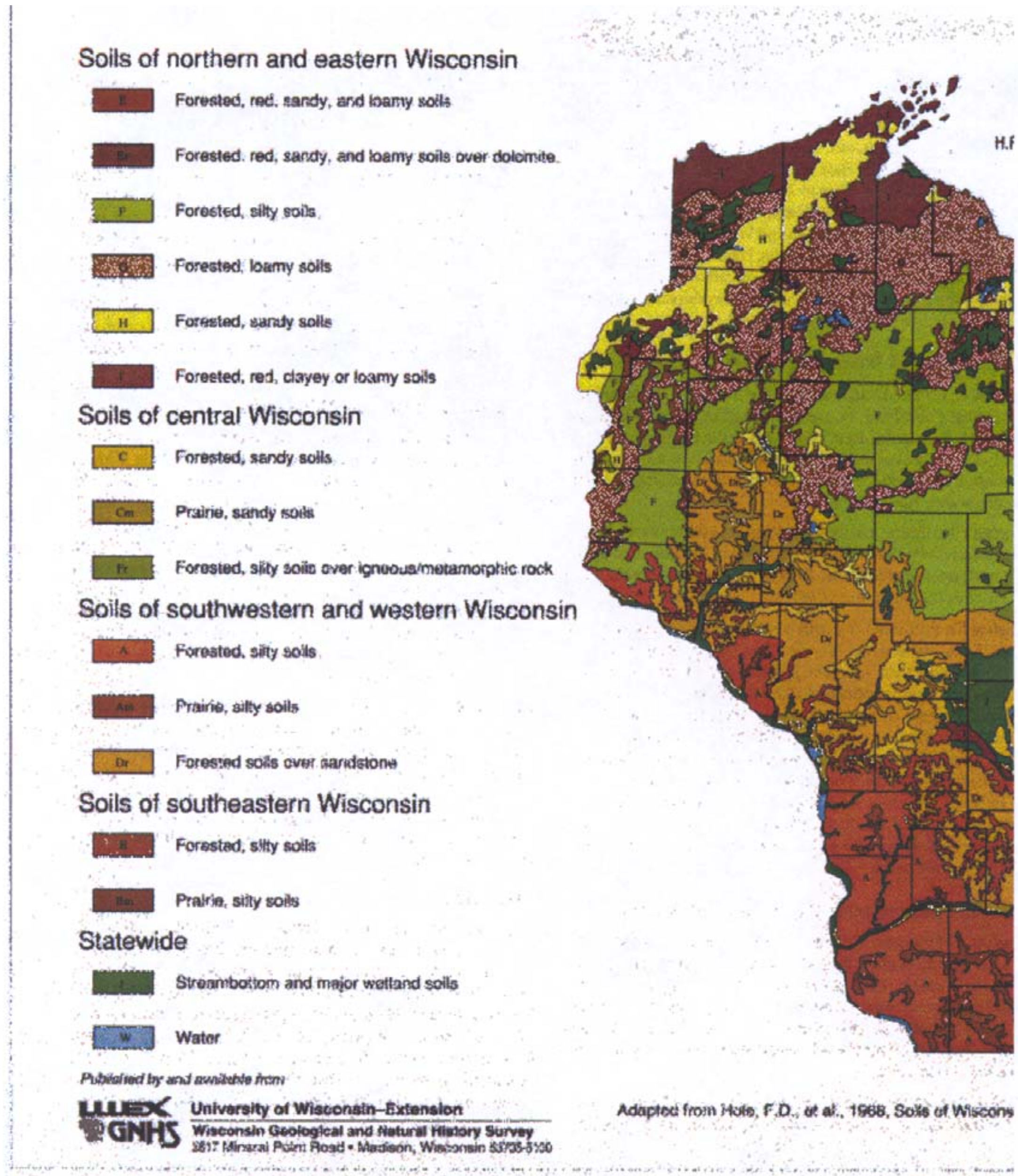
APPENDIX

Table of Contents


THICKNESS OF UNCONSOLIDATED MATERIAL IN WISCONSIN
UNIVERSITY OF WISCONSIN- EXTENSION
GEOLOGICAL AND NATURAL HISTORY SURVEY
Meredith E. Ostrom, Director and State Geologist
1983
EXPLANATION
0-50 feet
50-100 feet
100-200 feet
200-300 feet
300-600 feet
(after Trotta and Cotter, 1973)

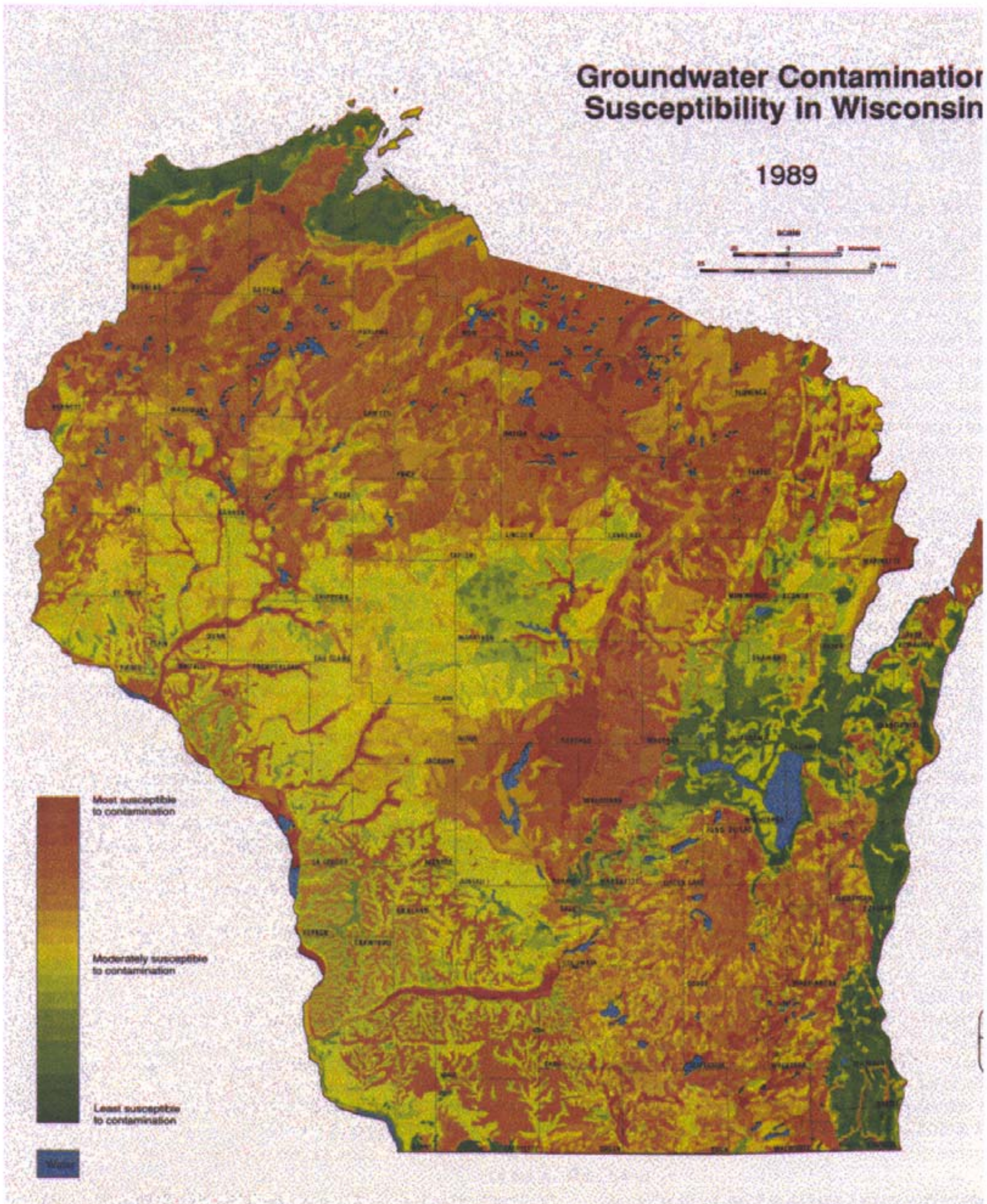
Appendix A1

University of Wisconsin-Extension
Geological and Natural History Survey (1993)



Appendix A2

University of Wisconsin-Extension
Geological and Natural History Survey (1989)



Appendix A3

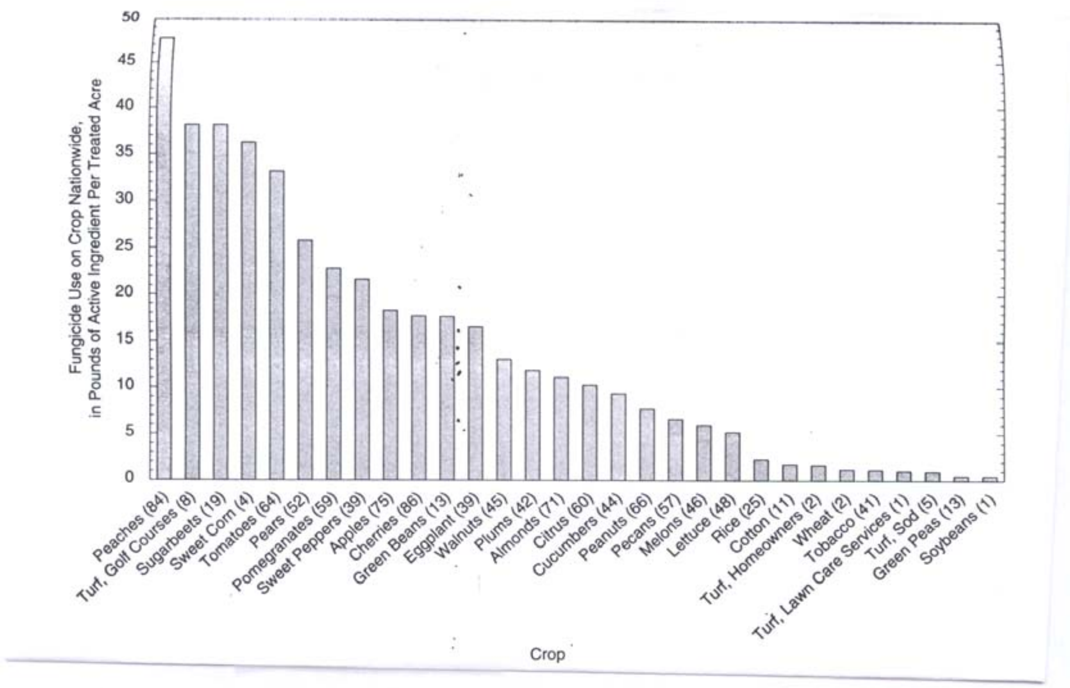
Pesticides reported in ground waters of the United States by the monitoring studies and data compilations examined for this book, listed according to chemical or use class

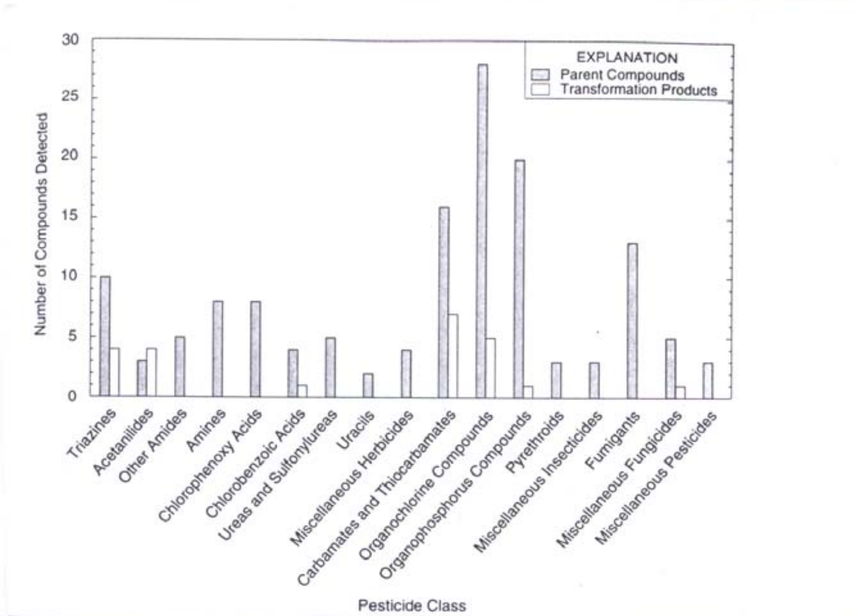
Pesticide Class	Numbers of Compounds Within Each Class Detected by Each Study										
	Monitoring Studies									Data Compilations	
	Cooperative Private Well Testing Program	Midcontinent Pesticide Study			National Pesticide Survey		National Alachlor Well Water Survey	Metolachlor Monitoring Study	State and Local Studies	Pesticides In Ground Water Database	1988 Survey of State Lead Agencies
		Pre-Planting	Post-Planting								
			1991	1992	CWS	RD					
Insecticides—Continued Organochlorine compounds					1	1			23	22	20
Degradates				1					5	4	1
Organophosphorus compounds				1					17	16	12
Degradates										[4]1	
Miscellaneous									6	3	
Miscellaneous Fungicides									3	3	
Degradates									1	1	
Fumigants					1	2			10	11	4
Miscellaneous Pesticides									1	2	
Totals		9	9	28	7	10	5	1	132	131	67
References	Baker and others, 1994	Kolpin and others, 1993; Kolpin and Goolsby, 1995			USEPA, 1990a, 1992a		Monsanto Agricultural Company, 1990; Holden and others, 1992	Roux and others, 1991a	See Table 2.3	USEPA, 1992b	Parsons and Witt, 1989

[1]Specific compounds not discernible with the immunoassay procedure used (see Section 2.8.2). Compounds to which the triazine immunoassay responds include atrazine, cyanazine, simazine, "and several other triazine herbicides, as well as some triazine breakdown products" (Wallrabenstein and Baker, 1992).
[2]Specific compounds not discernible with the immunoassay procedure used (see Section 2.8.2). Compounds to which the acetanilide immunoassay responds include alachlor, metolachlor "and various alachlor breakdown products" (Wallrabenstein and Baker, 1992).
[3]Includes 1-naphthol, which was presumed to have been a degradate of carbaryl (Majewski, 1993).
[4]Pertains to 4-nitrophenol, a degradate of methyl parathion. Because it is also used as a fungicide, this compound was included in both categories, following the approach adopted by the authors of the Pesticides In Ground Water Database.

**Information obtained from *Pesticides in Groundwater; Distribution, Trends, and Governing Factors.* Barbash, Jack E. and Resek, Elizabeth A. (1996).

Appendix A4





**Information obtained from *Pesticides in Groundwater; Distribution, Trends, and Governing Factors.* Barbash, Jack E. and Resek, Elizabeth A. (1996).

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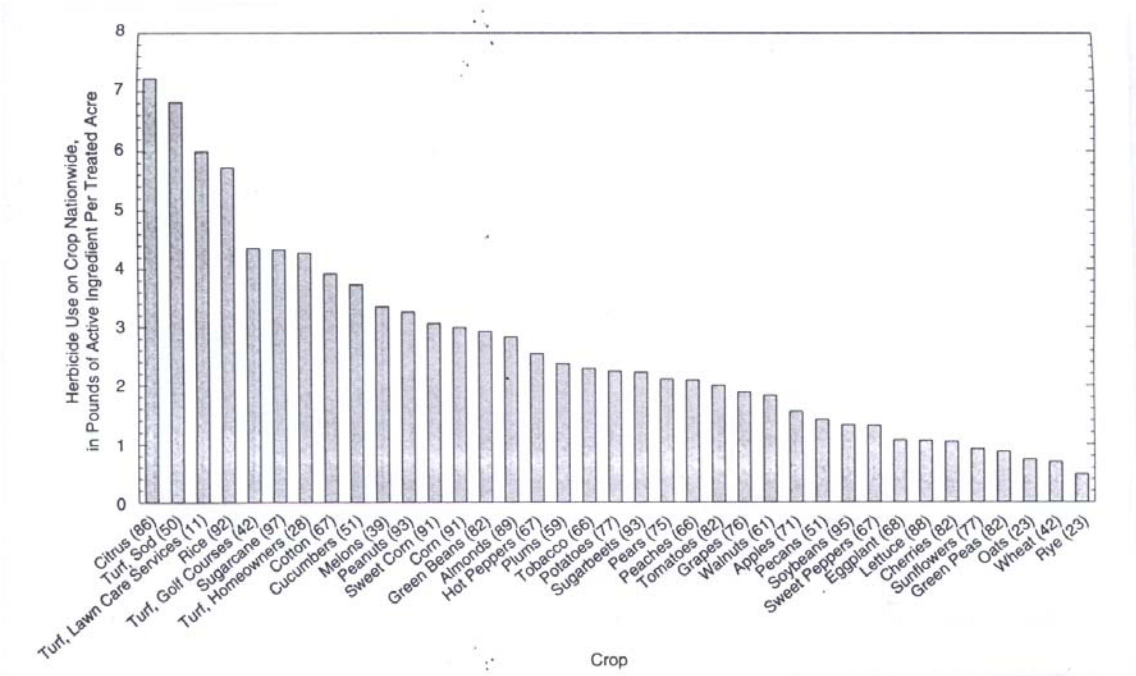
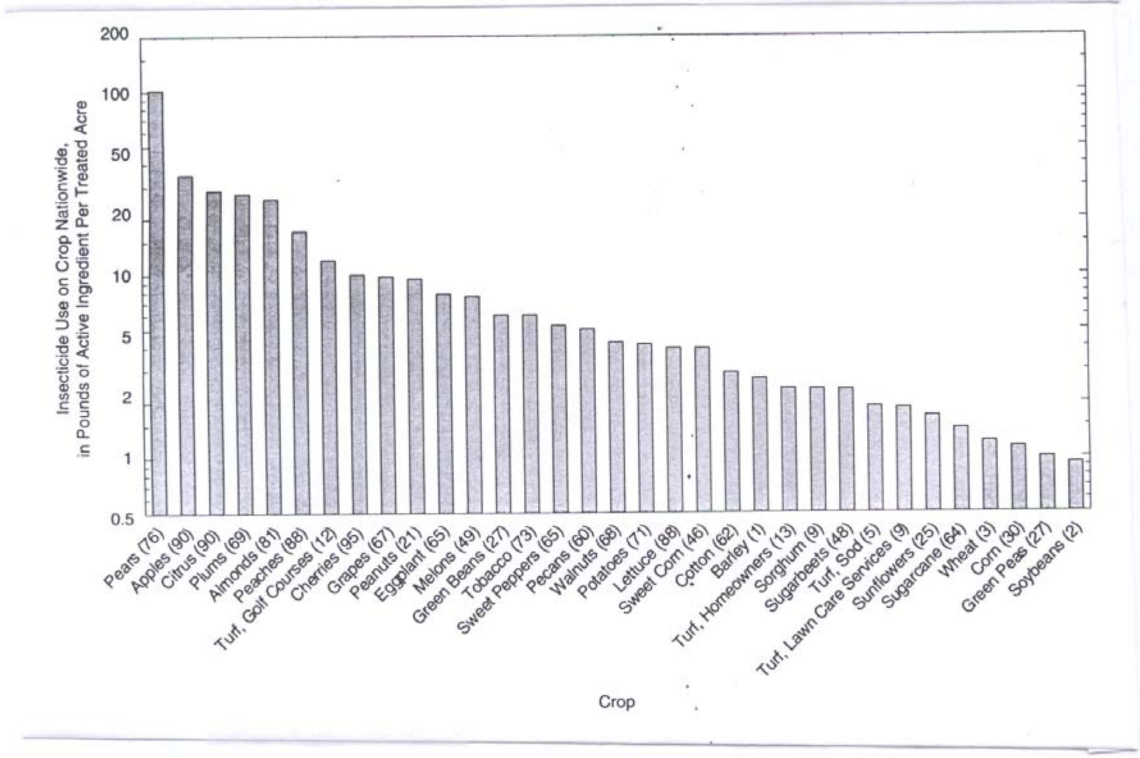
Page 1 of 2





**Information obtained from *Pesticides in Groundwater; Distribution, Trends, and Governing Factors.* Barbash, Jack E. and Resek, Elizabeth A. (1996).

State Regulatory Groundwater Management Tools in Wisconsin

Activity	Regulator	Admin. Code	Focus of Regulations
Groundwater Quality Standards:	DNR	NR 140	Sets groundwater quality standards for substances detected in groundwater or having a reasonable probability of entering groundwater resources of the State.
Waste Disposal: *Municipal and industrial landfills*	DNR	NR 180 NR 185	Licensing of all sites; standards for location, design, operation, construction, monitoring, and abandonment.
Environmental response and repair	DNR	NR 500	DNR maintains an inventory of sites that might pollute and hazard ranking list of the sites; sets procedures for emergency response and repair.
Municipal and industrial wastewater	DNR	NR 110 NR 206 NR 214 NR 213	DNR regulates through NPDES permit process. NR 110 governs municipal sewage lagoons; NR 206 land disposal of municipal wastewater; and NR 214 land disposal of industrial wastewater. NR 213 establishes design, construction and location criteria for industrial wastewater storage structures such as lagoons.
Sanitary Sewers	DILHR DNR	ILHR 82 NR 110	DILHR regulates laterals. DNR regulates interceptors and collectors.
Private wastewater systems	DILHR DNR	ILHR 83 ILHR 85 NR 114	DILHR regulates siting, design, installation, and inspection of systems and licensing of installers and evaluators. State inspection system (vs. local) is required for large-scale systems. DNR requires certification for operators of septage servicing vehicles. NR 114 eliminates state licensing exemptions for registered pumpers and licensed plumbers.
	DNR	NR 113	DNR can prohibit tanks in areas where they cause a water quality problem; the code establishes requirements for septic disposal.

**Information obtained from *Eau Claire County;Groundwater Advisory Committee* (1994).

Appendix A6
Page 1 of 4

State Regulatory Groundwater Management Tools in Wisconsin

Activity	Regulator	Admin. Code	Focus of Regulations
Municipal sludge disposal	DNR	NR 110 NR 204	NR 110 requires approval of land for sludge disposal. NR 204 regulates land spreading of sludge.
Septage and holding tank waste disposal	DNR	NR 113 NR 206	DNR licenses persons for holding-tank maintenance and waste disposal and regulates land spreading of domestic wastewater.
Nonpoint source pollution abatement	DNR	NR 120	Establishes the administrative framework for the implementation of the State's non-regulatory urban and rural nonpoint source pollution abatement program. The program is run in conjunction with DATCP.
Agriculture *Soil and water resource management*	DATCP	ATCP 166 ATCP 45	Sets requirements for county animal waste management plan, including ordinances establishing minimum standards for earthen manure storage facilities; provides cost-sharing for farmers involved in animal waste management program. Provides for sustainable agriculture demonstrations.
	DNR	NR 112 NR 243 NR 120	DNR regulations for livestock feeding operations include well location distances, runoff structures, use of NPDES permits, design standards, and storage requirements. NR 120 provides cost-sharing through the Nonpoint Source Pollution Abatement Program.
Fertilizer bulk storage	DATCP	ATCP 32	Contains standards for storage containers and appurtenances, loading areas, secondary containment, abandoned containers; the emphasis is on liquid fertilizer.
Pesticide storage, transport, and use	DATCP	ATCP 29	Rules require good handling practices and prohibit entry of pesticide into the ground-water above an enforcement standard; also has aldicarb restrictions and groundwater sampling requirements.

**Information obtained from *Eau Claire County;Groundwater Advisory Committee* (1994).

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State Regulatory Groundwater Management Tools in Wisconsin

Activity	Regulator	Admin. Code	Focus of Regulations
	DATCP	ATCP 33	Standards and requirements parallel those of fertilizer bulk storage. Rules governing the use of atrazine with restrictions on frequency, application rates, timing and soils to protect groundwater. Determines atrazine prohibition areas.
	DNR	NR 80	DNR can prohibit use of pesticide; Pesticide Review Board review is required.
Regulation of agricultural chemicals	DATCP	ATCP 31	Establishes standards for groundwater test reporting and the regulatory and enforcement actions to prevent and control groundwater pollution from agricultural activities.
Hazardous Materials and Waste			
Hazardous waste	DNR	NR 500-555	Establishes criteria for identifying the characteristics of hazardous waste and management regulations for their treatment, storage, and disposal.
Engine waste oil	DNR	NR 183	Requirements for location, design, and operation of facilities.
PCBs	DNR	NR 157	Establishes procedures for collection, storage, transport, and disposal of PCBs and products containing PCBs.
Liquid storage tanks	DILHR	ILHR 10	Leak detection program, plan review, tank inspection and approval, design and construction standards, and record keeping.
Spills	DNR	NR 158	Contingency plan required for emergency response to hazardous substances. DNR has authority to request remedial action.
Abandoned containers	DNR	NR 551	Establishes criteria and procedures for developing contingency plans to respond to abandoned containers of hazardous substances.

**Information obtained from *Eau Claire County;Groundwater Advisory Committee* (1994).

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State Regulatory Groundwater Management Tools in Wisconsin

Activity	Regulator	Admin. Code	Focus of Regulations
Other Activities			
Well construction and abandonment	DNR	NR 112 NR 811	DNR licenses well drillers and pump installers, specifies well design and construction, sets minimum separating distances between wells, and potential pollution sources, and requires proper abandonment of all wells.
	DNR	NR 145	DNR can authorize counties to administer NR 112 at one of four delegation levels.
Well compensation	DNR	NR 123	DNR provides partial reimbursement for replacing contaminated wells.
Drinking water standards	DNR	NR 809 (proposed)	DNR sets drinking water standards and public water supply monitoring requirements.
Highway salt storage	DOT	TRANS 277	Provides for DOT response when the prevention action limit for chloride has been exceeded at a storage facility and sets requirements for remedial action.
Wisconsin water management and conservation	DNR	NR 142	Provides for registration and reporting requirements, regulation for determining consumptive use and water loss information, and special requirements for inter-basin diversions.
Mining	DNR	NR 130 NR 131 NR 132 NR 133 NR 134 NR 182	Provides for the regulation of prospecting, exploration, mining, mining waste disposal and mine reclamation, oil and gas exploration and high level radioactive waste site exploration. Extensive portions intended primarily for groundwater protection.

**Information obtained from *Eau Claire County;Groundwater Advisory Committee* (1994).

Appendix A6
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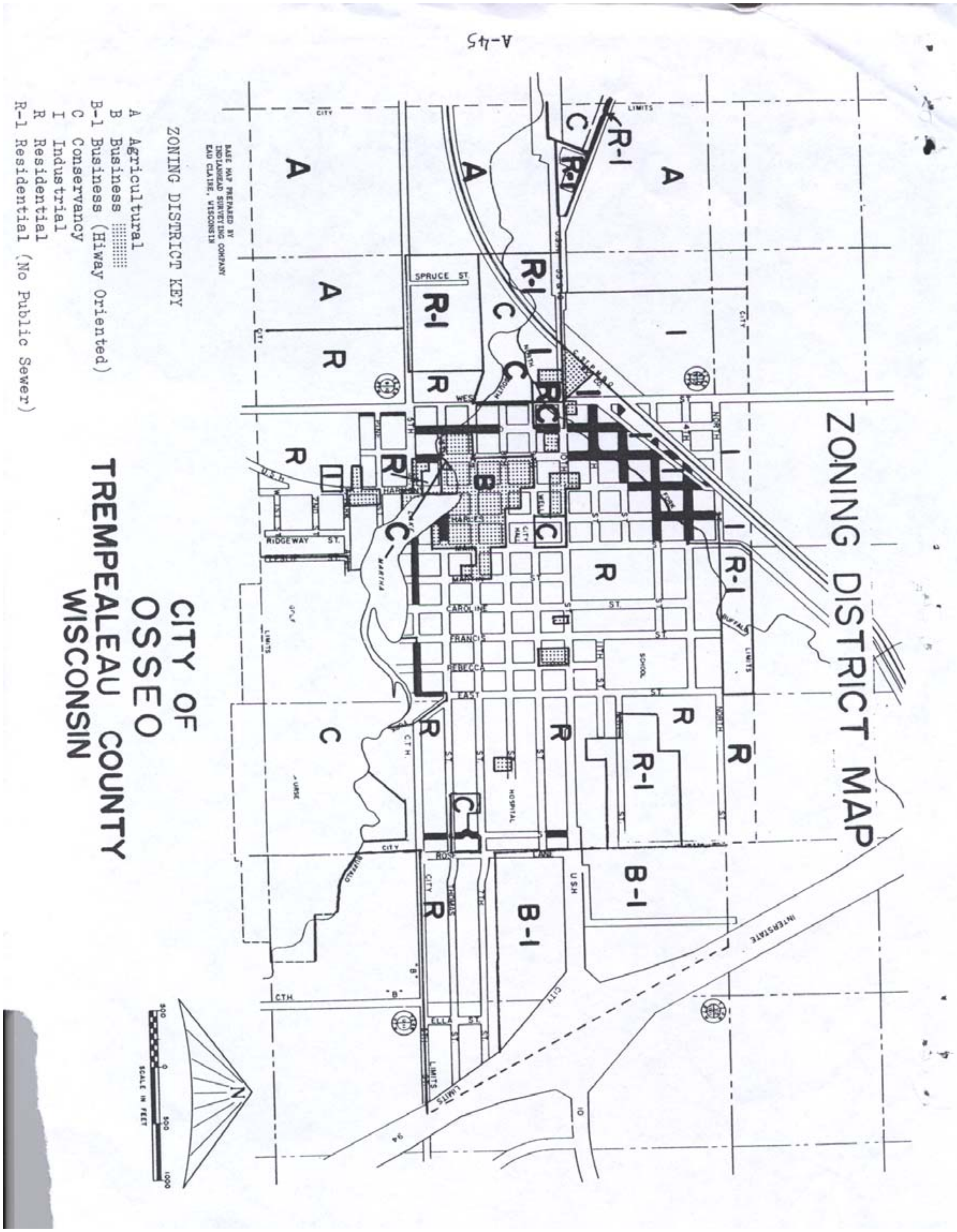
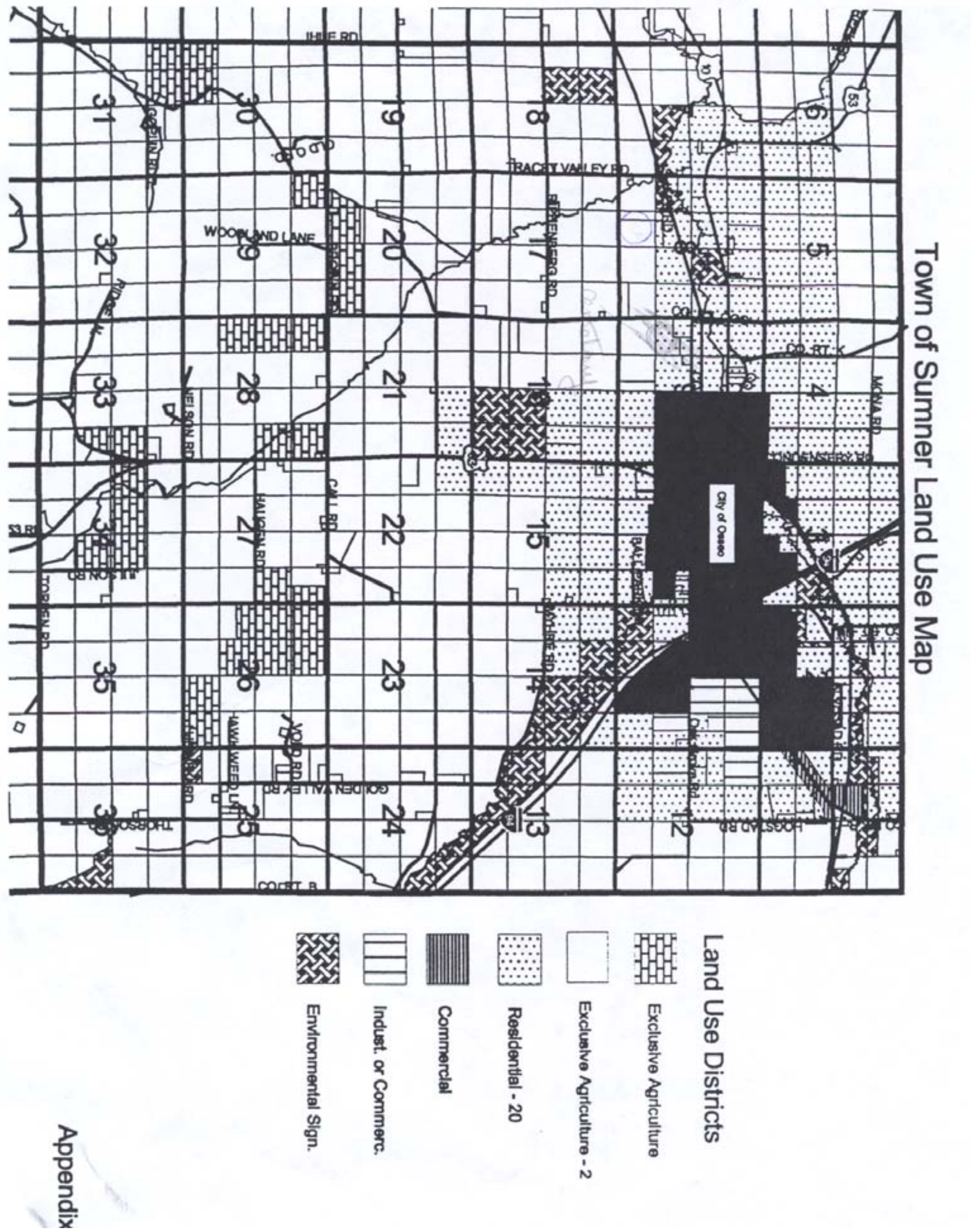

A-45
ZONING DISTRICT MAP
CITY OF
OSSEO
TREMPEALEAU COUNTY
WISCONSIN
ZONING DISTRICT KEY
A Agricultural
B Business
B-1 Business (Hiway Oriented)
C Conservancy
I Industrial
R Residential
R-1 Residential (No Public Sewer)
BASE MAP PREPARED BY
INDIANHEAD SURVEYING COMPANY
EAU CLAIRE, WISCONSIN
SCALE IN FEET
SPRUCE ST
RIDGEWAY ST.
CAROLINE
FRANCIS
REBECCA
EAST
NORTH
SCHOOL
HOSPITAL
INTERSTATE
CITY LIMITS

Appendix A7


Town of Sumner Land Use Map
Land Use Districts
Exclusive Agriculture
Exclusive Agriculture - 2
Residential - 20
Commercial
Indust. or Commerc.
Environmental Sign.
City of Osseo

Appendix A8

CITY OF OSSEO
CROSS CONNECTION SURVEY FORM

Date: ____________________

Name of Company, Corporation or Business: ______________________________

Address: ______________________________

____

Name of Contact: ______________________________

Type of use: ________Industrial ______Commercial ___Government__________Other__________

Location of Service: ______________________________

Size of Service: _____Inch Metered? .... Yes _____No___

Require non-interrupted water service?.. Yes_____No___

Does boiler feed utilize chemical additives?...Yes_____No___

Is backflow protection incorporated?.. Yes_____No___

Are air conditioning cooling towers utilized?...Yes_____No___

Is backflow protection incorporated?.. Yes____ No___

Is a water saver utilized on condensing lines or cooling towers? N/A ......Yes____No___

Is the make-up supply line backflow protected?............................ Yes_____No___

Is process water in use, and if so, is it potable supply water or raw water?

N/A__________Potable________Raw__________Protected_______Unprotected___________

Is fire protection water separate from the potable supply?..........................Yes_____No___

Are containment devices in place?..Yes_____No___

Summary

Degree of hazard...High____Low___

Type of device recommended for containment......RPZ_____DCV________None________

Fixture outlet protection required?..Yes_____No___

If so, where? ______________________________

Appendix A9

Primary Drinking Water Standards in Wisconsin

The following table lists all the contaminants with enforceable standards which are currently regulated in Wisconsin under Administrative Code Chapter NR 809.

Total Coliform Rule (TCR)

Nameof Contaminant	Maximum Contaminant Level (MCL) (mgAL unless noted)	Health Effects of Contaminant
* **Total Coliform** * **Fecal Coliform** * **Escherichia Coli**	Less than 40 samples/mo., more than 1 positive. 40 samples or more a mo., more than 5% positive.	The presence of total coliform indicate that other disease causing organisms, like E. Coli, may be present in the drinking water. Total coliforrn detection in exceedance of the MCL triggers testing for fecal coliforms/E. Coli which are organisms associated with sewage or animal wastes. I

Surface Water Treatment Rule (SWTR)

Name of Contaminant	**Maximum Contaminant Level (MCL) (mg/L unless noted)**	Health Effects of Contaminant
*Turbidity	* 1 NTU (average/mo.)	*None, interferes with disinfection
*Giardia lamblia *Enteric Viruses * Legionella * Heterotrophic Plate Count	Treatrnent Technique	* Giardiasis *Gastrointestinal and other viral infections *Legionnaire's Disease *Gastrointestinal Infections

Appendix A10

June,2000

Dear Water Utility Customer:

The 1996 Amendment to the Safe Drinking Water Act (SDWA) created a new public information requirement for municipal water systems. The City of Osseo Water Utility is required to annually publish a Consumer Confidence Report (CCR) and to distribute a copy to the water utility customers. This is the second annual report, which we have titled "Osseo Municipal Water Quality Report - 1999". The report describes the results of testing on the water system for calendar year 1999, along with information about the water supply. As can be seen by the results, none of the tests conducted this past year exceeded the strict drinking water standards set by the U. S. Environmental Protection Agency (EPA) and the Wisconsin Department of Natural Resources (Wis. DNR).

If you have any questions about the Water Quality Report, please contact the Water Utility at (715) 597-2207.

Water Utility
City of Osseo

Appendix A11
Page 1 of 4

Osseo Municipal Water Quality Report - 1999

The purpose of this report is to summarize the results of the water testing conducted by the Osseo Water Utility during the calendar year 1999. The report has been prepared to meet the requirements of the 1996 Safe Drinking Water Act (SDWA) adopted by Congress and to provide our customers with information about their municipal water system. In the tests conducted on the drinking water system, none of the strict standards set by the U.S. Environmental Protection Agency (USEPA) and the Wisconsin Department of Natural Resources (Wis. DNR) were exceeded. Our constant goal is to provide you with a safe and dependable supply of drinking water, and we are working diligently to assure delivery of reliable and safe drinking water. Our water sources are from two wells pumping from the Mt. Simon Sandstone aquifer. One well is located at 9th and Charles Streets, and a second is at 12th Street and Rose Lane. The 9th Street well has a water treatment filter to remove iron and manganese before it is pumped into the water distribution system. These minerals are not a health concern and are removed because they can discolor the water and create a slight taste of iron. The water is also chlorinated at both wells for disinfection before it is pumped into the water pipe system.

Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories

The Osseo Water Utility encourages public interest and participation in our community's decisions affecting drinking water. If you have any questions about this report or concerning your water utility, please contact Jim Deich, Director of Public Works, at (715) 597-2207. If you want to learn more, regular City Council meetings are held on the 2d Monday of each month at 5:30 P.M. in the Council Room, located in the Osseo City Hall.

As the water passes through the ground it can pickup dissolved minerals and in some cases substances that result from human and animal activity. For these reasons the Osseo Water Utility routinely monitors for constituents in the drinking water according to Federal and State laws. The testing is carried out as it is pumped from the ground and after it has been treated and delivered into the distribution system. All samples are analyzed at state certified laboratories.
To ensure that tap water is safe to drink, the USEPA prescribes limits on the amount of certain contaminants in water provided by public water systems. The Federal Drug Administration (FDA) regulations establish limits for contaminants in bottled water. The attached table shows the results of our monitoring for the period of January 1, 1999 to December 31, 1999.

All drinking water, including bottled drinking water, may be reasonably expected to contain at least small amounts of some constituents. It is important to remember that the presence of these constituents does not necessarily pose a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline (800)426-4791 or the Wisconsin Department of Health and Family Services (608)266-0923.

WATER QUALITY TABLE - 1999
PWS ID 66203280 OSSEO WATERWORKS
(Detected Substances)

INORGANIC CONTAMINANTS

Contaminant (units)	MCL	MCLG	Level Found	Range	Sample Date (if prior to 1999)	Violation	Typical Source of Contaminant
COPPER (ppm)	AL=1.3		0.5800	0.5800		NO	Corrosion of house- hold plumbing systems; Erosion of natural deposits; Leaching from wood pn@@qrvatives
FLUORIDE (ppm)	4	4	0.3	0.3		NO	
LEAD (ppb)	AL=15	0	7.00	7.0		NO	Corrosion of household plumbing systems; Erosion of natural deposits
NITRATE (NO3-N) (ppm)	10	10	1.08 (average)	nd - 1.50		NO	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits
GROSS ALPHA EMITTERS (pCi/l)	15	0	0.1	0.1	03/04/1997	NO	Erosion of natural deposits

DEFINITION OF TERMS

Term	Definitions
AL	Action Level: The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water svstem must follow.
MCL	Maximum Contaminant Level: The highest level of a contaminant that is allowed in drinking water. MCL's are set as close to the MCLG's as feasible using the best available treatment technology.

MCLG	Maximum Contaminant Level Goal: The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLG's allow for a margin of safety.
Ppm	parts per million, or milligrams per liter (mg/l)
Ppb	parts per billion, or micrograms per liter (ug/l)
PCi/l	picocuries per liter (a measure of radioactivity)
nd	Non-Detects: Laboratory analysis indicates that the contaminant is not present.
n/a	Not Applicable

Note: All substances detected were below the MCL.

All sources of drinking water are subject to potential contamination by constituents that are naturally occurring or man made. Those constituents can be microbes, organic or inorganic chemicals, or radioactive materials. All drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that the water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline at 1-800-426-4791.

MCL's are set at very stringent levels. To understand the possible health effects described for many regulated constituents, a person would have to drink two liters of water every day at the MCL level for a lifetime to have a one-in-a-million chance of having the described health effect.

Total Coliform: The Total Coliform Rule requires water systems to meet a stricter limit for coliforrn bacteria. Coliform bacteria are usually harmless, but their presence in water can be an indication of disease-causing bacteria. When coliform bacteria are found, special follow-up tests are done to determine if harmful bacteria are present in the water supply. If this limit is exceeded, the water supplier must notify the public by newspaper, television or radio.

Some people may be more vulnerable to contaminants in drinking water than the'gencral population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with IHV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/CDC guidelines on appropriate means to lessen the risk of infection by cryptosporidium and other microbiological contaminants are available from the Safe Drinking Water Hotline (800-426-4791).

Thank you for allowing us to continue providing your family with clean, quality water this year. In order to maintain a safe and dependable water supply we sometimes need to make improvements that will benefit all of our customers. These improvements are sometimes reflected as rate structure adjustments. Thank you for understanding.
For additional information, contact the Osseo Water Utility at (715) 597-2207.

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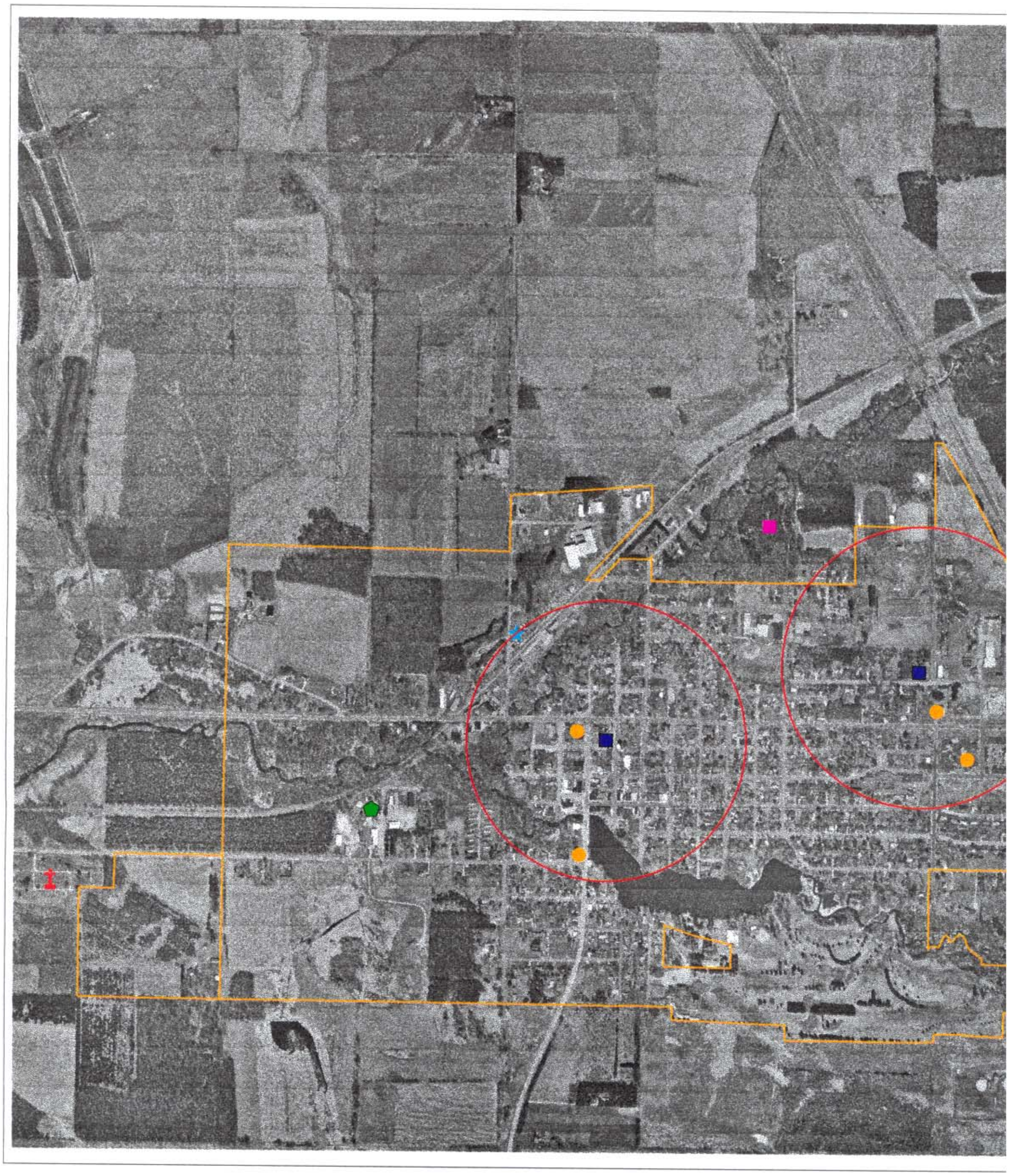
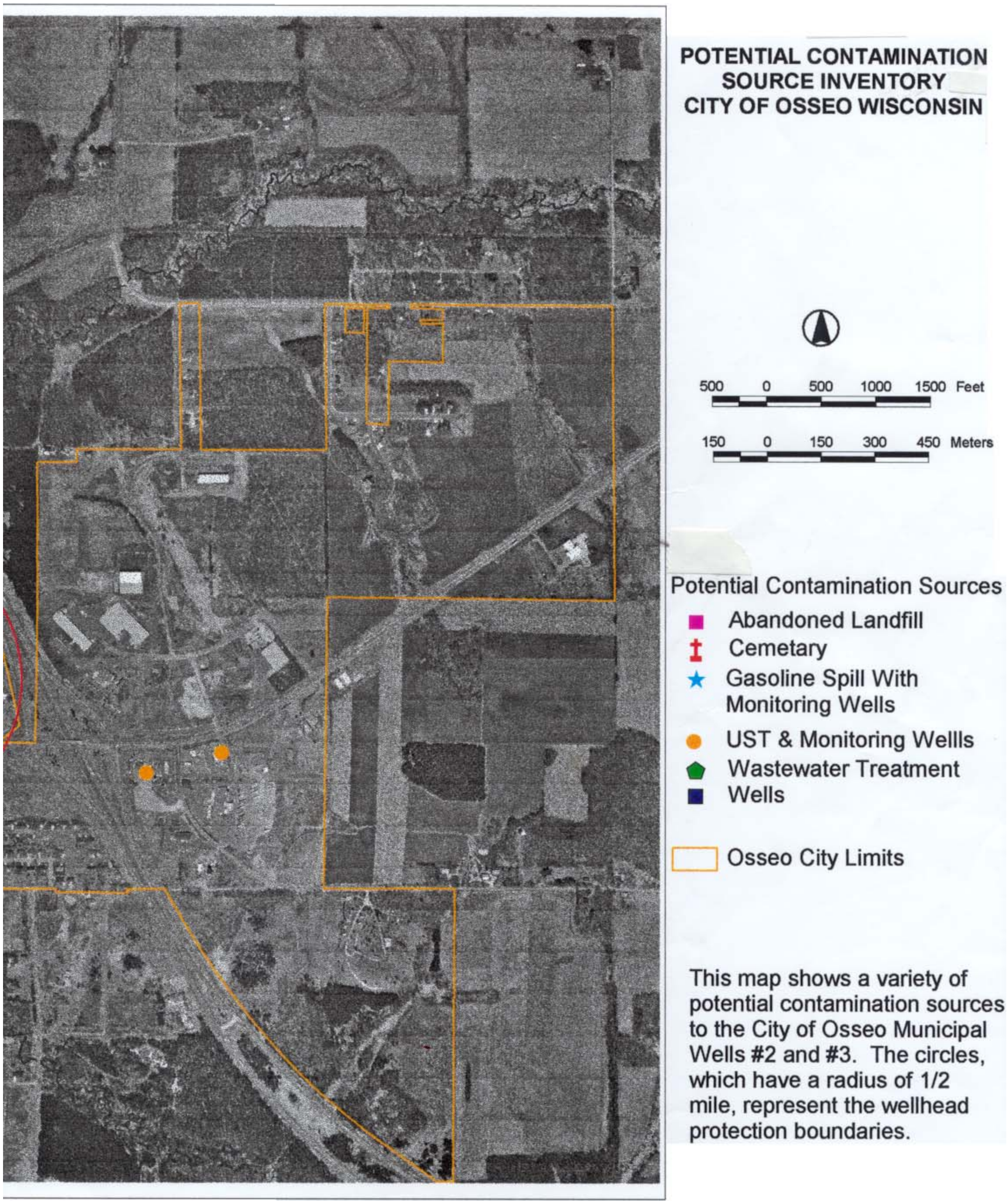


Graphical Source Inventory – City of Osseo, Wisconsin

Appendix A12 (Page 1 of 2) – left side of total picture



Graphical Source Inventory – City of Osseo, Wisconsin

Appendix A12 (Page 2 of 2) – right side of total picture

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